Urgent need for sustainable fishing of Blue-barred Parrotfish Scarus ghobban (Forsskal, 1775) in Wallace Line, Spermonde Islands, Makassar Strait, Indonesia

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Abstract. The Spermonde Islands has an area of approximately 2,500 km^2 and 120 islands. These reefs are crossed by the Wallacea Line. The Spermonde waters are a fishing area located on the densely populated coast of South Sulawesi Island. Ecologically, Blue-barred parrotfish *Scarus ghobban* has an important role in controlling the macroalgae population which can inhibit coral growth. Economically, Blue-barred parrotfish has important economic value because besides being consumed, it is also an ornamental fish for sea water aquariums. The high economic value makes Blue-barred parrotfish exploited intensively. Until present there has been no research on the exploitation rate of Blue-barred parrotfish in the Spermonde Islands waters. This study aims to analyse the exploitation rate of Blue-barred parrotfish in the waters of the Spermonde Islands, South Sulawesi, Indonesia. Fish samples were obtained from the fishermen catch operating in the Spermonde Islands waters who landed at the Paotere Fish Landing in Makassar City in 2020. Age groups were analysed using the Bhattacharya method. The growth rate was estimated using the Von Bertalanffy method. Total mortality (Z) was estimated using the catch conversion curve method. The natural mortality rate (M) was estimated using the Pauly empirical formula. The catch mortality rate (F) was estimated using the equation F = Z-M. The exploitation rate (E) was estimated using the Beverton and Holt equations, namely E = F/Z. The growth rate equation was $L_t = 75[1 - e^{-0.31(t-0.4166)}]$. The total mortality rate was 6.84, the natural mortality rate was 0.65, the fishing mortality rate was 6.19, and the exploitation rate was 0.90. The high exploitation rate indicates that the Blue-barred parrotfish in the Spermonde Islands requires an urgent call for sustainable fishing.

1. Introduction

The Spermonde Archipelago is an archipelago consisting of 120 islands with an area of approximately 2,500 km^2 [1]. The Spermonde Islands lie in the Makassar Strait, where the Wallacea Line passes [2]. The name Spermonde was supposedly given by the Dutch, which came from the word sperm (sperm) because from the air, the islands located in the Makassar Strait look like a row of sperm movement. The Spermonde Islands are located in a sea area that stretches from Takalar Regency to Barru Regency. The Spermonde Islands are included in The State Fisheries Management Area of the

Republic of Indonesia, number 713 [3]. In the waters of Spermonde, there is a relatively vast expanse of coral reefs, making the Spermonde Islands have great potential fisheries resources with a very diverse diversity of reef fish species [4-6].

Of the 49 species of parrotfish living in the Indo-Pacific region, an estimated 36 species are found in Indonesia [7]. of the 36 species, 34 are found in the waters of the Spermonde Islands [8-10]. The parrotfish species that can be found in the waters of the Spermonde Islands are the Blue-barred Parrotfish *Scarus ghobban*.

The Blue-barred Parrotfish is a diurnal fish. Blue-barred Parrotfish are generally active during the day; only a few of the Blue-barred Parrotfish are active at night. Blue-barred parrotfish live in abundance in tropical and subtropical waters in the Indo-Pacific region [11,12]. Blue-barred Parrotfish live at a depth of 2-30 m [13].

Blue-barred Parrotfish have essential ecological and economic roles. Ecologically, Blue-barred Parrotfish are algae eaters whose presence is significant to keep corals from being covered by macroalgae—another ecological role of white sand producing Parrotfish. Parrotfish live on coral reefs and spend their days chewing on corals. The microstructure of the Parrotfish's teeth resembles a chain that has an extraordinary bite force. Each Parrotfish has about 1,000 teeth, lined up in 15 rows and fused to form a beak structure used to bite coral. If the Parrotfish's teeth are worn out, they will fall to the seabed. When they fall, the teeth in the second row are ready to move forward to eat the coral. Parrotfish teeth are made of fluorapatite, which contains calcium, fluorine, phosphorus, and oxygen. Parrotfish teeth are the second hardest biomineral in the world. Fluorapatite is at a score of five on the Mohs hardness scale, making Parrotfish teeth harder than copper, silver, and gold. No biomineral in the world is stiffer than the tip of the Parrotfish's teeth. Parrotfish teeth can also withstand high pressure. One square inch of Parrotfish teeth can tolerate 530 tons of pressure which is equivalent to the weight of about 88 elephants. Parrotfish can spend 90 percent of their time per day chewing food. Parrotfish clean live coral reefs by eating algae that inhibit coral reef growth. Parrotfish excrete dirt in the form of fine white sand. Each adult Parrotfish will excrete 450 kilograms of fine white sand every year [14]. Beautiful white sandy beaches with a beautiful coral reef population are the work of Parrotfish. Parrotfish are herbivorous fish that are very small in number in nature. If the parrotfish continues to be caught, the number of algae will increase in the sea so that the condition of the coral reefs is no longer healthy. The presence of reef fish in coral ecosystems is vital because it is part of the coral reef ecosystem food chain [15].

The economic role of the Blue-barred Parrotfish is a target fish for consumption. In addition to consumer needs, small Blue-barred Parrotfish are marketed alive for saltwater aquariums. Market demand for consumption and ornamental fish needs that continues to increase can lead to over-exploitation of the Blue-barred Parrotfish stock. An indication of over-exploitation is a decrease in the size of the fish caught. The results of previous research indicated that the reproductive biology aspects of reef fish in the Spermonde Islands had been widely practiced [16-21], but aspects exploitation has not been done much. There has been no research on the exploitation rate of Blue-barred parrotfish in the Spermonde Islands waters until the present. The study aims to analyze the exploitation rate of Blue-barred Parrotfish in the waters of the Spermonde Islands, South Sulawesi, Indonesia.

2. Materials and Methods

Samples of Blue-barred Parrotfish are the catch of fishermen in the waters of the Spermonde Islands, South Sulawesi. Blue-barred Parrotfish samples were taken every mid-month. The Blue-barred Parrotfish samples were measured in total length from the tip of the mouth to the end of the tail using a measuring rod with a precision of 1.0 mm.

The age group of Blue-barred Parrotfish was determined using the Bhattacharya method [22, 23]. Calculation of the age group of Blue-barred Parrotfish using the FAO-ICLARM Fish Stock Assessment Tools (FISATII) program [24]. The estimation of Blue-barred Parrotfish growth parameters using the Von Bertalanffy growth formula [25, 26]: $L_t = L_\infty (1 - e^{-K(t-to)})$, where Lt was the length of Blue-barred Parrotfish at age t (mm), L∞ was asymptote length of Blue-barred Parrotfish

(mm), K was growth rate coefficient of Blue-barred Parrotfish, t_o was the theoretical lifespan of Blue-barred Parrotfish at the same length with zero (years), t was the age of the Blue-barred Parrotfish at time t (years). To determine the length of the Blue-barred Parrotfish L∞ and K asymptotes used the Ford and Walford method [25, 27], namely by plotting L (t + Δt) and L (t) according to the equation: L(t+Δt) = a + bL(t), if L(t+Δt) = Y and a + bL (t) = X, then a simple regression equation was obtained [28]: Y = a + bX, where a = L∞ (1-b) and b = $e^{(-K)}$, so that L∞ = a/1-b and K = -1/Δt (lnb). Furthermore, to determine the t_o value of the Blue-barred Parrotfish, the formula was used [29]: Log (-t_o) = -0,3922 - 0,2752(Log L∞) - 1,038(Log K).

The natural mortality of Blue-barred Parrotfish was estimated using Empirical Pauly [29]: Ln M = 0,8 x exp (-0,152 - 0,279 ln L ∞ + 0,6534 ln K + 0,4634 ln T°C, where T was the mean surface temperature of the Spermonde Islands waters (°C). The total mortality (Z) of Blue-barred Parrotfish was estimated using the Beverton and Holt equations [25]: $Z = K\frac{L\infty - L}{L - L'}$, Fishing mortality (F) of Blue-barred Parrotfish was estimated using equations [25]: Z = F + M → F = Z – M. The exploitation rate (E) of the Blue-barred Parrotfish was obtained using the Beverton and Holt equations [25]: $E = \frac{F}{Z}$.

3. Results

The number of samples of Blue-barred Parrotfish (Figure 1) obtained during the study was 154 individuals, with a total length range of 12.3 - 39.3 cm. Long Blue-barred Parrotfish were grouped into 29 classes, using 1 cm intervals. The analysis of the total length structure showed that the Blue-barred Parrotfish population consisted of five age groups or cohorts. The separation index was bigger than two, so the separation of the five cohorts is valid (Table 1). The cohorts that dominate the catch are the second and third cohorts (Figure 2).

Figure 1. Blue-barred Parrotfish *Scarus ghobban* captured in Wallace Line, Spermonde Islands, Makassar Strait, Indonesia

Table 1. Average length and standard deviation of each age group or cohort of Blue-barred Parrotfish *Scarus ghobban* in Wallace Line, Spermonde Islands, Makassar Strait, Indonesia

Age Group or Cohorts	Average Length (cm)	Standard Deviation (cm)	Population (individual)	Separation Index
1	17.89	0.84	16.69	n. a
2	20.83	1.50	72.07	2.06
3	24.83	1.36	44.17	2.10
4	29.50	1.08	15.08	2.17
5	35.34	2.94	7.63	2.12

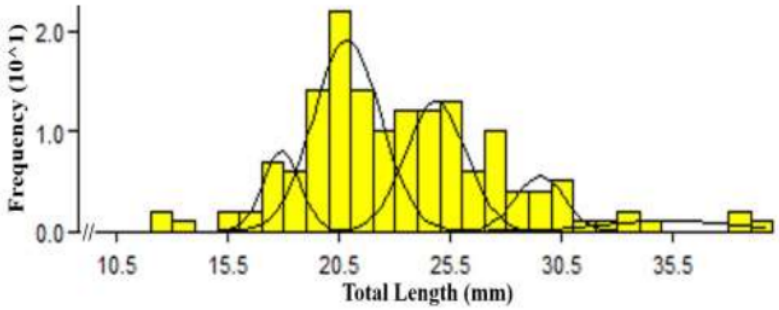

Figure 2. Histogram total length of Blue-barred Parrotfish *Scarus ghobban* in Wallace Line, Spermonde Islands, Makassar Strait, Indonesia.

Estimated values of growth parameters indicate that Blue-barred Parrotfish have a slow growth rate (Table 2), so that it takes a long time for Blue-barred Parrotfish to reach their asymptote length (Figure 3).

Table 2. Estimation of growth parameters of Blue-barred Parrotfish *Scarus ghobban*in Wallace Line, Spermonde Islands, Makassar Strait, Indonesia

Parameters	Estimated Value
L_∞ (cm)	75.0
K ($year^{-1}$)	0.31
t_0 (year)	-0.4166

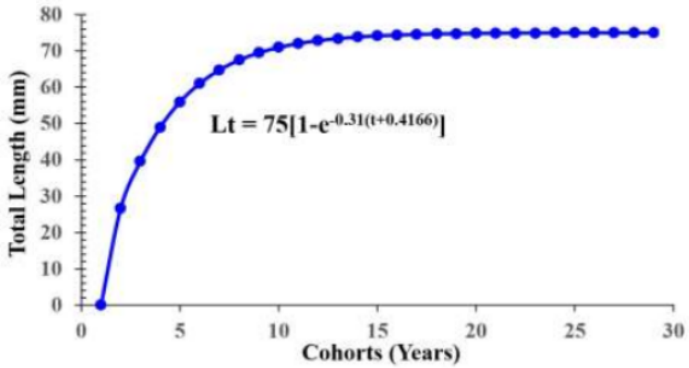

Figure 3. Growth curve of Blue-barred Parrotfish *Scarus ghobban* in Wallace Line, Spermonde Islands, Makassar Strait, Indonesia

The estimated high mortality and exploitation rates (Table 3) indicate that the Blue-barred Parrotfish population was in danger. Sustainable fishing of Blue-barred Parrotfish in Wallace Line, Spermonde Islands becoming in Wallace Line, Spermonde Islands, Makassar Strait, Indonesia urgently needs.

Table 3. Estimated value of blue-barred parrotfish *Scarus ghobban* in wallace line, Spermonde Islands, Makassar Strait, Indonesia

Parameters	Estimated Value (year^{-1})
Total mortality rate (Z)	6.84
Natural mortality rate (M)	0.65
Fishing mortality rate (F)	6.19
Exploitation rate (E)	0.90

4. Discussion

The separation index value greater than two indicates that the separation of the age group of the Blue-barred Parrotfish can meet the requirements of the Bhattacharya method. The separation index is a measure of quantity. Separation of cohorts is considered eligible if the separation index value is bigger than two; if it is lower than two, it cannot be separated because there will be considerable overlap between the two cohorts [25]. The results of size or age group estimation can describe the condition of a fish population; the results of age group estimation can also be used to predict future fishery production [30].

The size distribution or cohort is an essential factor in fisheries biology. The size distribution associated with the gonad maturity phase will give the size at the first maturity [31]. From the size at the first maturity, it can be seen whether the caught fish have spawned at least once or not [32]. The exploited population must have done a minimum of one spawning to reproduce at least once before being caught. Thus, we can determine the success or failure of reproduction in an exploited population [31].

Growth is a measure of the increase in length or weight over time. Growth is influenced by many factors, including the amount and size of available food, water temperature, dissolved oxygen, age and size of fish, and maturity of the gonads. The importance of estimating growth in population dynamics is to determine when the organisms in the population reach the size or age at first spawning (maturity), the age composition of the population or stock, recruitment into a stock, and the yield potential of a stock.

Growth parameters indicate that the Blue-barred Parrotfish has slow growth because it takes a very long time to reach its asymptote length. The growth rate of Blue-barred Parrotfish was lower than other herbivorous fish caught in the waters of the Spermonde Islands [33]. A growth rate coefficient of less than 0.5 is categorized as a fish that has slow growth. Conversely, if the value of the growth rate coefficient is more than 0.5, it is categorized as having fast growth [25]. The growth rate of a fish is not constant throughout its life. Growth is very fast early in the fish's life. Blue-barred Parrotfish can reach 75% of their asymptote length in the first five cohorts. The increase in fish length will decrease in line with the age of the fish. Young fish have a faster growth rate than older fish. Old fish generally suffer from a lack of energy for growth because most of the energy from their diet is used for body maintenance and movement [34]. If growth is related to the structure of the catch life, it is difficult for Blue-barred Parrotfish to reach its asymptote length. The first five cohorts of Blue-barred Parrotfish caught were in a period of rapid growth.

The mortality rate is a measure of the chance of fish mortality at certain time intervals. Fish that have high mortality are fish that have a short life cycle. The short period lives of a population usually have a high ability to change stock and have high reproductive capacity. Mortality in the same fish species but living in different locations may have different mortality rates, depending on the predators and competitors.

The population structure of the Blue-barred Parrotfish is affected by both natural and fishing mortality. The natural mortality rate is related to the growth rate. The low growth rate of Blue-barred Parrotfish indicates that the natural mortality rate was low [25]. The population structure of Blue-barred Parrotfish in Wallace Line, Spermonde Islands, was mainly influenced by fishing mortality.

The high fishing mortality rate illustrates the high pressure on the Blue-barred Parrotfish stock in Wallace Line Spermonde Islands.

The exploitation rate is the ratio between the number of fish caught and the total number of fish that died due to natural and catch factors. Determining the rate of exploitation is one factor that needs to be known to determine the condition of fisheries resources in the study of fish stocks [35]. The exploitation rate of Blue-barred Parrotfish, which is close to 1.0 $year^{-1}$, indicates that the population of Blue-barred Parrotfish in Wallace Line Spermonde Islands is in danger. The optimum exploitation rate of a fish resource is 0.5; the closer it is to 1.0, the closer it is to the point of extinction [36]. Populations that are overexploited will impact the reduction of the number of fish adult. Catching small fish can result in no new recruitment into the stock, which in turn will cause the fish stock to be depleted [35].

5. Conclusion

The size group or cohorts of the Blue-barred Parrotfish in Wallace Line, Spermonde Islands, Makassar Strait consist of five age groups. The Blue-barred Parrotfish falls into the slow growth category. The fishing mortality value was higher than the natural mortality value, indicating that the Blue-barred Parrotfish has been over-exploited. This overexploitation was a warning that the sustainable fishing of Blue-barred Parrotfish in Wallace Line, Spermonde Islands, is becoming an urgent need. Therefore, it is necessary to stipulate a management policy, which can be in the form of prohibiting the use of non-selective fishing gear, limiting fishing grounds, and sanctions for those who violate fishing rules.

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Urgent need for sustainable fishing of Blue-barred Parrotfish Scarus ghobban (Forsskal, 1775) in Wallace Line, Spermonde Islands, Makassar Strait, Indonesia

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GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9