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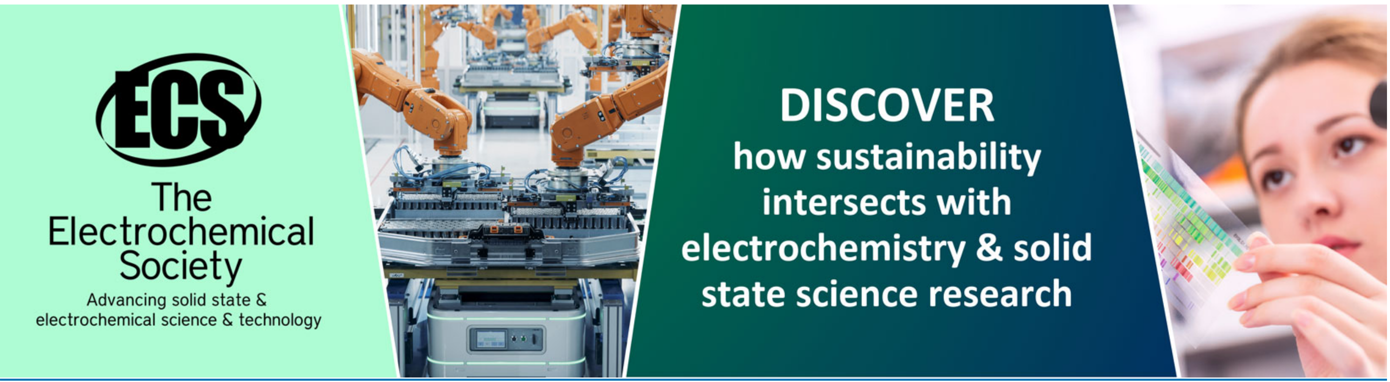

Population dynamic of red snapper (*Lutjanus gibbus*) at Alor waters East Nusa Tenggara Province, Indonesia

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Abstract. This study aims to analyze the population dynamics of red snapper in Alor waters, conducted from March 2018 to March 2019. Fish total length data is collected from red snapper fishermen twice a week using a stratified random method. Size structure, cohort numbers and average length of fish per cohort using Bhattacharya method, asymptotic length and growth rate using Ford and Walford methods, total mortality, capture and natural using linearized length converted catch curve using Pauly methods, exploitation rate and Y/R by Beverton and Holt methods. The results show that red snapper measuring 180-555 mm, male 220 - 555 mm, females 180 - 330 mm, consisting of four cohort, L∞ 594.25 mm, K 0.69 per year, F, M, and E are 0.84, 0.63 and 0.56 per year respectively, the actual Y/R and Y/R are optimal at 0.0773 and 0.0989 grams per recruitment. The conclusion that catches are dominated by young and pre-adult fish, population consists of four cohort, fish in the population quickly reach L∞, the ratio of F and M rate are greater than one (F/M> 1), high F rates cause high rate of E and impact on the recruitment process that is not optimal.

1. Introduction

Alor Regency is one area that has wide territorial waters where the territorial waters are almost the same as the total land area. The Alor land area covers 13,638.26 km^2 while the Alor water area covers 10,773.6 km2. According to the Central Statistics Agency of Alor Regency [1], in Alor Regency the number of households in the capture fishery business is 4,697 household, consisting of 365 household dugout and plank built boats, 2,404 household outboard motor, 1,269 household out board motor, and 659 households inboard motor. Furthermore, the type of fishing gear used by Alor Regency fishermen consisted of 27 units of traditional seine net, two units of purse seine, 1,867 units of gill nets, 578 units of traps, 28 units of boat lift net, 627 units of trolling line, 1,811 unit of other line fishing and others 226 units. In Alor Regency the maximum sustainable potential (MSY) of fish resources is 164,604.3 tons per year and the total allowable catch is 131,683.4 tons per year. The annual fishery production level in 2017 is 17,218.5 tons, consisting of 17,217.2 tons of marine fisheries and 1.3 tons of inland fisheries. The current level of production is 13.08% of its potential [2].

One of the fish resources of Alor Regency waters that has high potential is red snapper (*Lutjanus gibbus*). Red snapper has a high selling value and a very large market demand encourages fishermen to catch fish intensively throughout the year without regard to its sustainability. FAO [3] states that the right to capture fish resources must accompanied by management obligations. To maintain the sustainability of fish resources, rational use and use of environmentally friendly fishing gear needs to be encouraged [4]. It further explained that fish resources whose population was declining require management efforts to restore their condition. To manage red fish, data and information related to biological aspects, population dynamics, stock conditions and, fisheries aspects usually needed. Some researchers report that red snapper in Indonesian waters has a high catch rate [5][6][7][8][9]. Based on the description above, it considered very important to conduct a study of population dynamics of red snapper in the waters of Alor, East Nusa Tenggara Province.

The purposes of research are analyzing the size structure and age group, growth rate, mortality and exploitation rate of red snapper in the waters of Alor waters East Nusa Tenggara Province.

2. Materials and methods

2.1. Research Time and Location

This research was conducted for approximately one year, namely from March 2018 to March 2019 in the waters of Alor, East Nusa Tenggara. Sampling was carried out in the fishing landing site or fishing base of red snapper fisheremen in the waters of Alor, namely in Treweng Island Pantar Timur District, Pura Besar Island Pura District, and Buaya Island Alor Batar Laut District. The geographical position of the study location is 8º6' - 8º36' South Latitude and 123º48' - 125º48' East Longitude (Figure 1) [1].

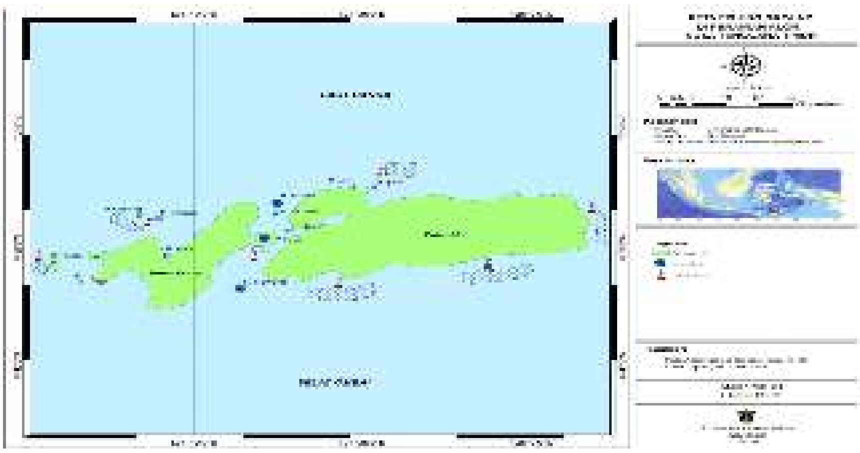

Figure 1. The research location

2.2. Research materials and equipment

The materials used in this research are red snapper, aquadest, 10% formalin, data sheet tables, interview boards, and writing instruments, and equipment such as measuring boards, digital scales, sample bottles, GPS, digital thermometers, cameras, computers and software.

2.3. Data collection

Fish length data (TL in mm) collected through direct measurements on fishing boats during fishing operations and at fish landing sites. Data collection done twice per week using a stratified random sampling method if the number of fish caught is very large. Before measuring, the fish grouped in large, medium and small fishes, and then each size group measured 10% [10,11]. If the number of fish caught is a little or less than 100 fish then all fish measured. The number of sample fish from three study locations presented in table 1.

Table 1. Number of research samples by location

No	Sampling location	Number of sample
1	Traweng Island waters	1360 fish
2	Pura Besar Island waters	2150 fish
3	Buaya Island waters	590 fish

2.4. Data analysis

2.4.1. Size structure. The size structure of the fish caught in a descriptive analysis is plotting between frequencies according to the middle class and middle class fish size and presented in the form of a histogram (column diagram).

2.4.2. Age group. The number of age groups and the average length of individuals according to the age group of Alor waters red snapper analyzed by difference logarithm frequency method of Bhattacharya [12], where fish are divided into several long classes. The frequency of each class length converted into a logarithm and then the difference between the logarithm of a class and the previous class sought.

2.4.3. Growth rate. The growth of red snapper analyzed using the Von Bertalannffy exponential growth equation [13] as follows:

$$L_t = L_\infty[1 - e^{-K(t-t_0)}]$$

Where, Lt = fish length in t (tahun), $L\infty$ = asymptote length (cm), K = growth rate coefficient (per year) and t_0 = theoretic age in length zero (year). To determine the fish asymptotes length ($L\infty$) and growth rate coefficients (K) the Ford and Walford methods [13].

2.4.4. Total mortality. Total mortality rate (Z) calculated using the method Linearized length converted catch curve [14-17] with the following equation as follow:

$$\ln \frac{C(L1,L2)}{\Delta t(L1,L2)} = C - Z\left(\frac{t(L1)+t(l2))}{2}\right)$$

Where, y = ln C (L1, L2)/Δt (L1, L2), x = {t (L1) + t (L2)}/2, and slope (b) = - Z**.**

2.4.5. Natural Mortality. Estimation of natural death (M) uses Pauly's emphiric method [11] with the equation as follows:

$$M = 0.8 * \exp[-0.0152 - 0.279 * \ln L\infty + 0.6543 \ln K + 0.463\ T]$$

Where: M = natural mortality, $L\infty$ = fish asymptote length, K = growth rate coefficient, and T = temperature of the waters where fish are caught

*2.4.6. Fishing Mortality***.** Fishing mortality rate (F) assumed by using the equation

$$F = Z - M$$

*2.4.7. Exsploitation Rate***.** The exploitation rate (E) is estimated using the Beverton and Holt equations [11], as follow:

$$E = F / Z$$

Where, F = Fishing mortality (per year), Z = total mortality (per year), M = natural mortality (per year) and E = rate of exploitation (per year)

2.4.8. Yield per Recruitmen (Y/R). Yield per recruitment (Y/R) values known from the Beverton and Holt equation [13], as follow:

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

Where $U = 1 - \frac{Lc}{L\infty}$, $m = \frac{1-E}{M/K}$, E = exploitation rate (per year), Lc = length of the smallest fish that has been caught ≥ 50% (cm), M = natural mortality rate (per year), K = growth rate coefficient (per year) and L∞ = fish asymptote length (cm).

All parameters above calculated using the help of FISAT II software.

3. Result and discussion

3.1. Size structure

In this study, as many as 4,100 red snapper measurements taken, consisting of 2,635 male fish with a length of 235 - 538 mm and 1,465 female fish with a length of 183 - 315 mm. The male red snapper dominated by fish measuring 285 - 375 and there are small sized fish in small numbers, while female fish dominated by size 225 - 255 mm and not large fish (figure 2). The data in figure 2 explained that the length and size range of male red snapper is greater than female red snapper. The combined population of female males has a length range of 183 - 538 mm and the dominant size is in the length range of 225 - 345 mm (figure 3).

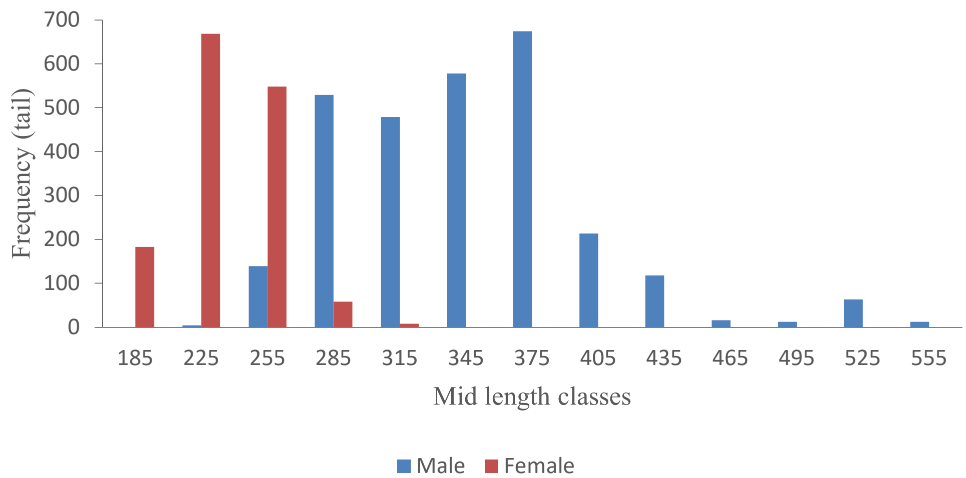

Figure 2. Size structure of red snapper male and female in Alor waters

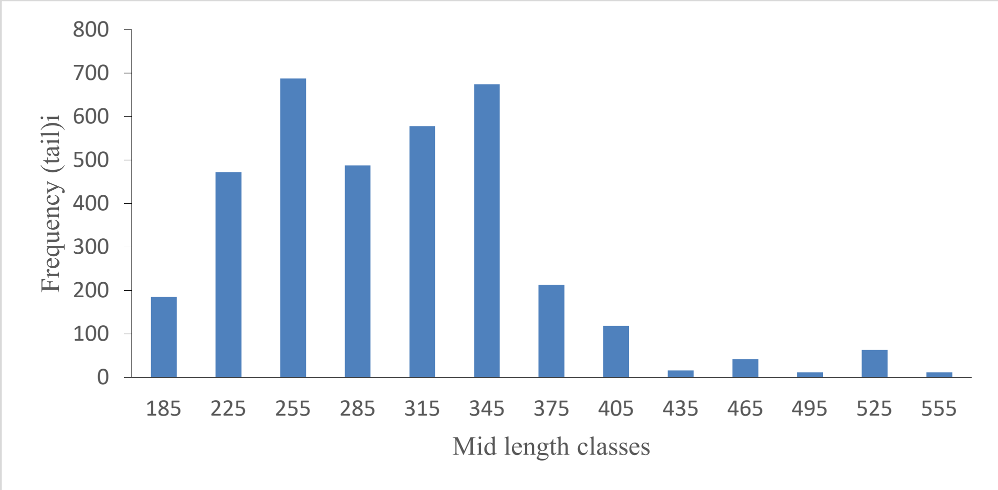

Figure 3. Size structure of combine male and female of red snapper in Alor waters

The size structure of Red Snapper fish in Alor waters is not much different in other waters, both in Indonesia and some waters in the world as reported by several other researchers. The red snapper (*L. gibbus*) caught by the hand line and bottom longline fishing in the South Banten Sunda Strait had a length range of 103–415 mm and an average length of 222 mm. The male red snapper has sizes ranging from 103-360 mm and females ranges from 147 to 324 mm, where male fish have a longer size than female fish [18]. Red snapper (*L. gibbus*) in the waters of the Bunaken Marine Park had a length (FL) range 151 - 312 mm for the combined population, 160 - 312 mm in male and 151 - 289 mm in female populations [19]. Red snapper (*L. gibbus*) caught in the waters of the Micronesia State Phonpei has a length range of 198 - 335 cmFL, in the Philippine Bay of the Philippines 2009 - 2012 has a length range of 85 - 380 mm FL [20]. Red snapper (*L. gibbus*) caught by fishermen in the waters of Tuematu Atoll, Tahiti French Polynesia has a length range of 150 - 340 mm [21]. Red snapper *(L. gibbus*) in Kamiali Wilidlife Management Area, Papua New Guinea measuring 130 - 300 mm, average length of 200 mm and maximum length of 420 mm [22]. Red snapper (*L.gibbus*) of Guam coral waters has a long range of 150-515 mm in females and 150-54 mm in males [23]. The size structure of a type of fish caught from various waters can be different which can be caused by differences in growth rates, recruitment processes, exploitation rates and fishing gear used [17,24].

3.2. Number of age group (Cohort)

Analysis of the age group of red snapper done using the Bhattacharya method with the help of the ELEFAN I program and FISAT II software. The analysis showed that the red snapper fish population in Alor waters consisted of four age groups (figure 4). The number of fish in each group and the average length of fish by age group presented in table 2.

Based on table 2 that red snapper in Alor waters can reach an average length of 210±28.59 mm at one year, 287±28.28 mm at two years, 394±33.24 mm at three years and 519±32.85 mm at four years. Furthermore, based on the size structure of red snapper presented in figure 2, it can explained that the red snapper in Alor waters dominated by fish aged one to three years in combined male female population, in male fish dominated by fish aged two to three years and in female fish dominated by fish aged one to two years. Red snapper in the waters of the Tuematu Tahiti French Polynesia Atoll consists of three age groups and dominated by fish of 200 mm in size or 1-2 years old [21].

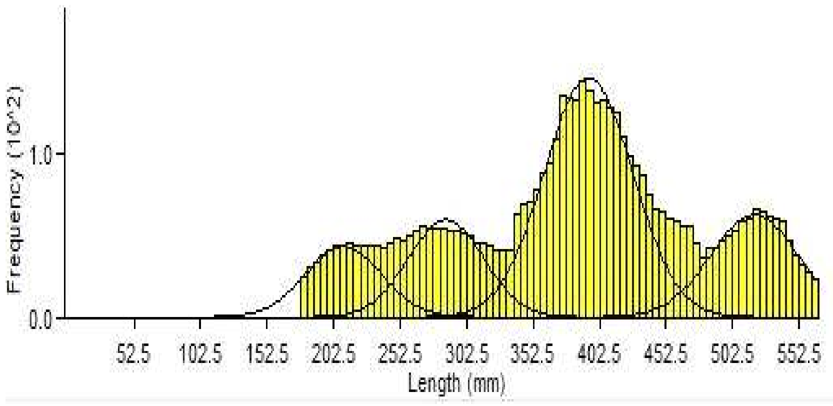

Figure 4. Number of age group of red snapper in Alor waters

Table 2. Number and the average length of fish in each age group of red snapper in Alor waters

Age group	Average length (mm)	Deviation Standard (SD)	Population (ekor)	Separation Index (SI)
1	210	28.59	617	n.a
2	287	28.28	840	2.17
3	394	33.24	2427	2.29
4	519	32.85	216	2.27

3.3. *Growth rate of red snapper (L. gibbus)*

Analysis of growth parameters using Ford and Walford methods by inputting the average length of fish in each age group in Table 2, the coefficient of growth rate (K) and asymptot length ($L\infty$) of red snapper in Alor waters in East Nusa Tenggara Province can be known. Furthermore, using the Pauly method, the theoretical age value (t_0) also found. The K, $L\infty$ and t_0 values of the red snapper of Alor waters presented in table 3.

Tabel 3. Value of $L\infty$, K and t_0 of red snapper in Alor waters

Parameters	Value (male & female)
Asymptot length, L_∞ (mm)	594.25
Growth rate coefficient, K (per year)	0.69
Theoritic age in fish length equal to nul, t_o (year)	0.1027

Based on the parameter values presented in table 3, the Von Bertalanffy's exponential growth equation can be write as follows:

$$Lt = 594.25 \; [1 - e \; \{^{-0.89(t + 0.1027)}\}$$

The length and age relationships and the estimated length according to the age of the Alor Red snapper fish presented in figure 5.

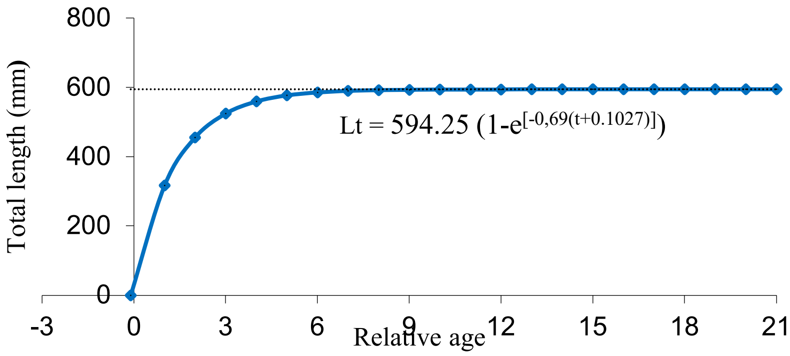

Figure 5. Von Bertalanffy growth curve of red snapper in Alor waters East Nusa Tenggara Province.

The value of the growth rate coefficient (K) of 0.69 per year obtained explains that the population of red snapper fish in the waters of Alor East Nusa Tenggara has fast growth (K> 0.5 per year), which means that the population within a few years has approached length asymptote (L∞). Furthermore, it can explained that red snapper grows fast in years I - IV and starts to slow down in years V-VI and in theory will reach its maximum length after year XVIII. Fish or other aquatic organism will grow rapidly in their early life that is generally in years I - III and growth will begin to slow down exponentially in the years afterwards [24]. Theoretically the higher the K value the faster the fish in the population reach the length of the asymptote [13,24]. Rapid growth of red snapper has also reported in the waters of Bunaken National Park [1], in the waters of Australia's Great Barrier Reefs 20]. Conversely slow growth of red snapper (K <0.5 per year) occurs in the waters of Tuematu Tahiti French Polynesia [21], in the waters of Ishigaki Island Okinawa [25], in the waters of Wangi -Wangi Island Southeast Sulawesi [26], in the southern waters of the Sunda Strait Banten [9]. In the waters of Kota Baru, South Kalimantan [8], and in the waters of the Kaviang Papua New Guinea [20] Value of L∞, K and t_0 of red snapper according to anothers research presented in table 4.

The difference in the value of L∞ and K red snapper according to some researchers caused by differences in the physical chemical and biological conditions of the waters in which the fish live and the size structure of the observed fish. The values of L∞ and K can be different in the same species. This can be caused by differences the size structure of fishes be observed, the level of maturity of fish, the availability of food, physical and chemical water parameters and others [24]. In the same species, the small fish will give a greater K value than large fish [17]. The differences in growth parameters in the same fish species can caused by differences in fish size, fishing season, fishing gear used and catching area [26]. The differences in K values can also caused by aquatic environmental conditions [27].

3.4. Mortality and exploitation rate of red snapper

Calculation of total mortality using the method of "Length converted catch curve" with the help of FISAT II software (figure 6) can be known the value of Z, and the results of the calculation of the value of M and F and E of red snapper (*L. gibbus*) in Alor waters are presented in table 5.

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Table 4. Value of L∞, K and t_0 of red snapper in Alor waters.

Areas	L∞ (mm)	K (year^{-1})	t_0 (year)	References
The waters of Atol Tuematu, Tahiti, Polynesia Prancis	361.4 mm (F+M)	0.39	-	Patty, (2005)
The waters of the Bunaken Marine Park Sulawesi Utara, Indonesia	274 mm,FL (F+M)	0.780	-0.240	Holloway et.al., (2015)
Ishigaki Island, Okinawa Jepang	303 FL (F) 391 FL (M)	0.256 0.210	-0.305 -1.880	Nanami et.al., (2010)
Great Barrier Reefs dan Eastern Torres Strait	544 TL (F+M)	0.560	-	Anonim (2019)
The southern waters of Banten, Sunda strait	435.75 TL (F+M) 383.25 TL(F) 341.25 TL (M)	0.360 0.220 0.480	0.260 0.280 0.170	Prihatiningsih (2017)
The waters of Kota Baru, South Kalimantan	578.6 TL (F+M)	0.238	-	Prihatiningsih et.al., (2012)
The waters of the Kaviang, Papua New Guinea	442.00 TL (F+M)	0.310	-	Anonim (2019)
The waters of the karang Guam	303 mm FL (F+M)	0.25	-3.25	Nadam (2019)
The waters of the Wangi-Wangi Island, Southeast Sulawesi	500 ,00 TL (F+M)	0.160	-	Patanda et.al., (2017)
The waters of the Alor East Nusa Tenggara	594.25 TL (F +M)	0.690		This study

T: total length, FL: fork length, F: female, M: male

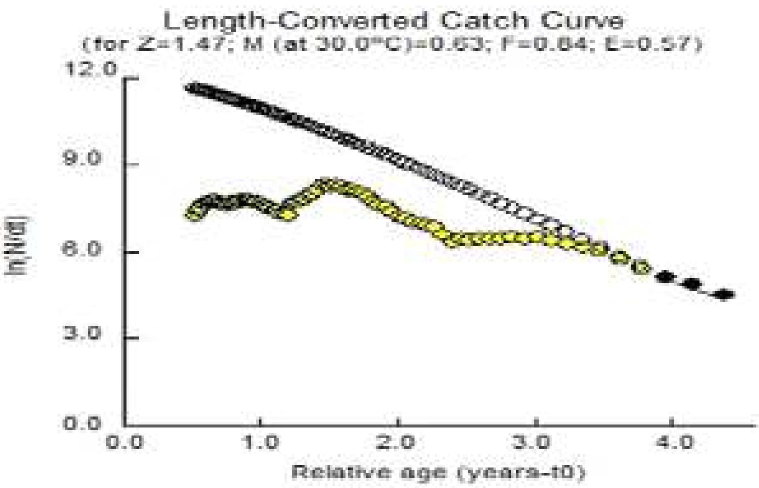

Figure 6. Length converted catch curve of red snapper in Alor waters

Table 5. Value Z, M, F and E red snapper in Alor waters

No	Mortality rate	Estimated value (y^{-1})
1	Total mortality (Z)	1,47
2	Natural mortality (M)	0,63
3	Fishing mortality (F)	0,84
4	Exploitation rate (E)	0,57

Based on the results in Table 5 it can explained that the total mortality rate obtained is in line with the number of age groups in the Alor waters red fish population. Ttheorically, the higher the total mortality value (Z) the faster an age group disappears. It was further explained that at Z approaching the value of two per year the number of age groups in the population ranges from 1-3 age groups, at the value of Z = 1 the number of age groups in the population can be 3 to 5 age groups [17,24].

Another thing obtained from the data in Table 6 is that F/M > 1 which explains that the fishing mortality (F = 0.84 per year) is greater than the natural mortality rate (M =0.63 per year), and this usually occurs in populations that experience high exploitation. Fishing mortality rates higher than the natural mortality rate reported in red snapper (*L. gibbus*) in the southern waters of Banten [9], and in the waters of Kota Baru Kalimantan [8]. Otherwise, in Guam coral waters the natural mortality rate of red snapper (0.12 per year) is higher than the capture mortality rate (0.09 per year) [23]. The fishing mortality rates that are high compared to mortality rates also occur in other types of red snapper (*L. malabaricus, L. ruselli* and *L johnii*) in the northern waters of the Cirebon Java Sea [28]. Fishing mortality rates higher than natural mortality rayes also reported in red snapper (*L. malabaricus*) in the East Sea waters namely F of 0.55 per year and M of 0.49 per year [29]. In the Timor Sea and Arafura, namely F of 1.14 per crop and M of 0.22 per year [30], red snapper (*L. quenqulineatus*) in the waters of the Red Sea, Egypt [31]. In an age group or several groups in the population that have not entered into the size can caught, the fish mortality in the population is only due to natural mortality. At the beginning of the fish began to enter the size that can be caught, fish mortality in the population can be caused by natural mortality and fishing mortality, and in this condition natural mortality are higher than fishing mortality. When individuals in the age group fully exploited or fish in the age group can caught and have reduced predation, the value of the fishing mortality rate is greater than the natural mortality rate [13,24].

The results of data analysis explain that the rate of exploitation (E) of red snapper in Alor East Nusa Tenggara waters is 0.57 per year. This explains that more than 50% of red snapper deaths caused by fishing. The current E value > 0.5 per year red snapper also occurs in the waters of South Banten [9]. High rate of exploitation (E = 0.53 per year) was reported in red snapper (*L. malabaricus*) in East Java waters [29]. Normally, in populations where the individuals in it fully exploited, the rate of exploitation is greater than 0.5 per year. It further explained that even though the exploitation rate had exceeded the optimum value (current E> 0.5 per year) but the population is not in over fished condition, it could still tolerated [24]. Management of fish resources in relation to the rate of exploitation that is how to regulate the rate of exploitation so that it is not too high (E equal to 0.5per years). Management of the rate of exploitation through control of mortality rates due to capture [31]. The value of exploitation rate greatly influences the recruitment process of a population, where in general the high rate of exploitation makes the recruitment process not optimal [17].

3.5. Yield per recruitment (Y/R)
In this study, the estimation of Y/R value uses the Beverton and Holt equation [27] by entering the values of L∞, K, F, M and E previously obtained. Based on the analysis results that value of actual Y/R is 0.0773 grams per recruitment and optimal Y/R values of 0.0993 grams per recruit (figure 7).

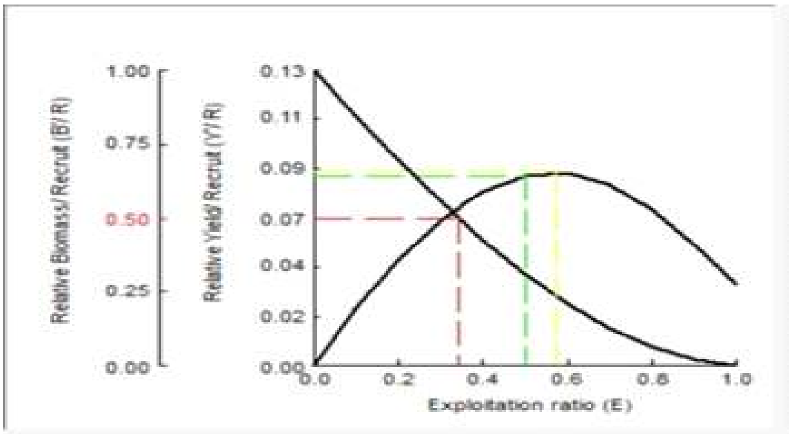

Figure 7. The graphic Y/R of red snapper in Alor waters, East Nusa Tenggara.

The analysis shows that the actual Y/R value is smaller than the optimal Y/R value, which can interpreted that the recruitment process is not going well. Events where the actual Y/R value is smaller than the optimal Y/R can occur in populations or stocks with high exploitation rates (E> 0.5 per year). In general, if a population has a high exploitation rate or E > 0.5 per year, the recruitment process is not optimal [17]. Inadequate recruitment process in red snapper in South Banten waters due to the high rate of exploitation [9].

4. Conclusion
Based on this study, researchers can conclude a number of things relating to the dynamics of red snapper populations in Alor East Nusa Tenggara waters as follows: Fishermen's catches consist of young, pre-adult and adult fish, young fish, where young and pre-adult fish are the most part of the catch and the population consists of four age groups characterizing red snapper populations under moderate pressure conditions, Red snapper of Alor waters has fast growth so that it can quickly reach its asymptote length (L∞), The total mortality rate is high, the main cause of red snapper death is due

to fishing activities, and the F / M ratio> 1.0 per year indicates that exploitation is quite high in red snapper, The rate of exploitation of red snapper in Alor waters is quite high causing the actual Y/R value is smaller than the optimal Y/R value.

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