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STOCK CONDITION EVALUATION USING POPULATION DYNAMIC PARAMETERS : CASE OF RED SNAPPER (*LUTJANUS GIBBUS*) AT ALOR WATERS, EAST NUSA TENGGARA, INDONESIA

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Abstract

Red snapper is an important fishery commodity in East Nusa Tenggara Province, exploited throughout the year without management policies, so it is feared that the condition of the fish stocks has decreased. This study aims to evaluate the condition of red snapper stock in the waters of East Nusa Tenggara. Fish length data were collected from March 2018 to March 2019. Stock conditions were analyzed using the Mallawa Scoring method. Population dynamics parameters used in the analysis of the stock size structure of fish size, number of age groups, growth rate, mortality rate of capture, exploitation rate, yield per recruitment were calculated using the help of FISAT II software, and percentage of eligible capture size using the Mallawa method. The results of the study that red snapper stock is dominated by pre-adult fish, the population consists of three age groups, the population growth rate is high enough, the mortality rate of capture and exploitation rate is relatively low, the recruitment process is close to optimal and the percentage of eligible capture size in catches is quite high.
The conclusion is that the red snapper stock in East Nusa Tenggara waters is good condition.
***Keyword*:** Red snapper, stock condition, population parameters, Alor Waters

Introduction

The condition of the population or stock of exploited fish will change by four main variables, namely growth, recruitment, capture mortality, and natural mortality, where the stock can increase or decrease in the number of individuals or biomass spatially and temporally. If the amount of biomass from growth and recruitment is greater than the amount of biomass by capture and natural death, the population or stock will grow, otherwise the population or stock will decrease if the amount of growth and recruitment biomass is smaller than biomass by capture and natural death (Mallawa, 2012). The characteristics of the stock condition of a type of fish have decreased namely the size of fish in the catch is getting smaller, the growth rate is relatively low, the number of age groups in the population is not much. Other are the mortality rate due to fishing is high, high exploitation rate, the recruitment process is not optimal and the percentage of eligible capture size in catches is low (Mallawa *et al*., 2017).

Stock assessment in the tropics is generally more difficult than in temperate waters. There are a large number of reasons for this, and two of them may be listed here. First, tropical fisheries especially demersal fisheries often exploit a number of species simultaneously, with the result that neither the commercial fishery nor the artisanal fisheries even when relatively well monitored, can be expected to provide detailed catch and catch per effort statistics on a per species basis. For this reason, it is common in tropical fisheries to treat whole species assemblages as if they were single species. Second, tropical countries generally have a relatively limited research capability as far as fisheries research is concerned which often leaves most of the stocks sustaining their fishery completely uninvestigated (Gulland, 1997). The habit of fishermen who do not land their catches on official fishing ports but are scattered along the coast according to fishermen 's residence and too many types of fishing gear used causes annual production data and annual efforts to be biased (Gulland, 1983). Ministry of Maritime and Fisheries of the Republic of Indonesia, (Mallawa *et al*., 2018) released information about the conditions of fisheries stocks in Indonesia generally uses the approach of utilization level or exploitation rate. Potential and utilization rates are presented according to fish groups (small pelagic fish, large pelagic fish, demersal fish, consumption reef fish etc.) and per the Indonesian Fisheries Management Area (WPP-RI). The MSY value is generally calculated using the Ricker and Fox Production Surplus method with annual production data and annual effort input data. Based on the level of stock utilization, fish groups in the WPP RI are stated to be in over exploited, moderate exploited and low exploited.

Red snapper is one type of reef fish that has a high economic value so that it becomes a target of catch by fishermen in various waters in Indonesia so that it is suspected that there has been a decline in the condition of its stock. In the waters of East Nusa Tenggara, red fish is one of the fisheries commodities that become fish target fishermen because it can provide high income for them. This type of fish is exploited throughout the year using traditional fishing tools such as hand line, bottom traps, and bottom gill net without a management policy (Mallawa *et al*., 2018). (MMAF 2016). Explained that the condition of stocks of a type of fish can decrease as a result of intensive fishing, the use of unsustainable fishing equipment and the absence of good and correct management policies.

Research on the condition of red snapper stock in Indonesia has been conducted in the waters of the Sunda Strait in Banten, Indonesia by (ARFS, 2017) using the Surplus Production Model and by (Prihatiningsih *et al*., 2017) using the Length-based Spawning Potential Ratio (SPR) method, both results the study explained that the condition of red snapper stock decreased. Catching activities in the waters of Palau have caused the condition of red snapper stock to decline which is marked by a decrease in the average length of fish in the catch of fishermen and the value of the Spawning Potential Ratio (SPR) in the last twenty years (Satria and Sadiyah 2017; Hordyk *et al*., 2015; Hordyk *et al*., 2015; Lindfield, 2017). For stocks of a type of fish whose annual data are lacking the condition of the stock can be known using the Length-Based Spawning Potential Ratio (LB-SPR) method (Prince *et al*., 2015; Prince, 2017).

This study aims to evaluate the condition of red snapper stock in the waters of East Nusa Tenggara using several biological parameters and population dynamics including fish size structure, percentage of fish worth catching, population growth rate, catch mortality rate, exploitation rate and yield per recruitment,

Materials and Methods

Time and Research 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 area (fishing base) of fishermen who catch snapper in the waters of Alor, namely in Treweng Island, East Pantar District, Pura Besar Island, Pura District, and Buaya Island, Alor Batar Laut District. The geographical position of the study sites is 8 '6' - 8 '36' LS: and 123 '48' - 125 '48' BT (Figure 1).

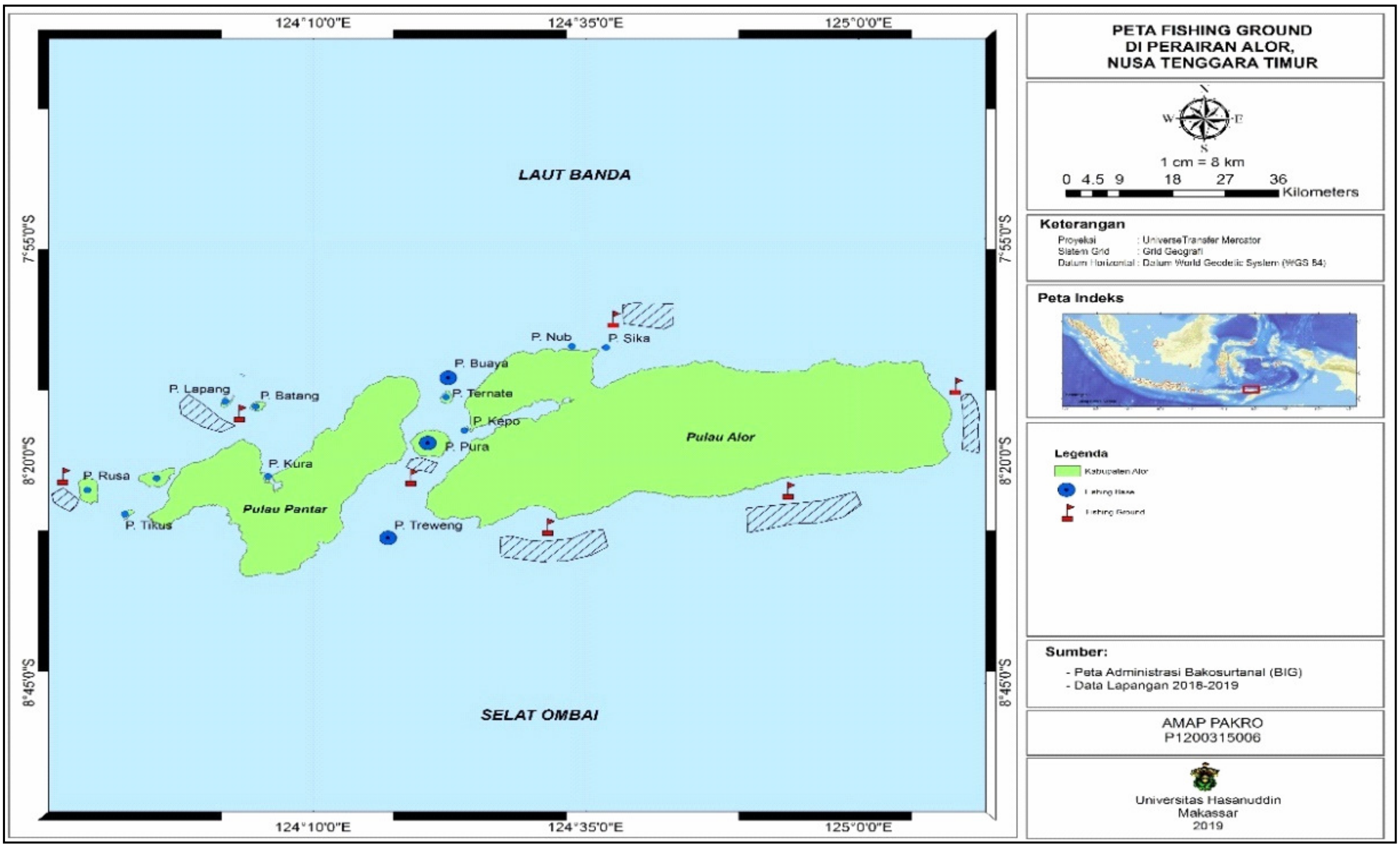

Fig. 1 : Research location [15]

Materials and equipment

The materials used in the study are red snapper, aquadest, 10% formalin, data sheet tables, interview boards, and equipment such as measuring boards, digital weighted, sample bottles, GPS, digital thermometers, cameras, computers and software such as SPSS and FISAT II.

Data Collection

Data on fish length (cm, TL) are collected directly by following the fishermen and at the fish landing site (TPI). Sample fish measurements are carried out twice a month from hand fishing fishermen and at three fish landing sites. Fish samples are taken using the stratified random sampling method, where as a stratum is a fishing ground, a place for observing fish and fish size. The number of sample fishes taken is adjusted to the number of catches, if the number of catches is large, sample fishes are taken 10% of the amount of fish caught and if the catch is less then all fishes are taken as sample fish (Sugiarto, 2009; Mallawa and Amir, 2019). During the study, as many as 4100 red snapper fish were measured, a combination of 1360 specimens in Traweng Island waters, 2150 specimens in Pura Besar Island and 590 specimens in Buaya Island.

Data Analysis

The condition of red snapper stock in Alor East Nusa Tenggara waters was analyzed using the scoring method (Mallawa *et al*., 2015). This method uses several biological parameters and population dynamics including size structure, number of age groups, population growth rate, catch mortality rate, exploitation rate, percentage of capture size and yield per recruitment. Each test parameter is weighted according to the level of influence on the stock conditions. Each parameter is divided into three sub-parameters and then a value is assigned according to the conditions of observation. Good condition sub-parameters are given a value of 5, moderate are given a value of 3 and not good are given a value of 1. Good condition sub-parameters are given a value of 5.0, moderate are given a value of 3.0 and not good are given a value of 1.0. Furthermore, we do a multiplication of the weights and the acquisition value of each parameter (Table 1).

Table 1 : Red snapper stock condition analysis table

Parameters and Sub Parameters	Weighted	Sub arameter Value	Weighted * Value
The size structure of fish Dominated by young fishes Dominated by pre-adult fishes Dominated by adult fish	1.00	1 3 5	
Number of age groups or age groups Less than three age groups Three to five age groups More than five age groups	1.00	1 3 5	
The fishing mortality rate F value is more than 2.0 F value is 1.0 to 2.0 F value is less than 1.0	2.00	1 3 5	
Exploitation rate value E value is more than 1.0 E value is equal 0.5 - 1.0 E value is less than 0.5	1.00	1 3 5	
Population growth rate K value is low than 0.4 per year K value is 0.4 until 0.5 per year K value is high than 0.5 per year	1:00	1 3 5	
Yield per Recruitment Y/R actual < Y/R optimal Y/R actual = Y/R optimal Y/R actual > Y/R optimal	2.0	1 3 5	
% of eligible capture size CSL is less than 20 % CSL is 30 until 50 % CSL is more than 50%	2.00	1 3 5	
Total	10,00		Σ B*V

(i) Size Structure and Number of age groups

Size structure analysis for the purpose of evaluating stock conditions is based on the level of maturity of the fish in the catch. In this research, red snapper are grouped into three categories, namely young fish, pre-adult fish and adult fish. In male red snapper, fish smaller than 265 mm (maturity stage I and II) are grouped into young fish, measuring 265 to 298 mm (maturity stage III) into pre-adult fish and larger than 298 mm (maturity stage IV and V) into adult fish. In female red snapper, fish smaller than 195 mm are grouped into young fish, 195 to 209 mm into pre-adult fish and larger than 209 mm into adult fish (Pakro *et al*., 2019). To find out the number of age groups in the population, a mapping is done between the frequencies per length class and the middle class length values (Mallawa and Amir, 2019; Pakro *et al*., 2019). Furthermore, the number of age groups can be determined through the number of histogram peaks formed.

(ii) Percentage of Eligible Capture Size

The percentage of eligible capture size in catches is calculated using the Mallawa equation (Mallawa *et al*., 2015). as follow:

$C_{ES} = (N_S/N_T) \times 100\%$

Where:

C_{ES} is percentage of eligible capture size

N_S is number of fish has been spawned

N_T is total number of fish measured

Male red snapper has spawned at 270 mm in size, and females at 207 mm in size (Pakro *et al*., 2019).

(iii) Fishing Mortality Rate

Fishing mortality rate is calculated by reducing the total mortality rate by the natural mortality rate (Pakro *et al*., 2020; Mallawa and Amir, 2019). Total rate is calculated using the liniarized length converted catch curve method (Pauly, 1983), while the mortality rate is calculated using the Pauly empirical formula (Pakro *et al*., 2019).

(iv) Exploitation Rate

The exploitation rate is calculated using the Beverton and Holt method (Mallawa and Amir, 2019) namely the capture mortality rate divided by the total mortality rate.

(v) Population Growth Rate

The population growth rate is expressed using the growth rate coefficient (K) from the Von Bertalanfy exponential growth equation. K values were calculated using the Ford and Walford methods (Sparre *et al*., 1989).

(vi) Yield Per Recruitment

Y/R values were calculated using the Beverton and Holt methods (Sparre *et al*., 1989). The result of the calculation produces the current Y / R value and the optimal Y/R value, where both values will explain whether the recruitment process is optimal or not.

The size structure, number of age groupss, fishing mortality rate, exploitation rate and yield per recruitment are analyzed using the help of the FISAT II program (Gayanilo and Pauly, 1997).

The condition of the stock (%) was calculated using the equation raised by (Pakro *et al*., 2020). namely:

$$Sc = \{\Sigma(B \times V)/F_v)\} \times 100\%,$$

where :

Sc is stock condition (%)

B is weighted of each parameter,

V is value of each sub parameter,

F_v is full value (equal 50).

The condition of stock determined using the reference as follows:

If the Sc value is 85 - 100%, the stock is very good condition,

If the Sc value is 65 - < 85%, the stock good condition,

If the Sc value is 50 - < 65%, the stock is quite good condition

If the Sc value is < 50%, the stock is less good condition, or under pressure

Results and Discussion

Size structure and number of age groups

The results of the analysis show that male red snapper caught by fishermen is dominated by adult fish, quite a lot of young fish and a few adult pre-adult fish, whereas in female red snapper the catch of fishermen is dominated by pre-adult and adult fish. Furthermore, in the combination of male and female, the catches is dominated by adult fish but there are quite a number of young fish and pre-adult fish (Figure 2).

Percentage of eligible capture size in catches

The observation that the size of mature red snapper gonads is different between male females, where female red snapper are smaller than males. Likewise, the size of the first spawning. Percentage of red snapper worth catching in catches of fishermen in Alor East Nusa Tenggara waters is presented in Figure 3.

The dynamic parameter value of red snapper

Fishing mortality rate (F), exploitation rate (E), growth rate coefficient (K), and yield per recruitment (Y/R) value used in the analysis of the condition of red snapper stock in Alor East Nusa Tenggara waters based on the results of Pakro's research (Pakro *et al.*, 2019). The value of each parameter shown in Table 2.

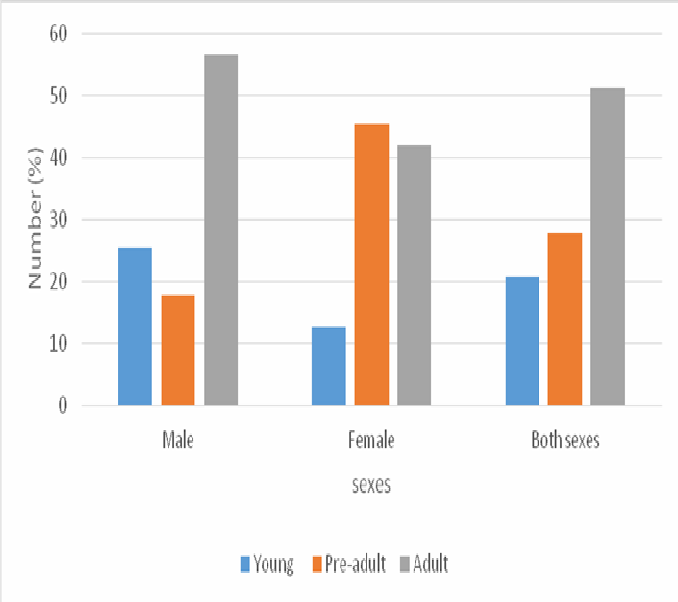

Fig. 2 : The composition of the catch is based on the maturity level of red fish in the waters of Alor, East Nusa Tenggara

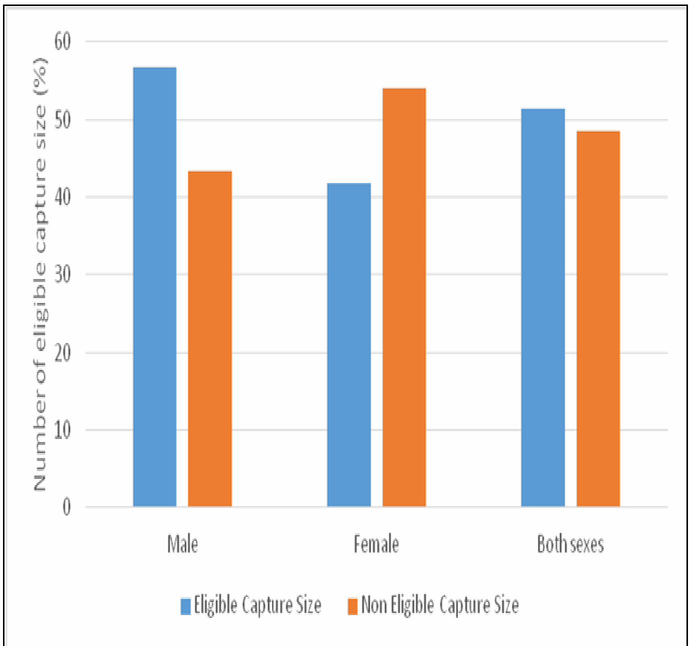

Fig. 3 : Percentage of eligible capture size of red snapper in Alor waters

Table 2 : Value of parameters for evaluating the condition of red snapper stock

No	Parameters	Analysis Result
1	Number of age groups	Population consist of four age group
2	Fishing mortality	F value is 0.84 $year^{-1}$
3	Exploitation rate	E value is 0.54 $year^{-1}$
4	Population growth rate	G value is 0.69 $year^{-1}$
5	Yield per recruitment	Current Y/R value is 0.0773 gr $recruit^{-1}$ Optimal Y/R value is 0.0993 gr $recruit^{-1}$

Furthermore, based on the parameter values in Table 2, an analysis of the condition of the red snapper was performed using the analysis table (Table 1) and the results are presented in Table 3.

The analysis process begins with assigning each parameter based on existing conditions. The parameter value is multiplied by the weight of each parameter, then the value of the parameter times the weight is calculated, the total value divided by the full value or the ideal value of the population.

Table 3 : Stock condition analysis of the red snapper stock in Alor East Nusa Tenggara waters

Parameters and Sub Parameters	Weighted	Sub Parameter Value	Weighted * Value
The size structure of fish Population dominated by pre-adult fishes	1.00	3.0	3.0
Number of age groups or age groups Population consist of three age groupss	1.00	3.0	3.0
The fishing mortality rate F value is 0.84 $year^{-1}$ or less than 1.0 $year^{-1}$	2.00	5.0	10.0
Exploitation rate value $year^{-1}$ or less than 1.0 $year^{-1}$	1.00	5.0	5.0
Population growth rate K value is 0.64 $year^{-1}$ or high than 0.5 $year^{-1}$	1.00	5.0	5.0
Yield per Recruitment Y/R actual < Y/R optimal	2.00	1.0	2.0
% of eligible capture size CSL is more than 50%	2.00	5.0	10.0
Total	10,00		38.00
Sc (%)	-		76.00

The results of the analysis (Table 3) explain that the achievement of the red snapper stock of Alor East Nusa Tenggara waters to the ideal condition of the stock based on seven parameters of population dynamics is 68.00%. This value explains that the condition of the red snapper stock is in the good category.

The thing that causes the red snapper stock in Alor waters is not in a very good condition, namely the loss of large red snapper in the population, which in turn affects the low percentage of eligible capture size, decreases the number of age groups in the population and makes the recruitment process not optimal. The main cause of the decline in the number of large fish in the population is fishing especially by the use unsustainable fishing gears (Mallawa *et al*., 2018; Prince, 2017; Gayanilo and Pauly, 1997). In the Palau waters, the average length of red snapper in catches decreased by a period of 287 mm in 1982 - 1984 to 278 mm in 1991-1992 and 272 mm in 2014 to 2015 as a result of the loss of large red snapper in the population by fishing (Hordyk *et al*., 2015). The low level of exploitation of red snapper in the waters of iQoliqoli Fiji makes the condition of fish stocks very good (Lindfield, 2017; Prince, 2017). Due to the high rate of the capture, the condition of red snapper stock in the waters of Northern Palau decreased which marked by a decrease in the average length of the fish in the catch over time (Lindfield, 2017).

Conclusions

The condition of the red snapper stock in Nusa Tenggara waters is in the good category. The main cause of red snapper stock is not in the very good category is the catch that is carried out continuously throughout the year and has implications for the loss of large red fish in the population.

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