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Research Article

Biological Parameters and Stock Status of Crimson Snapper (*Lutjanus erythropterus*) in Indonesia FMA 712 based at Brondong Fishing Port

Adjeng Peni Listyanto Putri[1], Am Azbas Taurusman[2*], and Ronny Irawan Wahju[2]

[1]Master Program of Marine Fisheries Technology, Faculty of Fisheries and Marine Science, IPB University, Bogor, West Java 16680. Indonesia
[2]Department of Fisheries Resource Utilization, Faculty of Fisheries and Marine Science, IPB University, Bogor, West Java 16680. Indonesia

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*) Corresponding author:
E-mail: azbas@apps.ipb.ac.id

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Abstract

The utilization status of crimson snapper stock in the Northern Java Sea (FMA 712) has reached optimum, tending to be over-exploited. This study aims to evaluate the stock status of crimson snapper (*Lutjanus erythropterus*) in FMA 712, especially in the northern waters of East Java. This research utilized catch data from the Brondong fishing port. The stratified random sampling method was utilized to collect samples at the research site. The findings indicate that the growth pattern of *L. erythropterus* exhibits a tendency towards negative allometry, with fishing mortality (F = 1.55) exceeding natural mortality (M = 0.89). The exploitation rate has reached a status of 'fully exploited' (E = 0.6). The Gonad Maturity Level (GML) of the catch is predominantly composed of GML I and GML II, suggesting that the majority of the captured fish have not yet spawned. It relates to the predominance of *cantrang* and *jaring tarik berkantong*, which capture fish of juvenile size. Thus, the Spawning Potential Ratio (SPR) parameter indicates it is 'fully exploited' (SPR = 0.22), i.e., the utilization rate has exceeded the limit of natural capacity for recruitment. This SPR value confirms: the utilization rate parameter (E), the fact that catch sizes tend to get smaller, and the results of previous studies in FMA 712. It is imperative to regulate the fishing efforts targeting the crimson snapper, as well as the deployment of *cantrang* and *jaring tarik berkantong*, which pose potential threats to the sustainability of this fishery.

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1. Introduction

Brondong Fishing Port (PPN Brondong) is part of FMA (WPPNRI) 712, one of the central locations for landing red snapper in Lamongan Regency, East Java. East Java Province is a major contributor to exports, reaching 47% of total exports in 2019 (PDSPKP, 2020). According to the annual Production Report of PPN Brondong, the production of red snapper has shown fluctuating trends each year, generally tending to decline. In 2018, red snapper production declined by 366 tons, followed by a further decrease of 169 tons in 2019 compared to the previous year. Additionally, local fishers have reported issues, specifically a reduction in the size of red snapper as the fishing areas extend further (Azkia *et al*., 2015). Research conducted by Rapi *et al*. (2023) in Pinrang Waters and Usman *et al*. (2014) in North Cirebon Waters has demonstrated that the average size of red snapper at first capture (Lc) is smaller than the length at first maturity size (Lm).

According to Fry *et al.* (2009), the length at first maturity of this fish species is 301 mm. The main factor contributing to the decline in fish stock is the increasing fishing effort, which results from the growing number of fleets and fishing gear (Demirel *et al*., 2023; Hilborn *et al.,* 2020; Palomares *et al.,* 2020). The high fishing pressure leads to overfishing conditions, which are characterized by specific indicators, including a decline in catch over time, an expansion of the fishing area, and a reduction in fish catch size (Yan *et al.,* 2021; Warren and Steenbergen, 2021; Widodo, 2002). The stock status of red snapper within fisheries areas can be assessed utilizing the Length-Based Spawning Potential Ratio (LB-SPR) approach. The LB-SPR is an index for assessing the relative reproductive rate in exploited fish stocks, as suggested previously in some works (Hommik *et al.,* 2020; Prince *et al.,* 2021; Fisch and Camp, 2022). The LB-SPR analytical method is applied to fish length-frequency data in conjunction with the growth and reproduction parameters of species from a specific aquatic environment. Several studies, including those by Wiadnya *et al*. (2023), Hapsari *et al*. (2023), Ayuningtyas *et al*. (2023), and Herwaty *et al*. (2023), employed this method to evaluate the stock status of particular fish species, demonstrating its effectiveness in estimating the stocks.

However, more information is required on the stock status of crimson snapper (*L. erythropterus*) based at Brondong Fishing Port. This research is important for the red snapper fisheries management in FMA 712, particularly those based at PPN Brondong. This process facilitates the evaluation of the resource's stock status by analyzing the Spawning Potential Ratio (SPR) value. Spawning potential ratio is very important in managing crimson snapper populations (Amorim *et al*., 2020). The information from the length-based SPR for crimson snapper from the catch of fishers in the Northern Java Sea on landing in PPN Brondong is the novelty of this study. Research on the status stock of crimson snapper in FMA 712, indicated by LB-SPR based at the PPN Brondong, is crucial for assessing the sustainability of fish stocks in the area, especially since PPN Brondong is one of the main fishing ports with intensive fishing activity. By estimating SPR, fisheries managers can assess whether fish populations can still reproduce at optimal levels or are experiencing excessive fishing pressure. The results of this study provide a scientific basis for developing data-driven management policies, such as gear restrictions, seasonal fishing regulations, or protection of spawning fish, to ensure the sustainability of fish resources and the livelihoods of fishers in the PPN Brondong area..The findings of this study are anticipated to inform fisheries management strategies for the Government (Ministry of Marine Affairs and Fisheries), Local Government, and other relevant stakeholders, particularly in the implementation of the Snapper and Grouper Fishery Management Plan (FMP).

Furthermore, it will be an important input in formulating the crimson snapper harvest strategy in the Northern Java Waters (FMA 712). The scientific information generated by this study is expected to contribute to the scientific development of red snapper fisheries management.

2. Materials and Methods

2.1 Materials

2.1.1 The equipment

The equipment used are a measuring board, digital scale, stationery, gloves, and dissecting stuff. While the tool used is Microsoft Excel, RStudio (TropFish package), and ArcGIS software.

2.1.2 The materials

The materials used in this study are 2000 samples of crimson snapper, which were collected to obtain data on the length and weight, and 50 samples of crimson snapper were utilized to assess the gonad maturity level.

2.1.3 Ethical approval

This study does not require ethical approval because it does not use experimental animals.

2.2 Methods

This research was conducted from August to November 2024 to collect biological data, located at Brondong Fishing Port, East Java. Brondong Fishing Port is one of the key facilities supporting fisheries management in the northern waters of East Java (Figure 1). Data collection in the form of fishing gear, catch composition, and fishing areas was carried out by field survey. A questionnaire was also used during the field survey to collect fishing data, including coordinates of fishing areas and catches, through face-to-face interviews with local fishermen. the field survey, there were 120 respondents, including 90 *cantrang* fishers, 10 *jaring tarik berkantong* fishers, 10 handline fishers, and 10 bottom longline fishers. A total of 2.000 crimson snapper samples (*L. erythropterus*) were measured for standard length (SL) and fish weight. In addition, 50 crimson snapper samples were used to observe the level of gonad maturity. Data collection of fish samples used a simple random sampling method, namely taking several samples that represent each category of fish size (small, medium, and large). Then, crimson snapper were dissected to observe the level of gonad maturity morphologically.

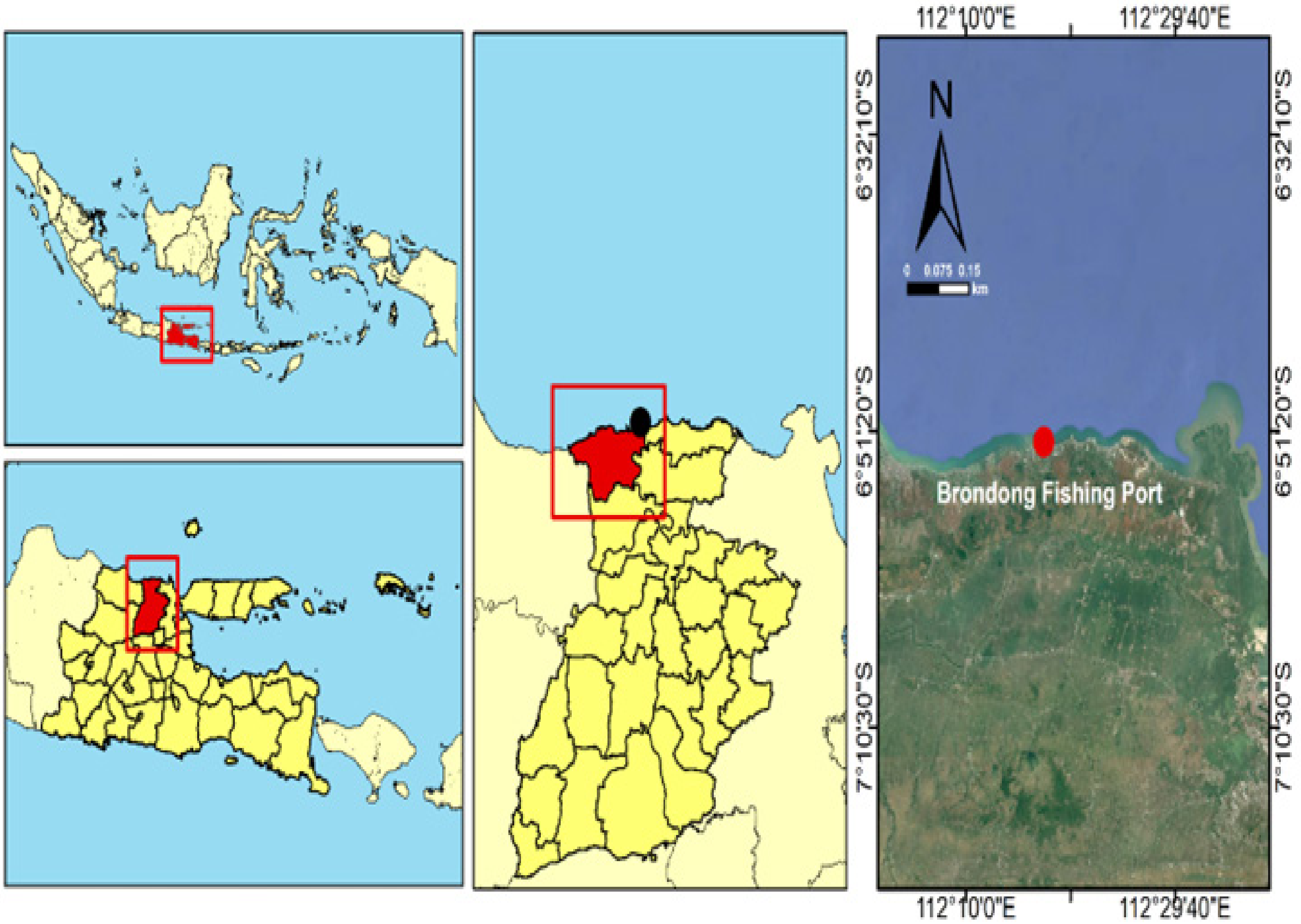

Figure 1. PPN Brondong is located in Northern East Java Province.

Participatory mapping was used to assist respondents in providing information on fishing area coordinates. The total number of each type of fishing gear is as follows: 507 *cantrang*, 19 *jaring tarik berkantong*, 50 handlines, and 13 bottom longlines. The study determined the sample size of 120 respondents from four fishing gears, which is referred to in the Handbook of Fisheries for Socio-economics, FAO (2017). During

2.3 Analysis Data

Several analyses were conducted to estimate the biological parameters and stock status of crimson snapper in WPPNRI 712, based on data from PPN Brondong, as follows:

2.3.1 Fishing gear

This analysis was conducted descriptively by detailing the fishing gear used to catch the crimson snapper. Data were gathered from interviews with fishers, focusing on the types of fishing gear and the size specifications of each component. Subsequently, the frequency distribution of the lengths of crimson snapper caught with each type of fishing gear was evaluated.

2.3.2 Fishing area

The coordinate data of fishing locations were obtained from participatory mapping and interviews with the fishers. The data were tabulated in Microsoft Excel and then converted into data positions (Degree, Minute, and Second/D⁰M'S"). Latitude and longitude data were transformed into numeric formulas, which were subsequently processed using ArcGIS 10.8 software to create a thematic map depicting the distribution of red snapper fishing areas based on PPN Brondong.

2.3.3 Length and weight relationship

The relationship between length and weight is essential in assessing the growth conditions of a specific species' population. Growth patterns can differ among species. The length and weight of the crimson snapper caught with each type of fishing gear were measured, and the relationship was then analyzed according to Effendie (1979), as follows:

$W = aL^{b}$ ....(i)

Where :

W = weight (grams)

L = length (cm)

the a and b are the regression intercept and coefficient, respectively. Length–weight relationship regression constants allow for comparing individuals within a population as well as between populations (Effendie, 1979): (1) The value b=3 indicates an isometric growth pattern; the increase in length and the increase in weight are relatively balanced. (2) The value b≠3 indicates an allometric growth pattern, namely: (a) b>3 indicates a positive allometric growth pattern, namely, the growth in fish weight is relatively higher than the growth in length. (b) b<3 indicates a negative allometric growth pattern, namely that the growth in length of the fish is higher than the growth in weight.

2.3.4 Gonad maturity level

Observation of gonads was carried out visually by considering the shape, color, and size of the ovaries or testes, referring to the characteristics of gonad maturity anatomically. Fish were dissected for sex observation based on primary sexual characteristics and Gonad Maturity Level (GML) based on Oktaviyani and Kurniawan (2017) as presented in Table 1.

2.3.5 Growth parameters

The analysis of growth parameters using crimson snapper length data involves calculating several essential parameters: the growth coefficient (K), asymptotic length (L∞), length at first maturity (Lm), and length at first capture (Lc). Additionally, the mortality rate is categorized into fishing mortality rate (F) and natural mortality rate (M), leading to the determination of total mortality (Z) and exploitation rate (E). Growth patterns were examined using the Von Bertalanffy model, calculated with the RStudio software and the TropFishR program (Sparre and Venema, 1999):

$Lt = L\infty\,(1 - e^{-K(t - t0)})$..(ii)

Where :

Lt = the length of the fish at age t (cm)

t_0 = the theory at which the fish is 0 years old.

2.3.6 Length based spawning potential ratio (*LB-SPR*)

The stock status of crimson snapper was evaluated using the Spawning Potential Ratio (SPR) method, an index measuring the relative reproductive rate of exploited fish stocks. SPR is determined by calculating the ratio of the number of fish that spawn during their lifetime and are subsequently caught to the number of fish that spawn without being caught (Brooks *et al.*, 2010). The Spawning Potential Ratio was determined using the length-based SPR approach within the RStudio Packages LB-SPR program. SPR analysis necessitates growth parameter data, specifically the M/K, F/M, and Lm/L∞ ratios, with the following parameters (Hordyk *et al.*, 2015):

SPR = SSBf / (SSBf = 0)......................................(iii)

The calculation of the LB-SPR method uses fish length data which is then processed with TropFishR using a simulation model from the R studio statistical software to obtain biological parameters in the form of the M/K ratio, asymptotic length (L∞), the proportion of 50% of fish that are gonad mature (L50), and the proportion of 95% of fish that are gonad mature (L95) (Hordyk *et al.*, 2015). Furthermore, biological parameter data is processed at *www.barefootecologist.com*. In equation (4), the potential spawning ratio is expressed in percent (%), SSBf is the current spawning stock biomass, while SSBf = 0 is the spawning stock biomass before any fishing. The

Table 1. Anatomical maturity level of crimson snapper gonads

GML	Condition	Female	Male
I	Immature	The ovaries are approximately 1/3 the length of the body cavity, clear and reddish in color. The eggs are not visible to the naked eye.	The testes are 1/3 the length of the body cavity and are whitish in color.
II	Development	Ovaries are approximately ½ the length of the body cavity, clear/ transparent. Eggs are not visible to the naked eye.	The testes are ½ the length of the body cavity and are whitish in color, more or less symmetrical.
III	Maturation	The ovaries are approximately 2/3 the length of the body cavity. Ovaries are reddish yellow, granular in appearance.	The testes are 2/3 the length of the body cavity, soft, and whitish to cream in color.
IV	Ripe	The ovaries fill the body cavity and are pink/orange in color, with blood vessels clearly visible on their surface. The eggs are ripe and translucent.	Testes fill the body cavity and are whitish/cream colored and soft.
V	Regeneration	The ovaries contract until about ½ the length of the body cavity. The ovaries may contain egg remains, dark or clear.	The testes shrink to half the length of the body cavity. The walls are loose.

limit reference point used in this study is 20% SPR, as used in *the Harvest Strategy* for Snapper and Grouper Fisheries in Indonesia and the National Commission for Fish Resource Assessment (2015). The SPR reference value, based on Prince *et al.* (2015), is divided into three criteria: < 20% (Over-exploited), 20% ≤ SPR ≤ 40% (moderate / fully exploited), and > 40% (Under-exploited).

3. Results and Discussion

3.1 Results

3.1.1 Fishing gear

Crimson snapper in PPN Brondong is captured using four types of fishing gear: *cantrang*, *jaring tarik berkantong*, handline, and bottom longline (Figure 2). *Cantrang*, a type of seine net, is the predominant gear employed by Brondong fishers. Its construction comprises three main parts: wings, body, and pocket, each with distinct mesh sizes. The wing section, measuring 20 to 25 meters with a mesh size of 7 to 9 inches, is designed to shock and prevent fish from escaping. The body section, 15 to 19 meters long with a mesh size of 3 to 5 inches, guides the fish into the bag. Finally, the pocket measures 2 to 3 meters with a mesh size of 2 inches.

The *jaring tarik berkantong*, based at PPN Brondong, is a type of cantrang that has been modified in the pocket section according to MMAF Decree No. 36 of 2023. PPN Brondong is actively promoting the transition of vessels utilizing *cantrang* to *jaring tarik berkantong* (modified *cantrang*). According to the conducted identification, the modified *cantrang* at PPN Brondong exhibits a mesh size of 2.5 – 3 inches in the pocket, with the upper rope measuring 50-70 meters in length and the top rope extending 800-900 meters.

Handline consists of a line, sinker, and hook. The handline based in PPN Brondong consists of a roller, a line made of nylon monofilament, an iron hook, a swivel, and a lead sinker, as shown in Figure 2. The handline used is a non-tuna J-type hook. Handline fishing based in PPN Brondong generally uses a handline with various numbers. Crimson snapper is usually caught using hooks numbers 7, 8, and 9.

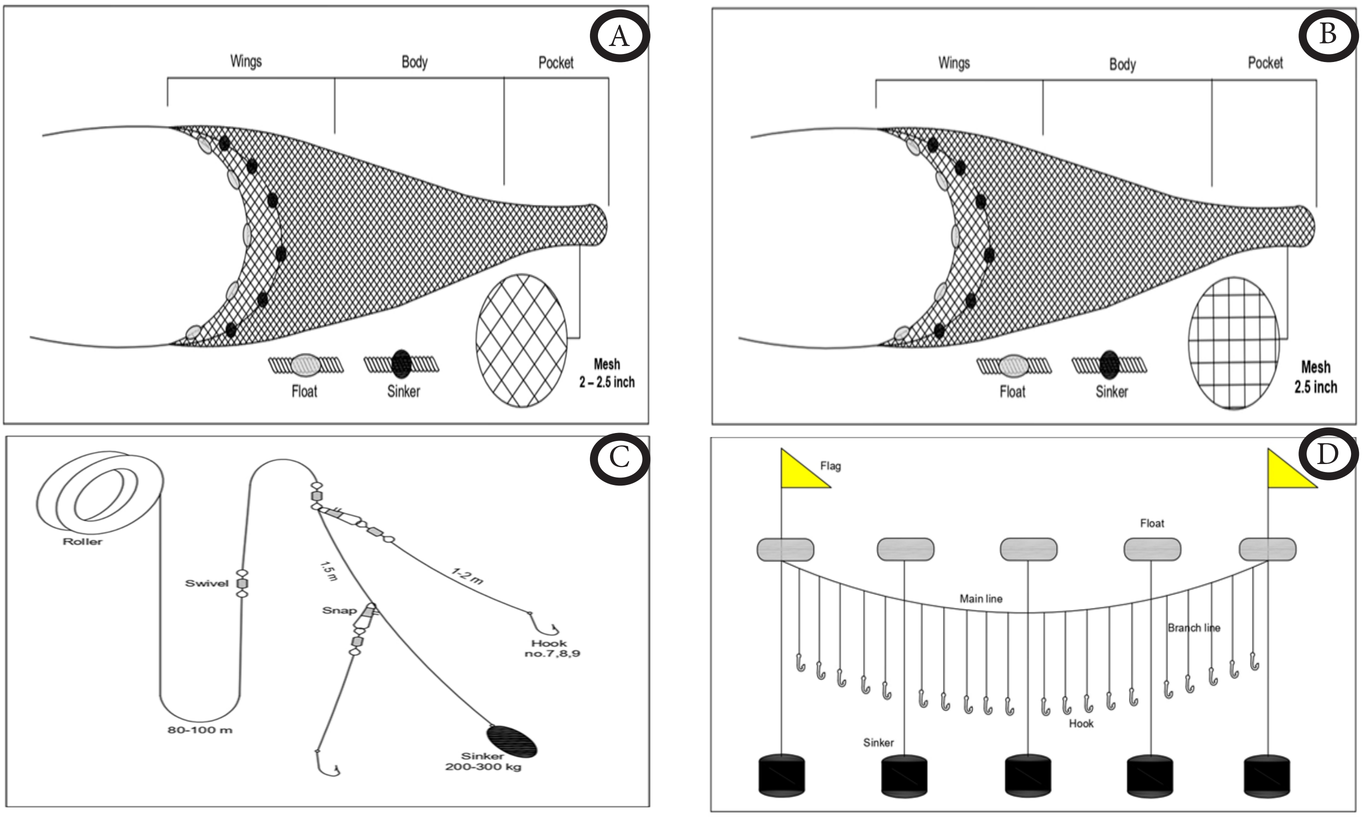

Figure 2. Design crimson snapper fishing gears: (a) cantrang, (b) jaring tarik berkantong, (c) handline, (d) bottom longline.

The local name for the bottom longline used by fishers in Brondong is 'pancing merawai'. Observations reveal that a single unit of this bottom longline comprises 2,000 to 3,000 hooks, with foam floats measuring 3 cm x 4 cm placed every 10 hooks. A 250-gram stone as a sinker is attached every 100 hooks to ensure they hang correctly. The distance between branch lines is 40 to 50 cm, and each branch line is 2 meters.

3.1.2 Fishing ground

Fishers at PPN Brondong do not use fish aggregating devices, so the fishing grounds for crimson snapper are not fixed. Interviews with local fishers reveal that crimson snapper fishing areas, utilizing four different types of fishing gear, are widely distributed across the Northern Waters of East Java. These areas include regions around Bawean Island, Madura, Kangean Island, Masalembu, Masakambing, and Keramean. Crimson snapper fishing is also conducted beyond the Northern Waters of East Java, specifically around the waters of South Kalimantan, Sampit, Matasiri Island, and near the Makassar Strait. As shown in Figure 3, fishing grounds for *cantrang* and *jaring tarik berkantong* are generally located in coastal waters, whereas handlines and bottom longlines are mostly operated in deeper offshore areas, particularly at depths exceeding 200 meters. Interviews with fishers reveal that most *cantrang* and *jaring tarik berkantong* fishers operate 100 to 200 miles from their fishing base, which is relatively closer than bottom longline fishers, who fish 140 to 300 miles away. All of the fishing vessels operate in the fishing lanes II and III. A map illustrating the crimson snapper fishing grounds and the types of gear used is shown in Figure 3.

3.1.3 Length-weight relationship

The length-weight relationship of *L. erythropterus* was measured using a sample of 2,000 individuals. The analysis of the length-weight relationship of the crimson snapper revealed a growth model value of $W = 0.1987\ SL^{2.4133}$ with an R^2 value of 0.8352. The value of b in the model is 2.41 ($b < 3$), indicating that the growth pattern of the crimson snapper is negatively allometric (Figure 4). This means that the fish's length increases at a relatively higher or faster rate than its weight.

3.1.4 Length frequency distribution

There is variation in the length distribution curve of crimson snapper (*L. erythropterus*) caught using 4 fishing gear types: *cantrang*, *jaring tarik berkantong*, handline, and bottom longline (Figure 5). The selectivity of some of these gears varies, leading

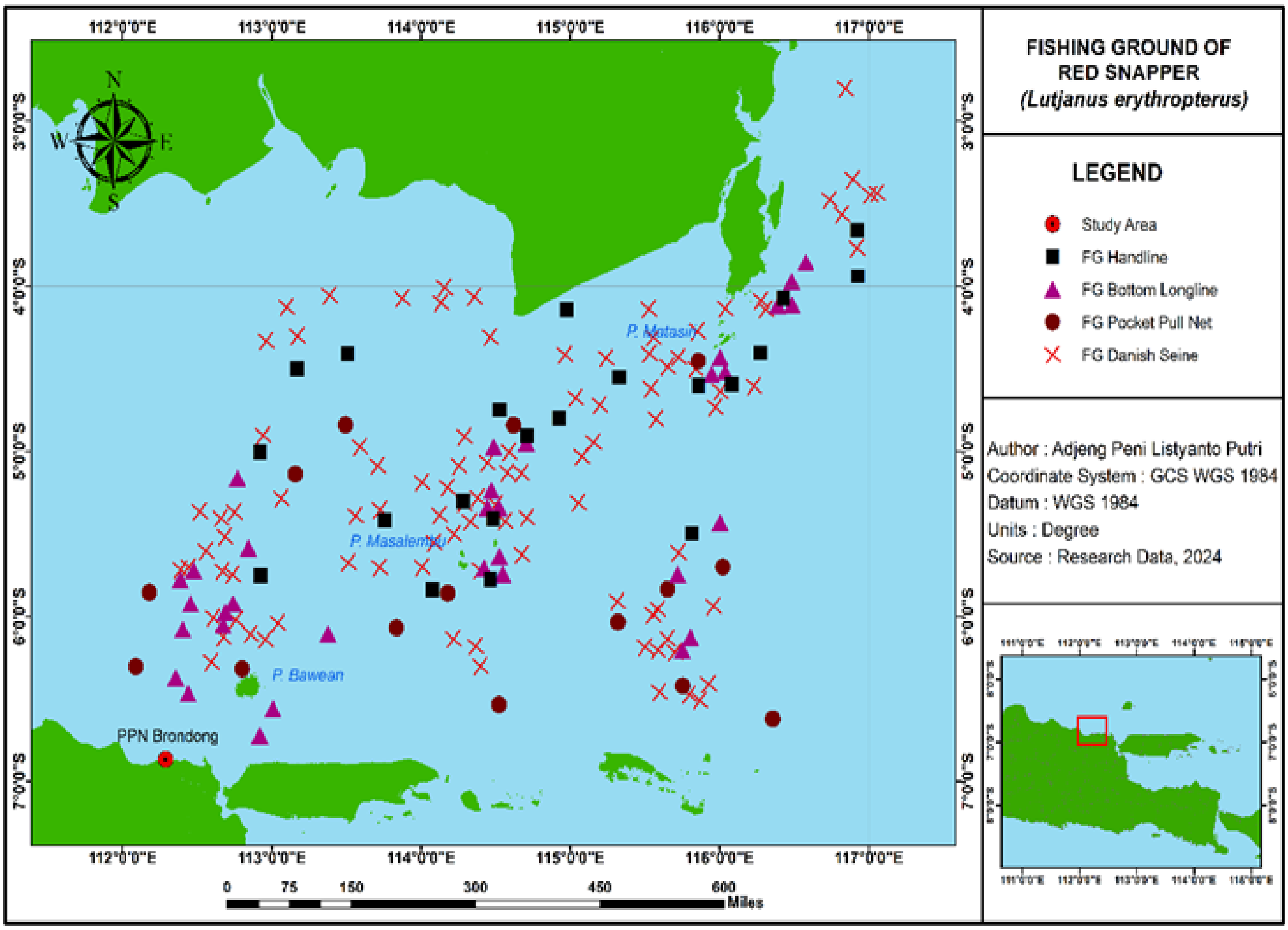

Figure 3. Map of the crimson snapper (*L. erythropterus*) fishing ground (FG) based in PPN Brondong.

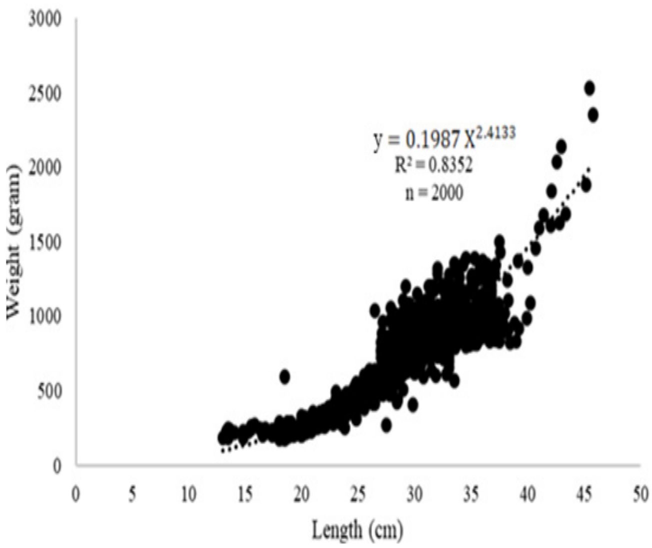

Figure 4. Length–weight relationship of crimson snapper (*L. erythropterus*) based at PPN Brondong.

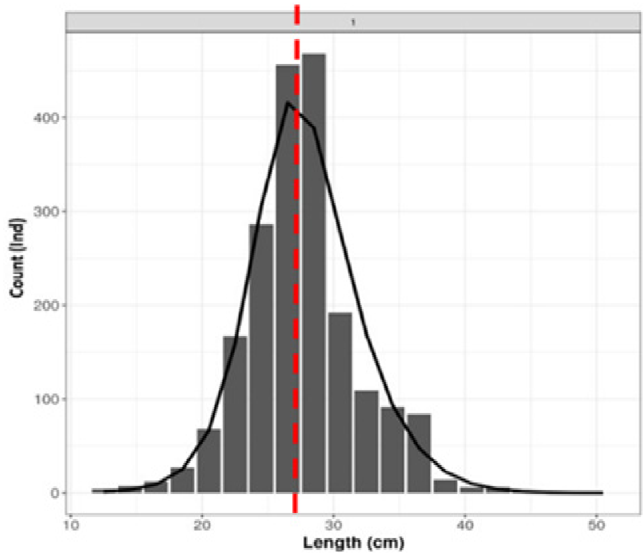

Figure 5. Length frequency distribution of crimson snapper (*L. erythropterus*) based on all fishing gears.

to differences in the length frequency of the crimson snapper caught. Overall, the average length of *L. erythropterus* caught was 27.7 cm, with a range of 13 - 45 cm, as presented in Figure 5.

The average length of crimson snapper caught using *cantrang* was 22.8 cm (ranging from 13.5 to 26.6 cm). On the handline, the average length was 29.2 cm (24 to 45 cm), while the *jaring tarik berkantong* yielded an average size of 23.6 cm (15 to 27 cm). For the bottom longline, the average length was 29.8 cm (24 to 37 cm). Using the method proposed by Froese and Binohlan (2000), the estimated length at first maturity (Lm) for *L. erythropterus* at the study site is estimated to be 26.8 cm based on these measurements. Referring to this value, it is evident that all catches from the seine net and bagged drag net consist of juveniles or those below Lm, whereas the catches from the handline (74%) and bottom longline (87%) are above Lm or considered allowable catch size (Figure 6).

servations were performed directly in the field by examining the shape, size, color, and development of the gonads (Effendie, 1979). Samples of crimson snapper (*L. erythropterus*) were used to observe the level of gonadal maturity in 50 fish. The results showed more female crimson snapper, 52% of the total catch, while the males were 48%. Subsequent observations of gonadal maturity levels revealed that 28 fish (56%) were classified as GML I, with lengths ranging from 27 to 34 cm. Additionally, 14 fish (28%) were identified as GML II, with lengths between 28 and 27 cm. Furthermore, five fish (10%) were categorized as GML III, with lengths from 29 to 37 cm, and three fish (6%) were classified as GML IV, with lengths from 32 to 34 cm (Figure 7).

3.1.6 Spawning potential ratio

The parameters needed for SPR analysis are mortality rate or natural mortality (M), growth coef

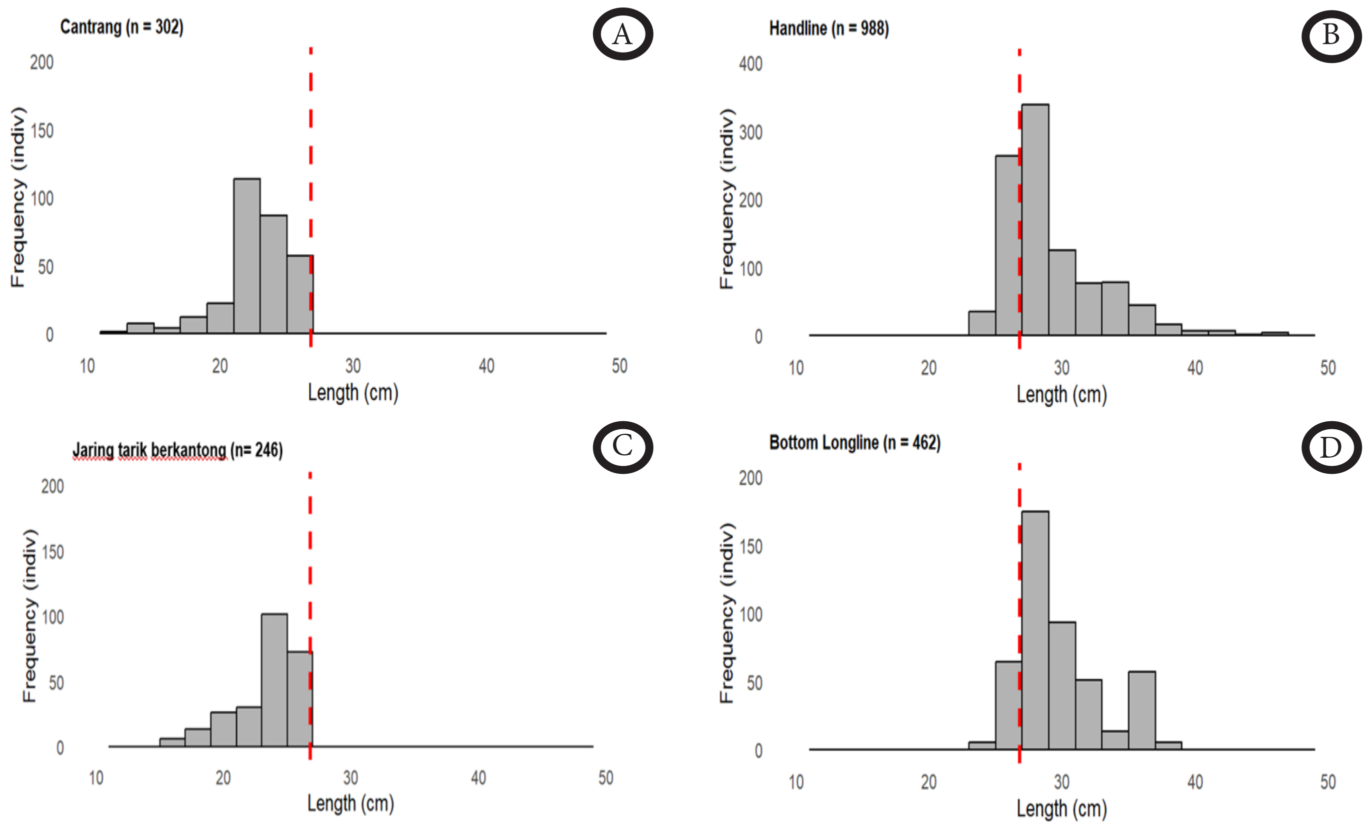

Figure 6. Length frequency distribution of crimson snapper (*L. erythropterus*) based on fishing gear used by fishers based in PPN Brondong.

3.1.5 Analysis of gonad maturity

One of the biological indicators utilized to assess the condition of fish through their reproductive organs is the development of the gonads. Gonad observations were made in two ways, namely morphologically and histologically. Morphological ob-

ficient (K), asymptotic length (L∞), and the length at first maturity (Lm). The results of growth parameter analysis showed that the asymptotic length (L∞) for *L. erythropterus* was 47.68 cm, with a growth coefficient of K = 0.4 per year. The K value for *L. erythropterus* is less than 1, suggesting that this fish species attains its asymptotic length relatively slowly. Total mortality

(Z) was found to be 2.44 per year, consisting of natural mortality (M) of 0.98 per year and capture mortality (F) of 1.55 per year. The exploitation rate (E) of *L. erythropterus* was determined to be 0.60, categorizing it within the "fully exploited" status criteria. The high fishing mortality rate is one of the causes of the low water stock and the potential for population reliance. Although fish are able to grow rapidly, the estimated adult population may decline further due to continuous fishing (Yonvitner *et al*., 2021). The decrease in asymptotic length indicates that the stock has decreased in size and the potential for overfishing (Tirtadanu *et al*., 2018). Based on the values of these biological parameters, the estimated value of the crimson snapper SPR was 22%. According to the criteria employed, e.g., Hordyk *et al*. (2015), this fish resource's stock status at the study site has reached a utilization level classified as "moderate or fully exploited", as presented in Figure 8.

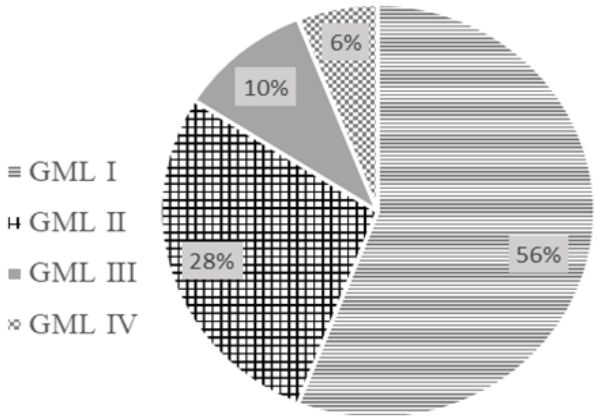

Figure 7. Proportion of gonad maturity level (GML) of crimson snapper (*L. erythropterus*).

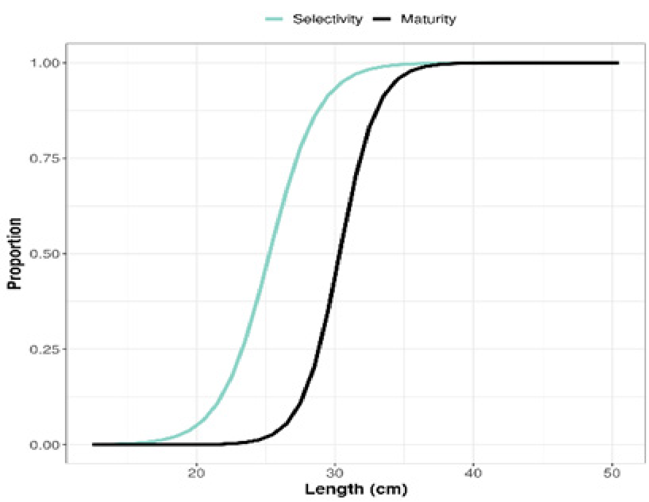

Figure 9. Selectivity curve of crimson snapper (*L. erythropterus*) based on PPN Brondong.

3.1.7 The relationship between length at maturity (Lm) and length at first capture (Lc)

Based on the selectivity curve (Figure 9), the length at first maturity (Lm) of the crimson snapper is 26.8 cm, and the size of the first caught (Lc is 30.33 cm, which means that most of those caught have exceeded the size of the first mature gonad (Lc > Lm). However, it is necessary to control fishing because the stock status based on the SPR indicator (22%) has reached the "fully exploited" status, especially due to fishing using *cantrang* and *jaring tarik berkantong*. The result of this analysis aligns with field observations, indicating that the size of the crimson snapper being caught is generally decreasing, the fishing grounds are becoming more distant, and the overall catch is tending to decline. The findings coincide with assessments conducted in other locations (Table 2).

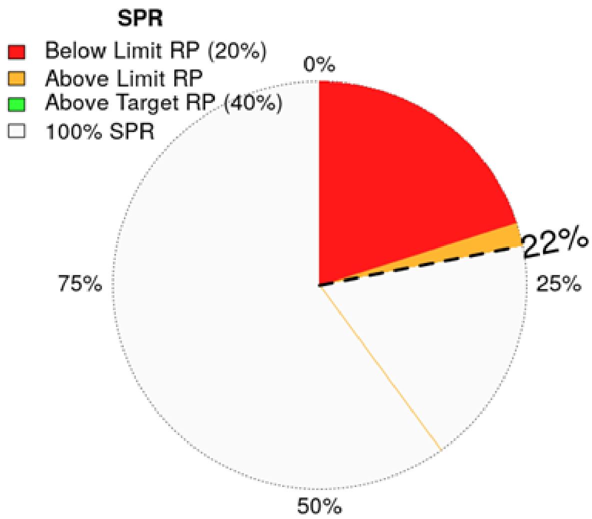

Figure 8. Spawning potential ratio (SPR) of crimson snapper (*L. erythropterus*) based at PPN Brondong.

Table 2. Length at first maturity (Lm) and length at first capture (Lc) at several research locations

Study area	Lm	Lc (L_{50})	Source
Brondong Fishing Port	26.8 cm (SL)	30.3 cm (SL)	This study
The central Great Barrier Reef	40 cm (SL)	45 cm (SL)	Newman *et al.* (2000)
Eastern Waters of Indonesia	Female : 29.6 cm (SL) Male : 30.9 cm (SL)	Female : 40.9 cm (SL) Male : 30.4 cm (SL)	Fry and Milton (2009)
Northern Waters of Australia	Female : 28.8 cm (SL) Male : 24 cm (SL)	Female : 35.1 cm (SL) Male : 26.8 cm (SL)	Fry and Milton (2009)
Java Sea	37 cm (SL)	32 cm (SL)	Amorim *et al.* (2020)
Arafura Waters	52 cm (TL)	50 cm (TL)	Ayuningtyas *et al.* (2023)

3.2 Discussion

3.2.1 Fisheries characteristic of crimson snapper (L. erytropterus)

Fishers based at the PPN Brondong use four types of fishing gear to catch the crimson snapper (L. erythropterus): cantrang, *jaring tarik berkantong*, handline, and bottom longline. Some of these gears have different selectivity, so the length frequency of the crimson snapper caught also varies. Crimson snapper (*L. erythropterus*) caught was 13 - 45 cm in length. The length of crimson snapper captured in this study closely aligns with the findings of Amorim *et al.* (2020) in the Java Sea, where the length ranged from 15 to 65 cm. The distribution of crimson snapper captured using four distinct fishing gears extends across the Northern Waters of East Java. It reaches towards the Waters of South Kalimantan, approaching the Makassar Strait. The distribution of fishing locations according to the type of fishing gear employed is relatively consistent, aligning with the findings of Amorim *et al.* (2020).

3.2.2 Biological parameters and stock status of crimson snapper (L. erytropterus)

The relationship between the length-weight of *L. erythropterus* reveals that the species exhibits a negative allometric growth pattern, characterized by a and b values of less than 3. This finding suggests that the increase in the length of the crimson snapper occurs at a relatively faster rate than its weight. Negative allometric growth patterns were also found in previous studies, for example, in Bunyu Waters, b = 2.23; R^2 = 95% (Firdaus *et al.*, 2020), Cirebon North Waters, b = 2.79; R^2 = 96% (Usman *et al.*, 2014), and Kupang, b = 2.71; R^2 = 97% (Nurulludin *et al.*, 2019). Several studies have shown that various Indonesian waters have varied growth patterns related to environmental conditions (Wahyuningsih *et al.*, 2013; Ernawati and Budiarti, 2020).

Analysis of the gonadal maturity of the crimson snapper (*L. erythropterus*) in the eastern region of WPPNRI 712 from August to November 2024 indicates that nearly 85% of this species exhibit immature gonads, classified as GML I and GML II. The fish is generally considered to be gonadally mature upon reaching GML III, e.g., (Oktaviyani and Kurniawan, 2017; Effendie, 1979). The length of crimson snapper with mature gonads (GML III and GML IV) ranges from 29 to 35 cm.

The results of the LB-SPR analysis showed that the crimson snapper (*L. erythropterus*) stock at the study site had reached the condition of "moderate or fully exploited" with an SPR value = 22%. The results are relatively similar to the study by Amorim *et al.* (2020) in Java waters using measurement data for three years (2016 - 2018), which obtained an SPR value = 27% (moderate / fully exploited). The relatively low SPR value is likely influenced by the extensive use of the seine net, specifically, *cantrang* and *jaring tarik berkantong*. These fishing gear predominantly capture juvenile crimson snapper, often below the Lm size, because they exhibit non-selective fishing gear and exploit almost all fish species (Taurusman *et al.*, 2025). The SPR method assesses fish stock status and serves as a basis for management policies such as catch limits, gear regulations, and habitat protection. However, this method has limitations due to its high reliance on accurate biological data, lack of consideration for migration or spatial dynamics, and limited applicability to multispecies fisheries like those in Indonesia. Consequently, SPR results should be integrated with other indicators to facilitate more comprehensive decision-making. In the context of sustainable snapper fisheries management, as outlined in the Fisheries Management Plan (FMP) for snapper and groupers and the harvest strategy established by MMAF, the stock status of the crimson snapper is quite similar to that of other snapper species prioritized for management. Based on this stock status, fisheries management measures are recommended to immediately control fishing efforts so that the stock status does not decline further (over-exploited). Immediate restrictions must be imposed on the *cantrang* and *jaring tarik berkantong* operating from PPN Brondong. Technically, this can be achieved by increasing the mesh size of the pocket, particularly in *cantrang* and *jaring tarik berkantong*.

4. Conclusion

The conclusion of this study indicates that crimson snapper (*L. erythropterus*) resources based in PPN Brondong are under fishing pressure. The Spawning Potential Ratio (SPR) value of 22% suggests that the crimson snapper stock is 'fully exploited', indicating that the number of fish caught from a stock is at the maximum sustainable level. Therefore, regulating cantrang and *jaring tarik berkantong* is essential, as the catches from these fishing gears are smaller than the allowable catch size or juvenile. In addition, controls are needed for *cantrang* and *jaring tarik berkantong*, as all the fish caught with these gear are juveniles. Furthermore, rigorous management is needed to prevent further population decline (over-exploitation) and ensure the sustainability of crimson snapper stocks. It is necessary to record catches, particularly by collecting biological data such as length measurements of each species throughout the year, at Brondong Fishing Port and other related locations to support the sustainable management of the red snapper in FMA 712. This study also contributes to implementing the national fisheries management plan for groupers and snappers in particular, as well as the development of a harvest strategy for snapper fisheries in FMA 712.

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Authors' Contributions

All authors contributed to the final manuscript. The contribution of each author is as follows: A.P.L.P. conceptualized and designed the work, collected data, analyzed data, and drafted the manuscript. A.A.T. conceptualized and designed the work, interpreted the data, and substantially revised. R.I.W. conceptualized and designed the work and substantially revised it. All authors gave final approval for publication.

Conflict of Interest

The writing team stated that there was no conflict of interest in the preparation of this article, and all teams agreed to publish the journal.

Declaration of Artificial Intelligence (AI)

No artificial intelligence (AI) tools, services or technologies were used in the creation, editing or enhancement of this article. All content presented is the result of the independent intellectual endeavors of the author, to ensure authenticity and integrity.

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