# Unregulated fishing impact on yellowfin parrotfish scarus flavipectoralis in Spermonde Islands, Makassar Strait, Indonesia

*by* Irmawati Irmawati

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**Ramla[1], J Tresnati[1], M T Umar[1], Irmawati[1], D W Inaku[1], I Yasir[2], A Yanti[3], P Y Rahmani[3], R Aprianto[3] and A Tuwo[2,3]**

[1]Fisheries Department, Faculty of Marine Science and Fisheries, Universitas Hasanuddin, Makassar, Indonesia
[2]Marine Science Department, Faculty of Marine Science and Fisheries, Universitas Hasanuddin, Makassar, Indonesia
[3]Multitrophic Research Group, Universitas Hasanuddin, Makassar, Indonesia

E-mail: jtresnati@yahoo.com

**Abstract**. The Spermonde Islands are a group of islands located in Makassar Strait, which stretches from the coast of the Takalar Regency in the South and to the coast of Barru Regency in the North 2,500 km$^2$. These waters are the fishing areas of artisanal fishermen who catch reef fish, such as the yellowfin parrotfish *Scarus flavipectoralis*. Yellowfin parrotfish is a Scaridae that lives in shallow waters in tropical and subtropical areas, especially in coral reef ecosystems. Yellowfin parrotfish is included in the Least Concern group, a species threatened by fishermen's catch if not adequately regulated. The exploitation of Yellowfin parrotfish in Spermonde Islands, Makassar Strait, Indonesia, has never been studied. This study aims to analyze the exploitation rate of yellowfin parrotfish in the Spermonde Islands waters. The yellowfin parrotfish Samples were taken from the catch landed at the Fish Landing Port, Makassar City. The growth rate was Lt = 40 [1-$e^{-0.28(t-0.5505)}$]. The total mortality rate was 3.29, the natural mortality rate was 0.73, the fishing mortality rate was 2.56, and the exploitation rate was 0.78. This exploitation rate indicated the unregulated fishing impact on yellowfin parrotfish, and if this unregulated fishing continues, the yellowfin parrotfish could become extinct in Spermonde Islands.

## 1. Intoduction

The outer islands of Sulawesi, which are located in the Makassar Strait, are called the Spermonde Islands [1]. The island cluster consists of 120 islands with about 2,500 km2 consisting of 50 vegetated islands and 70 non-vegetation dunes [2]. The waters of Spermonde have high ecological value because they are part of the world's coral triangle crossed by the Wallace Line [3]. Spermonde waters also have high economic value because they are Fisheries Management Area (FMA) 713 of the Republic of Indonesia [4,5]. In the 713 Fisheries Management Area (FMA), there are many coral ecosystems.

Ecologically, the coral ecosystem is one of the richest ecosystems in the world from the aspect of organic matter production based on the symbiosis of coral polyps with zooxanthella, the energy produced from this symbiosis which then flows to a higher food chain [6,7]. Spermonde waters is a coral habitat with a high diversity of reef fish [8]. The two families caught mainly by artisanal fishermen operating in the waters of Spermonde are Scaridae and Labridae. The two families are not

differentiated in terms of marketing. Locally, the two families are considered the same and are given the local common name *Laccukang*. The catch of artisanal fishers consists of 34 species of Scaridae or parrotfish [9,10], and 30 species of Labridae or Wrasses [11]. One of the target fish species caught by artisanal fishermen is the Yellowfin Parrotfish *Scarus flavipectoralis*.

Yellowfin Parrotfish live in coral reef ecosystems in tropical and subtropical areas [12]. Yellowfin Parrotfish have an essential ecological role in maintaining the balance of coral reef ecosystems and having important economic values so that they need to be managed sustainably. Yellowfin Parrotfish is one of the commodity fish caught by fishermen in great demand because of its delicious taste, including salted fish [13]. Yellowfin Parrotfish is quite popular and highly marketable and is an essential economic commodity exported fresh to Hong Kong, Taiwan, and Singapore [14]. In Taiwan, parrotfish are very popular and popular with seafood restaurant diners [15].

If the demand continues to increase and the fishing rate also continues to increase without sustainable management efforts, it will hurt the Yellowfin Parrotfish population. Continuous management of exploited stock needs to know the rate of exploitation. The population of reef fish in Spermonde waters, especially Scaridae or parrotfish [16,17] and Labridae or Wrasses [18–20] has been extensively studied. However, this study is only limited to the aspects of distribution, species composition and reproductive biology. Therefore, information related to age group, growth, mortality and rate of exploitation is needed. The study aims to analyze the exploitation rate of yellowfin parrotfish in the Spermonde Islands waters.

## 2. Materials and Methods

Yellowfin Parrotfish samples were taken from the catch of landed at the Fish Landing Port, Makassar City. Yellowfin Parrotfish samples were taken every mid-month. From the interviews and seeing the condition of the fish, it was found that fishers caught Yellowfin Parrotfish using spears or arrows, nets, and fishing rods. During the length measurement, Yellowfin Parrotfish samples were stored in a cool box containing ice crystals. The length of the Yellowfin Parrotfish is measured using a preparation board that has a measuring ruler with an accuracy of 1 mm (Figure 1).

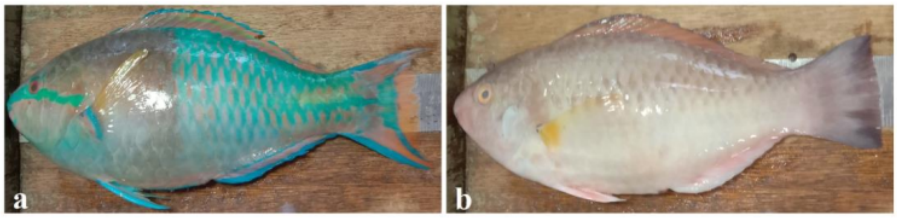


**Figure 1.** Yellowfin Parrotfish *Scarus flavipectoralis* captured in Spermonde Islands, Makassar Strait, Indonesia. a: male, b: female

The age groups of Yellowfin Parrotfish were determined using the Bhattacharya method by dividing the fish into several length ranges. Separation of age groups was carried out using the FISAT II program [21]. The growth of Yellowfin Parrotfish was estimated using the growth equation for Von Bertalanffy [22]: $Lt = L_\infty [1\text{-}e^{-K(t-t0)}]$, where Lt was long of Yellowfin Parrotfish at age t (cm), $L \infty$ was the asymptote length of Yellowfin Parrotfish (cm), K was the growth rate coefficient ($year^{-1}$), $t_o$ was the theoretical lifespan of the Yellowfin Parrotfish at zero-length (years), the age of the Yellowfin Parrotfish at time t (years ). The FISAT II program was used to calculate the asymptote length value of the Yellowfin Parrotfish and the growth rate coefficient [21]. Estimation of theoretical life at the time the length of the Yellowfin Parrotfish is equal to zero ($t_o$), estimated using the empirical formula [23]: $\log(-t_o) = -0.3922 - 0.2752 (\log L_\infty) - 1.038 (\log K)$, where $L\infty$ is the asymptote length of the Yellowfin Parrotfish (cm), K is the growth rate coefficient of the Yellowfin Parrotfish ($year^{-1}$), $t_o$ is the theoretical lifespan when the length of the Yellowfin Parrotfish is equal to zero (years).

The total mortality rate of Yellowfin Parrotfish was estimated using the length converted catch curve method in the FISAT II program [23]:

$$\ln\frac{C(L1-L2)}{\Delta t\,(L1-L2)} = C - Z * t\,\frac{(L1-L2)}{2}$$

This equation was estimated through linearization in the form of simple linear regression $y = b_0 + b_1$. with $y = \ln\frac{C(L1-L2)}{\Delta t\,(L1-L2)}$ as an ordinate, and $X = t\frac{(L1-L2)}{2}$ as abscissa, and $Z = -b_1$. The natural mortality rate of Yellowfin Parrotfish was estimated by the Pauly empirical equation [23], which used data on the average temperature of Spermonde waters in South Sulawesi (T°C) with the equation:

$$\log (M) = -0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T$$

where M was the natural mortality rate of Yellowfin Parrotfish (year$^{-1}$), L∞ was asymptote length of Yellowfin Parrotfish (cm), K was growth coefficient of Yellowfin Parrotfish (year), T was the average water temperature (°C) as measured by the Makassar Meteorology and Geophysics Agency, which was 28.92°C. The catch mortality rate was estimated using the following equation:

$$Z = F + M \text{ or } F = Z - M$$

where F was fishing mortality from Yellowfin Parrotfish (year$^{-1}$), Z was total mortality rate from Yellowfin Parrotfish (year$^{-1}$), M was natural mortality (year$^{-1}$). The exploitation rate of Yellowfin Parrotfish was estimated using the Beverton and Holt equations [22]:

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

where F was capture mortality of Yellowfin Parrotfish (year$^{-1}$), Z was the total mortality rate of Yellowfin Parrotfish (year$^{-1}$), Natural mortality of Yellowfin Parrotfish (year$^{-1}$), E was exploitation rate of Yellowfin Parrotfish.

## 3. Results

There were 596 Yellowfin Parrotfish during the research with a total length range of 12 - 28 cm. The total length of Yellowfin Parrotfish was grouped into 17 classes with 1 cm intervals. Analysis of the length structure showed that the Yellowfin Parrotfish population consisted of three age groups (Table 1 and Figure 2).

**Table 1.** Average length and standard deviation of each age group or cohort of Yellowfin parrotfish *Scarus flavipectoralis* in Spermonde Islands, Makassar Strait, Indonesia.

| Age Group or Cohorts | Average Length (cm) | Standard Deviation (cm) | Population (individua) | Separation Index |
|---|---|---|---|---|
| 1 | 18.45 | 2.19 | 442.17 | n.a |
| 2 | 23.09 | 0.9 | 133.43 | 2.15 |
| 3 | 25 | 0.92 | 17.1 | 2.01 |

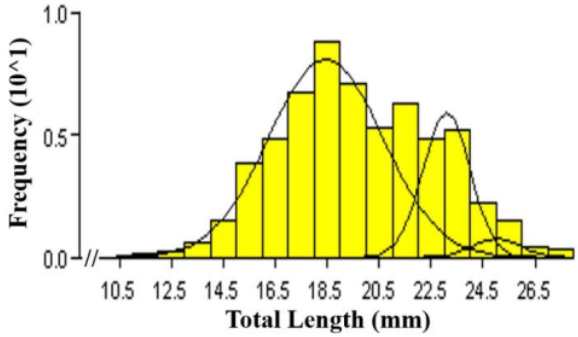


**Figure 2.** Histogram total length of Yellowfin parrotfish *Scarus flavipectoralis* in Spermonde Islands, Makassar Strait, Indonesia

Yellowfin parrotfish have a relatively slow growth rate (Table 2), taking decades to reach their asymptote length, but early in their life, 80% of their asymptote length was achieved in the first five cohorts (Figure 3).

**Table 2.** Estimation of growth parameters of Yellowfin parrotfish *Scarus flavipectoralis* in Spermonde Islands, Makassar Strait, Indonesia.

| Parameters | Estimated Value |
|---|---|
| $L_\infty$ (cm) | 40 |
| K (year$^{-1}$) | 0.28 |
| $t_0$ (year) | -0.5505 |

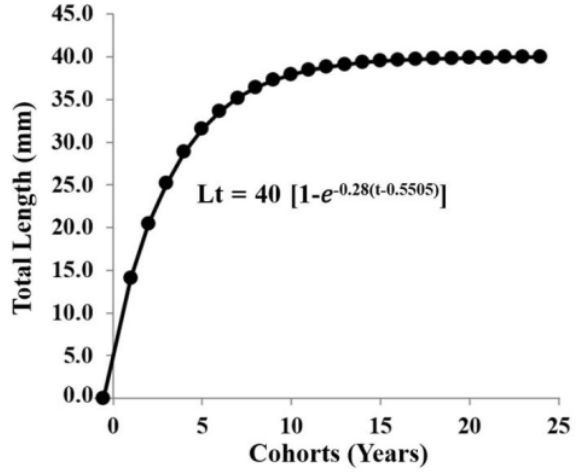


**Figure 3.** Growth curve of Yellowfin parrotfish *Scarus flavipectoralis* in Spermonde Islands, Makassar Strait, Indonesia.

The catch mortality rate was 3.5 times greater than the natural mortality rate, and the very high exploitation rate (Table 3) indicates that fishing for Yellowfin parrotfish needs to be done immediately

because there has been an unregulated fishing impact on Yellowfin parrotfish *Scarus flavipectoralis* in Spermonde Islands, Makassar Strait, Indonesia.

**Table 3.** The estimated value of Yellowfin parrotfish *Scarus flavipectoralis* in Spermonde Islands, Makassar Strait, Indonesia.

| Parameters | Estimated Value (year$^{-1}$) |
|---|---|
| Total mortality rate (Z) | 3.29 |
| Natural mortality rate (M) | 0.73 |
| Fishing mortality rate (F) | 2.56 |
| Exploitation rate (E) | 0.78 |

## 4. Discussion

Morphologically, Yellowfin parrotfish are highly recognizable by their color. Yellowfin parrotfish pectoral fins are yellow, both in male and female fish. Yellowfin parrotfish live in shallow waters in tropical and subtropical areas, especially in coral reef ecosystems [24,25]. Parrotfish, including Yellowfin parrotfish, have a wide distribution in Indo-Pacific waters, and can live from shallow water to a depth of 25 m [12]. Parrotfish, including Yellowfin parrotfish, live in groups and are active during the day in search of food [14]. This grouping behavior makes Parrotfish, including Yellowfin parrotfish, easy to catch using illegal fishing gear, such as explosives and cyanide. Yellowfin parrotfish is a parrotfish species that is commonly found in the catches of fishermen operating in the waters of the Spermonde Islands [9,10,26].

The study of the age composition of the catch of an exploited fish population is critical because it is related to the management of fish resources. Age composition can indicate the portion and size of fish that have escaped capture or are still alive so that the success or failure of reproduction in an exploited fish population can be predicted.

A separation index of Yellowfin parrotfish that is more than two indicates that it is acceptable or valid to split the total length measure into multiple cohorts. The separation index is a measure of quantity. If the value is less than two, cohort separation cannot be carried out because there will be a large overlap between the two size groups [22,27]. The portion caught at the small size (first cohort) indicates that the Yellowfin parrotfish population in Spermonde Islands is experiencing very high fishing pressure. About 75% of Yellowfin parrotfish caught are an average of 18.45 cm. The small size catch is very dangerous because Yellowfin parrotfish are protogenic hermaphrodites [26], meaning that Yellowfin parrotfish caught in small sizes (first cohort) are female. The results of previous studies on the Yellowfin parrotfish population in the Spermonde Islands show that the size at the first maturity of Yellowfin parrotfish in the Spermonde Islands is 18.0 cm [26]. This size indicates that the average length of Yellowfin parrotfish caught on the fist cohort was very close to size at physical maturity.

Growth is a measure of the increase in length or weight over time. Growth is a complex biological process because it is influenced by many factors affecting dynamic or soft organs, such as meat, and more static or rigid organs, such as bone [28]. Rigid organs are more stable when used as a measure of growth, so the fish length is generally used to measure the growth. This study shows that the growth of Yellowfin parrotfish is very low (0.28 year$^{-1}$). Fish with a growth rate less than 0.5 are categorized as fish with a low growth rate. The closer the growth rate value is to zero, the slower the fish will grow [22]. Low growth can be influenced by several factors, including genetic factors, gender, age, disease, food availability, and water temperature [29]. Very fast growth at the beginning of life is thought to be closely related to biological performance, which is still very good because physiological disorders and diseases are still minor, and the availability of good food because the volume of food is still small. Rapid growth in early life is something that is often found in fish. The growth of fish length is very fast when the fish are young and slows down with age until they reach the maximum length [30].

Total mortality is a description of the number of fish lost during a one-time interval. In fisheries, mortality is grouped into two, namely natural and catch mortality. Total mortality is the rate of decline

in fish abundance over time. Yellowfin parrotfish in Spermonde Islands have a high mortality rate due to fishing. If the fishing mortality value is greater than natural mortality, the death will be caused mainly by non-natural causes but by exploitation factors.

The rate of exploitation is a description of the portion of fish taken from the waters. The rate of exploitation can also be interpreted as the ratio of the number of fish caught to the total number of fish that died due to natural and fishing factors [23]. Determination of the rate needs to be known to determine the condition of fisheries resources that are being exploited. Stock must be managed optimally for economic benefits without neglecting the ecological function. Under-exploited stocks cause economic losses because dead resources are useless; therefore, fish stocks must be utilized. However, the utilization must be regulated so that there is no over-exploitation because it will cause economic and ecological losses. The Yellowfin parrotfish rate (0.78) has far exceeded the allowable or safe values. The optimum exploitation rate for the resource is 0.5 $year^{-1}$ [31]. For Yellowfin parrotfish whose catch size was very close to the size at the first maturity [26], the exploitation rate allowed should be only 50% of the optimal fishing rate, to be precise only 0.25 $year^{-1}$. The results of this study indicate the need for an urgent plan to prevent a more severe impact than unregulated fishing on Yellowfin parrotfish in Spermonde Islands, Makassar Strait, Indonesia.

## 5. Conclusion

The yellowfin parrotfish caught in Spermonde Islands has three cohorts with very low growth rates. Yellowfin parrotfish in Spermonde Islands have a high mortality rate due to fishing. The rate of Yellowfin parrotfish that has far exceeded the allowable value indicates the need for an urgent plan to prevent a more severe impact than unregulated fishing on Yellowfin parrotfish in Spermonde Islands, Makassar Strait, Indonesia.

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