Population Dynamic Of Rabbit Fish (Siganus Canaliculatus) In Gulf Of Bone Luwu Regency, South Sulawesi

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Abstract: Rabbitfish (Siganus canaliculatus) is ones of coral reef inhabitants are exploited intensively and suspected population decline , so the necessary management measures was needed. The study aims to analyze aspects of the dynamics of rabbit fish populations in the Bone Gulf Luwu waters. Data was collected by Staratied Random Sampling, estimation of the size structure, the number of age groups and average length of fish per age group use a column diagram and Bhattacharya method. Population growth is analyzed using the Von Bertalanffy equation exponential growth, the value of L ~, K, by Ford and Walford method and t0 by Pauly method. The total mortality, fishing mortality, the rate of exploitation and Y / R were estimated by methods of Beverton and Holt, and natural mortality by method of Pauly. The results showed that the population of rabbit fish in the waters of the Gulf of Bone Luwu consists of five age groups, has the average length and the lenth range of 8.0904 cm and 5.7 to 9.0 cm on the relative age of one year, 10.9222 cm and 9.0 to 12.3 cm on the relative age of two years, from 12.3 to 15.6 cm 14.1543 cm on the relative age of three years, 16.8949 cm and 15.6 to 18.9 cm on the relative age four years, and 19.4906 cm and 18.9 to 20.7 cm on the relative age of five years. Maximum length ($L\infty$) of 30.5814 cm and the growth rate coefficient (K) of 0.1572 per year, while the t0 value of -1.4815 ofyear. The total mortality (Z) of 1.6913 per year, the mortality (M) of 0.6109, fishing mortality t 1.0804 per year, the rate of exploitation (E) of 0.6388 and optimal exploitation rate (Eopt) of 0.50, the value of Y / R is now 0.0127 and the value of Y / R optimal 0.0150. The conclusion that the population is dominated medium sized fish, slow population growth as a result of the high mortality rate of the capture and exploitation as well as the recruitment process is not optimal.

Keywords: Population dynamics, Siganus canaliculatus, Bone Bay Luwu

Introduction

Rabbit fish (Siganus canaliculatus) in the waters of the Gulf of Bone Luwu is one of the fisheries resources which can be developed both as activity of economy of coastal communities especially the fishermen regionally, and also as source of district revenue. This fish species is one characteristic of the waters of the Gulf of Bone Luwu because it has a taste more delicious than in other waters [1]. In the Karang-Karangan village Bua District South Sulawesi rabbit fish population has been exploited intensively by fishermen used guiding barrier non selective fishing gear, throughout the year especially during the spawning season, caught both small fishes (juveniles) and large size (adult fishes). This condition and without management policy can caused decreasing of the rabbit fish population both quantitatively and qualitatively characterized by increasingly small size of the fish caught, and if it continues population will be disrupted. In purporse and effort to exploit optimally and rationally data and information about population dynamics of the rabbit fish must be known [2].

Objectives of Research

This study aims to analyze the dynamics of population of rabbit fish in the waters of the Gulf of Bone Luwu, South Sulawesi. The results of the study can be useful as the important data and information in the management of these resources.

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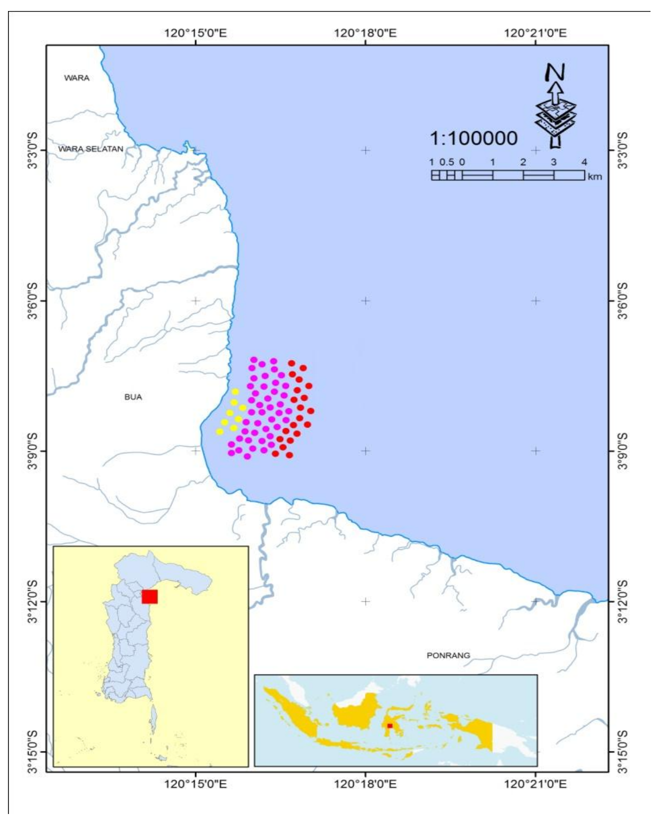
Data Collection Methods

The study was conducted from November 2013 to April 2014 in the waters of the Gulf of Bone Luwu, South Sulawesi, Indonesia. Location of study and area of sampling i.e Karang-Karangan village Bua District South Sulawesi was 3 6'27, 19 "-3 8'37,81" latitude and 120 14'4,35 "-120 17'36,17" BT geographically as shown in.Figure 1.



Pigure 1. *Research location*

Rabbitfish samples obtained directly from the catch of fishermen of fishing gear owner. To represent their individual size structure that exists in nature in a sample, the number of individuals in the sample or the number of samples should be kept as much as possible. Some researchers require the number of samples more than 1,000 fish and the number of cohort more than two cohorts. [4]. Sample of fishes were obtained by Stratified Random Sampling where as the strata are the fishing area of fishing gear , and the size of the fish. Before the measurements are made of fish grouped by large, medium and small, then the size of the group were randomly selected fish were measured, the size of the fish used is the total length (LT).

Data Analysis Methods

Structure Size and Age Group

The determination fish size structures, the number of age groups, and the average length of individuals per age group using the method of column diagrams and natural logarithm difference length frequency [5]. If the length frequency distributions (observed frequencies) of fishes in the age group did not follow a normal distribution, it must be normalized by the normal distribution equation [2] as follows:

$$Fc = \frac{n.dl}{s\sqrt{2\pi}} \exp\left[\frac{-(X-x)^2}{2s^2}\right] \qquad (1)$$

Where:
Fc = Frequency
n = The number of fish measured
dl = the Interval class
s = standard deviation
x = The average length
X = Middle of class total length
π = 3.1415

Growth

Growth was analyzed using exponential Von Bertalanffy growth equation [2] as follows:

$$Lt = L\infty[1-e^{-K(t-to)}] \qquad (2)$$

Where:
Lt = length of fish at time t (years)
L∞ = Asimptot (cm)
K = coefficient of growth (per year)

Values of the length of the fish asimptot (L∞) and growth rate coefficient (K) were determinate by Ford and Walford methods [2], ie by plotting L (t + Δt) and L (t) by the following equation:

$$L\ (t + \Delta t) = a + b.\ L\ (t) \qquad (3)$$

The equation of the regression equation is the dependent variable (dependent variable) and the independent variable (independent variable), then put in a linear equation, namely:

$$Y = a + b\ x \qquad (4)$$

Where:
a = L∞ (1 – b)
b = exp (-K. Δt)

Thus obtained:

$$L\infty = \frac{a}{1-b} \qquad (5)$$

$$K = \frac{-1}{\Delta t} \ln b \qquad (6)$$

Furthermore, determinstion of t0 use the formula [6], namely:

$$Log(-t_0) = -0{,}3922 – 0{,}2752\ (LogL\infty) - 1{,}038\ (LogK) \qquad (7)$$

Where:
L∞ = Length asimptot of fish (cm)
K = Coefficient growth rate (per year)
t_0 = theoretical age of the fish at the time of a length equal to zero (years)

Mortality

Natural mortality rate of fish (M) is calculated using the empirical formula [6] as follows:

$$Ln\ M = -0.152 - 0.279\ 0.6543\ Ln\ Ln\ L\infty + K +0{,}4634\ Ln\ T^0C \qquad (8)$$

Where:
M = natural mortality rate (per year)
L∞ = Asimptot fish Length (cm)
K = coefficient of growth (per year)
T = average temperature of the waters (^{0}C)

For fish that live in groups, the above equation is multiplied by a value of 0.8. The rate of total mortality (Z) was calculated using the formula Beverton and Holt [2].

$$Z = K\left(\frac{L\infty - L}{L - L'}\right) \qquad (9)$$

Where:
Z = total mortality rate (per year)
L = The average length of fish caught (cm)
L’ = Length of the smallest of the fish caught (cm)
L∞ = Asimptot fish Length (cm)
K = coefficient growth rate (per year)

Mortality rate of Fishing (F) estimated using the equation): Z = F + M
So it can be obtained:

$$F = Z – M \qquad (10)$$

The rate of exploitation and Yield per Recruitment

The rate of exploitation (E) estimated using Beverton and Holt equation [2], namely:

$$E = F/Z \qquad (11)$$

Where:
F = Mortality arrest
Z = total mortality rate
M = natural mortality
E = rate of exploitation

While Yield Per Recruitment (Y/R), known from the equation Beverton and Holt [2], namely:

$$(Y/R) = E.U^{m}\left[1 - \frac{3U}{1+m} + \frac{3U^{2}}{1+2m} + \frac{U^{3}}{1+3m}\right] \quad (12)$$

Where:

$$U = 1 - \frac{Lc}{L\infty}$$

$$m = \frac{1-E}{M/K}$$

Where:

E = rate of exploitation
Lc = size of the smallest class of fish caught (cm)
M = natural mortality rate per year)
K = coefficient growth rate (per year)
L∞ = Asimptot fish Length (cm)

RESULTS AND DISCUSSION

Structure Size and Age Group

From 1032 fish sample being measured can be seen that the smallest and the biggest fish were 5.7 cm and 20.7 cm of length respectively. Fishes that have been measured are grouped by size into classes of length (0.3 cm) in which each class there are a number of individual fish, also known as frequency according to the length class. Mapping between the frequency of each class of length and, the middle value of class of length produce a histogram where each peak represents one age group. The number of age groups obtained in this study are five age group, more than the number of age groups obtained by [1] at the same location are four age groups. The result of calculation showed that the frequency distribution observed of the length of the each classes age was not normally distributed so normalized process of frequency disbution must be done using the equation of the normal distribution, was to recalculate the frequency of observed frequencies (F observed), become expected frequencies or frequency calculated (F calculated), as shown in Figure 2. Average length value in each age group of the fish as shown in Table 1 and Figure 3.

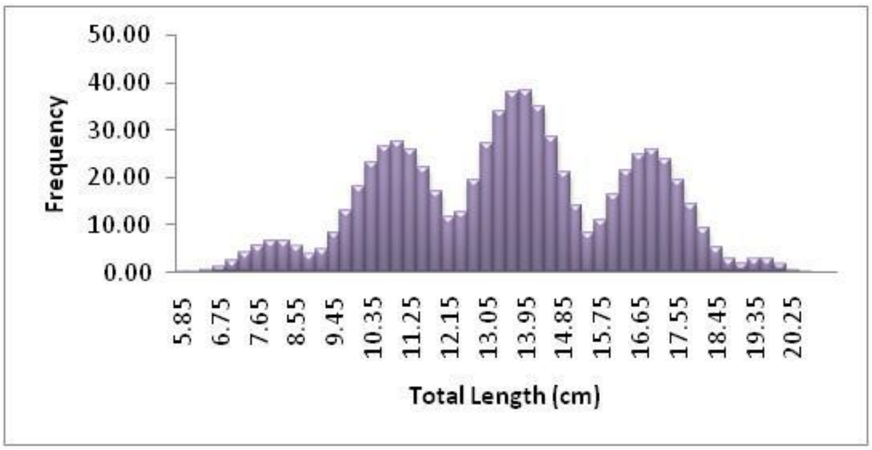


Figure 2. *Normalized histogram length frequency of the classes of fish length of rabbitfish*

Table 1. *Length class and the average length of fish for each age class of rabbitfish in the waters of the Gulf of Bone Luwu.*

Length class (cm)	Relative Age (years)	Average length of fish (cm)	Number of Fish
5.7-9/0	1	8.0904	59
9.0-12.3	2	10.9222	297
12.3-15.6	3	14.1543	370
15.6-18.9	4	16.8949	279
18.9-20.7	5	19.4906	27

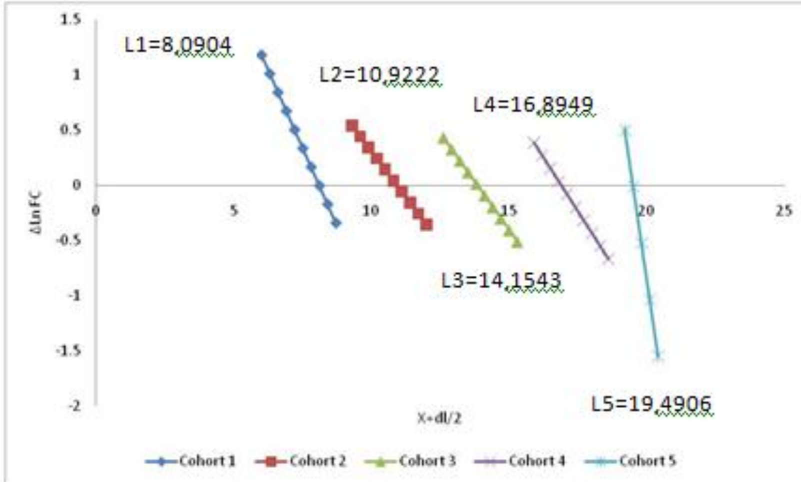


Figure 3. *Plotting between the Mid Values of Length Class and the values of logarithm Cumulative difference of Frequency of rabbit fish (Siganus canaliculatus) at Every Age Group.*

Based on Table 1 and Figure 3, that the rabbit fish in the waters of Bone Gulf Luwu can reach 8.0904 cm of an average length and length range from 5.7 to 9.0 on the relative age of one year, 10.9222 cm of an average length and 9.0 - 12.3 cm of length range on the relative age of two years, 14.1543 cm of an average length and 12.3 to 15.6 cm of length range on the relative age of three years, . 16.8949 cm of an average length and 15.6 to 18.9 cm of length range on the relative age of four years, 19.4906 cm of an average length and 18.9 to 20.7 cm of length range on the relative age of five years. Syamsuryani (2015) explained that the rabbit fish in the Flores Sea [i]waters Selayar Islands District consit of four age groups where the average length of 1st , 2nd , 3rd , 4th and 5th classes age were 13.49 cm, 19.43 cm, = 23.60 cm and 26.00 cm respectively. The difference relationship between length and relative age of fushes according to fishing area mainly caused by oceanographical condition, avaikability of foods and intensity of fishing.

Growth

Based on calculations using the Ford-Walford [2], i.e plotting the value of L (t + Δt) and L (t) the value of the maximum length (L∞) and growth rate (K) of rabbit fish caught in the waters of the Gulf of Bone Luwu were 30 , 5814 cm and 0.1572 per year respectively, while the value of t0 obtained from the equation [6] was -1.4815 year. Those values explained that if a rabbit fish in the Gulf of Bone Luwu grows continuously without dying and do not caught then the fish can reach a maximum length 30.5814 cm. Based on K, L∞, and t0 values obtained above, the exponential growth equation of Von Bertanlanffy of rabbit fish in the waters of the Gulf of Bone Luwu, could be write as follows:

$$Lt = 30.5814 \times [1-e^{-0.1572(t-(-.,4815)))}] \quad (13)$$

In using Von Bertalanffy growth equation, the age of every length of fish can be predicted easily (Figure 4).

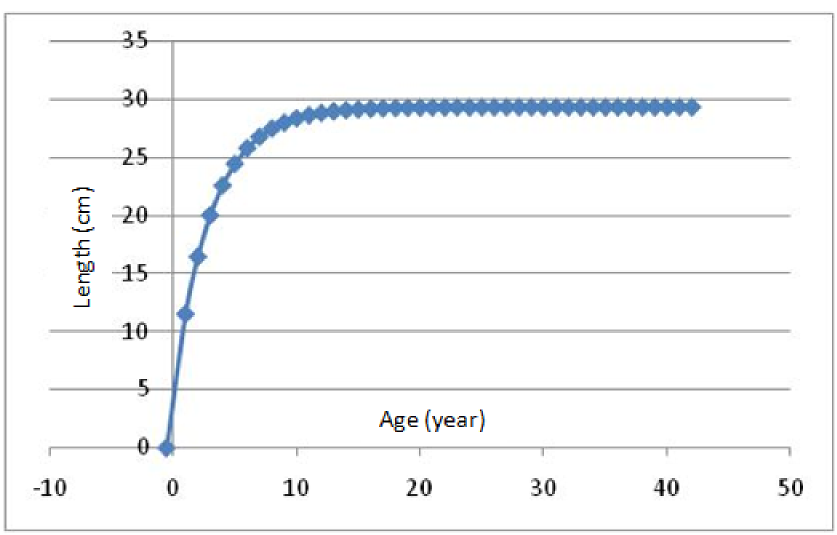


Figure 4. *Growth curve of Rabbit fish (Siganus canaliculatus) in the waters of the Gulf of Bone Luwu.*

Based on Figure 4 can be explained that at the rabbit fish in the beginning of their life cycles grow fast , can reach 20 cm of length in growth 3 years old and then slowly until asimptot length. Based on value of growth rate (K) it could be declared that rabbit fish live in the waters of the Gulf of Bone Luwu has a growth rate (K) is low (0.1572 < 0.5 yearly). caused of under 0.5 per year. It is also found that rabbitfish requires a long time to reach its maximum length. This is consistent with the statement [2] that the fish has a growth rate or the coefficient K ≤ 0.5 is classified as a slow growing fish and fish that have slow growth requires a long time to reach its maximum length. Samsuryani (2013) explained that rabbit fish caught in the Flores Sea waters Selayar Islands Disstrict can reach 30.87 cm of L ∞ and 1.28 per year of growth rate (K) , and - 0.12 years of t0.. Comparative values of K and L ∞ obtained by several of authors presented in Table 2 below.

Table 2. *Comparison of L∞ and K from several studies of rabbitfish in different areas*

Location	L∞	K	Reference
Palau, Western Pacific Ocean	28,10	1,95	[8]
Teluk Ambon bagian dalam	25,59	1,078	[9]
Gulf Waters, Saudi Arabia	36,00	1,33	[10]
Red Sea, Egyptian Sector	37,07	0,39	[11]
Western Indian, Ocean Waters	22,50	1,26	[12]
Arabian Sea off Oman	40,13	0,85	[13]
Gulf of Mannar, South India	24,50	1,60	[14]
Jubail Marine Wildlife Sanctuary, Saudi Arabia	35,38	0,58	[15]
Selayar Island, South Sulawesi	30,87	1,28	[7]
Bone Gulf, Luwu Regency, South Sulawesi	30,58	0,15	This reseach

Based on data from Table 2 that the values of L∞ and K were different according to fishing area where this phenomenon caused mainly by uceanographical condition of area, intensity of fishing and size structure of fishes caught.

Mortality

Total Mortality (Z)

Total mortality or total mortality rate (Z) of rabbit fish could be estimated using the method Beverton and Holt [2]. In this study, because fishing gear used by fishermen was not selective, so the smallest fish caught was 8.1 cm of length, with the assumption that all sizes of fish can be caught. The estimated value of total mortality (Z) was 1.6913 per year.

Natural Mortaliy (M)

Natural mortality can be estimated by empirical equations of Pauly [2]. The calcukation of M value using the values of K.1572 per year, L∞ 30.5814 cm of Von Bertalanffy equation above, and the value of an average water temperature of the Bone Gulf waters Luwu 29°C. The estimated value of natural mortality (M) was of 0.6109 per year.

Fishing Mortality (F)

Deaths of fish due to fishing or fishing mortality (Z) was calculated by the reduction of total mortality (Z) with natural mortality (F = Z - M), where the estimated value of F obtained was of 1.0804 per year .

The exploitation rate (E).

The rate of exploitation (E) is represent of the role of the fishing mortality (F) to the total mortality (Z), or E = F / Z. the value of rate of exploitation (E) obtained was of 0.6388 and optimal exploitation rate (Eopt) at 0. 50. Comparison of the estimated value Z, M, F and E in this study and other research results are presented in Table 3.

Table 3. *Comparison Value Z, M and F of Rabbit fish at various locations.*

Location	Z	M	F	Reference
East coast of Saudi Arabia	1,50	0,75	0,75	[16]
Oman, Arabian Sea	2,66	1,36	1,30	[13]
Jubail, Saudi Arabia	1,95	1,02	0,93	[15]
Selayar, South Sulawesi	5,40	2,08	3,32	[7]
Bone Bay Luwu South Sulawesi	1,69	0,61	1,08	This research

From the results of research on rabbitfish conducted in the waters of the Gulf of Bone Luwu, shows that the role of natural mortality in total mortality is very small, otherwise the role of fishing mortality very large or in other words that the activity of catching the fish populations uf rabbit fish in the waters of the Gulf of Bone Luwu quite high. If the fishing activities carried out an intensive and continuing to meet consumer demand in the absence of resources management plan, ut is predicted then rabbitfish resources within a certain time will decline the rabbit fish stocks drastically.

Yield per Recruitment (Y/R).

Estimation of relative yield per recruitment (Y/R) is one model that is commonly used as a basis for fisheries management strategy [17]. Y/R in this study estimated using Beverton and Holt equation [2]. Results obtained that value of Y / R of rabbit fish in the waters of the Gulf of Bone Luwu of 0.0127 grams.

The rate of exploitation and the relationships Yield per Recruitment

Relationsnip between exploitation rate and yield per recruitment can be used as an indicator to assess both the rate of exploitation (E) and tield per recruitment (Y/R) at this time is optimal or not. Relationship between E and Y?R is presented in Figure 5.

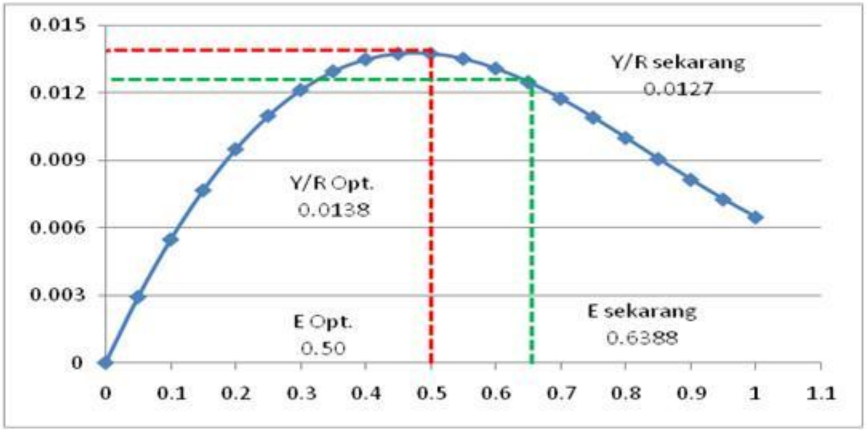


Figure 5. *Relationship between Yield per Recruitment (Y/R) and Exploitation rate value (E) of Rabbit fish in Gulf Bone Luwu district waters curve.*

The result of the calculation of the relationship between exploitation rate (E) and yield per recruitment showed that at the current rate of exploitation (E actual) of 0.6388 > F optimal (0.5) , the value of Y / R actual and value of Y/R optimal were 0.0127 and 0.0138 respectively. Based on the results of the calculation of the relationship between the rate of exploitation (E) and yield per recruitment (Y / R) as shown in Figure 5 above some pattern of management of resources rabbit fish resources to do, namely: (1) if the rate of exploitation on the current value (E = 0 , 6388) still wants to retain the ability recruiting fish rabbit populations are very small, it is only equal to 0.0127 grams per recruitment and this may impair the sustainability of the population of rabbit fish because the population recovered ability not too big, so it is necessary to the increase in population recruitment capabilities. Ability recruit rabbit fish populations can be enhanced through the enrichment of the stock (stock enhancement) eg, improvement of water environment, restrictions on the size of the captured, restocking, etc., (2) reducing the rate of current exploitation (E = 0.6388) to optimal exsplotation rate (E = 0.5) with the ability Y/R population of 0.0138. On the value of Y/R 0.0127 population's ability to self-renewable was not optimal and decreasing of population biomass of rabbit fish continuing by fishing. If the rate of exploitation is maintained at current levels (E = 0.6388) without any effort to increase the recruitment of the population it is feared that the rabbit fish population in the waters of the Gulf of Bone Luwu later develop over exploited (excess of fishing), and in the end will interrupt resources sustainability..

CONCLUSION

1) The population of rabbit fish in the waters of the Gulf of Bone Luwu consists of five age groups, and population grow was slowly.
2) The death of individuals in the population was very high due to the death because of the fishing.
3) The rate of exploitation of rabbitfish is currently very high more than optimal exploitation rate due to the high intensity of the fishing and consequently the process of recruitment was not optimal. And can distrup sustainability of rabbit fish population.

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