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MORPHOMETRIC ANALYSIS AND REPRODUCTION OF BIGEYE SCAD *Scomber crumenophthalmus* (BLOCH, 1793) CAUGHT AT TPI SOUTH BUTON REGENCY

Analisis Morfometrik dan Reproduksi Ikan Selar *Scomber crumenophthalmus* (BLOCH, 1793) yang Didaratkan di TPI Kabupaten Buton Selatan

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ABSTRACT

Bigeye scad (Scomber crumenophthalmus) is a small pelagic species of high economic value that is commonly found in tropical waters, including those in South Buton. This study aims to analyze the length-weight relationship, length distribution, gonadal maturity stages (GMS), and to determine the first maturity size (L_m) as a foundation for sustainable fisheries management. The research was conducted from July to September 2023 using a purposive sampling method, in which fish samples were collected from local fishermen's catches. The parameters measured included total length, body weight, and gonadal maturity stage. The length-weight relationship was analyzed using an allometric equation, while gonadal maturity stages were assessed through macroscopic classification. The results showed that bigeye scad had a length range of 176–223 mm, with the highest frequency in the 200–205 mm size class. The length-weight relationship followed the equation W = 2.4983L - 4.0765, indicating a negative allometric growth pattern (b < 3). The analysis of gonadal maturity stages revealed that most individuals were at GMS stages III–V, with the first maturity size (L_m) determined to be 194.455 mm. Based on the research period and GMS distribution, it is presumed that the spawning season occurs from October to early the following year. In conclusion, it is recommended to establish a minimum catch size above 194.455 mm and manage the fishing season with consideration of the spawning period, in order to maintain population balance and ensure the sustainability of bigeye scad stocks in South Buton waters.

Keywords: First Maturity Size, Gonadal Maturity Stage, Length-Weight Relationship, Scomber crumenophthalmus, South Buton

ABSTRAK

Ikan Selar (*Scomber crumenophthalmus*) merupakan salah satu ikan pelagis kecil bernilai ekonomi tinggi yang banyak ditemukan di perairan tropis, termasuk Buton Selatan. Penelitian ini bertujuan untuk menganalisis hubungan panjang-berat, distribusi ukuran panjang, serta tingkat kematangan gonad (TKG) dan menentukan ukuran pertama kali matang gonad (L_m) sebagai dasar dalam pengelolaan perikanan secara berkelanjutan. Penelitian ini dilakukan pada Juli hingga September 2023 dengan metode *purposive sampling*, di mana sampel ikan dikumpulkan dari hasil tangkapan nelayan. Parameter yang diukur meliputi panjang total, berat tubuh, dan tingkat kematangan gonad. Analisis hubungan panjang-berat menggunakan persamaan allometrik, sedangkan tingkat kematangan gonad dianalisis berdasarkan klasifikasi makroskopis. Hasil penelitian menunjukkan bahwa ikan Selar memiliki rentang panjang 176–223 mm, dengan frekuensi tertinggi pada kelas ukuran 200–205 mm. Hubungan panjang-berat mengikuti persamaan W = 2.4983L - 4.0765, dengan pola pertumbuhan alometrik negatif (b < 3). Tingkat kematangan gonad menunjukkan bahwa sebagian besar individu berada pada TKG III–V, dengan ukuran pertama kali matang gonad (L_m) sebesar 194,455 mm. Berdasarkan waktu penelitian dan distribusi TKG, diduga musim pemijahan terjadi pada Oktober hingga awal tahun berikutnya. Kesimpulannya, disarankan ukuran tangkap minimum di atas 194,455 mm serta pengelolaan musim penangkapan yang mempertimbangkan periode pemijahan, guna menjaga keseimbangan populasi dan keberlanjutan stok ikan Selar di perairan Buton Selatan.

Kata Kunci: Ukuran Matang Gonad, Tingkat Kematangan Gonad, Hubungan Panjang-berat, *Scomber crumenophthalmus*, Buton Selatan

INTRODUCTION

The bigeye scad (*Scomber crumenophthalmus*) is a small pelagic fish that has high economic value and is widely found in tropical waters, including in South Buton Regency. This fish belongs to the Carangidae family and lives in groups in coastal waters up to a depth of 80 meters (Fauzi et al., 2018). This species prefers neritic waters, especially around islands, and tends to be active at night in more turbid waters (Saranga et al., 2019).

In Indonesia, the scad is an important commodity in the capture fisheries sector, both for local consumption and the fish processing industry. High demand has led to quite intensive exploitation rates in several Southeast Asian countries, including Indonesia, Malaysia, and the Philippines (Kempter et al., 2015). Andriyono et al. (2022) reported that the exploitation of fish from the Carangidae family, including the scad, continues to be intensive to meet the need for animal protein and as raw materials in the fisheries industry in the Southeast Asian region. This fishing generally uses purse seine fishing gear, which is widely used by small and large-scale fishermen to catch small to large pelagic fish (Jatmiko et al., 2020).

South Buton Regency has great pelagic fisheries potential, including scad, which is the main target of small and medium-scale fisheries. This area is included in the Fisheries Management Area of the Republic of Indonesia (WPP RI 714), which includes the waters around the Banda Sea and Flores Sea. In 2014, the fisheries catch in South Buton Regency was recorded at 7,308 tons (DKP Buton Selatan, 2015). Many local fishermen depend on their livelihoods on the catch of small pelagic fish such as scad, which are then landed at the local Fish Auction Place (TPI).

Although scad has high economic value, scientific studies on the biological and reproductive aspects of this fish in the waters of South Buton are still very limited. One method that can be used to understand the population structure and dynamics of fish growth is morphometric analysis. The relationship between body length and weight is an important parameter in growth studies because it can show isometric growth patterns (balanced length and weight) or allometric (unbalanced length and weight). In addition, reproductive analysis,

such as gonad maturity level (TKG) and spawning season, is very necessary to understand the reproductive strategy of scomber crumenophthalmus and determine the right time to manage fishery resources.

This study aims to analyze the morphometry and reproductive aspects of bigeye scad (*Scomber crumenophthalmus*) landed at the TPI of South Buton Regency. The results of this study are expected to be the basis for developing a more sustainable fisheries management strategy, so that the stock of scomber crumenophthalmus is maintained and can be optimally utilized by fishing communities in South Buton Regency.

METHODS

Time and Place

This research was conducted from July 29 to September 23, 2023 at the Fish Auction Place (TPI) in South Buton Regency, Southeast Sulawesi. This location was chosen because it is one of the landing centers for fishermen's catches from the waters of South Buton, which is included in the Fisheries Management Area of the Republic of Indonesia (WPP RI 714). Sampling was carried out periodically during the research period to obtain representative data on the length, body weight, and gonad maturity level of scads (*Selar* spp.) caught in these waters.

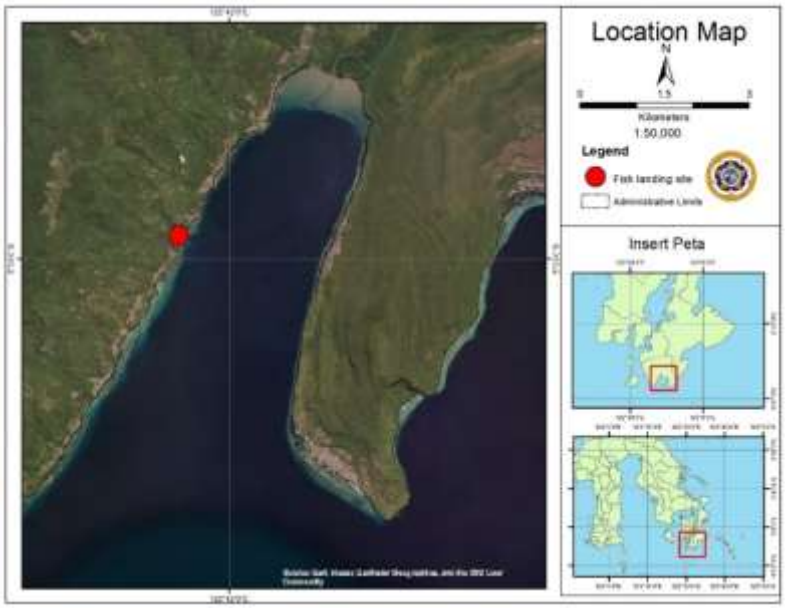

Figure 1. Map of Research Location

Sampling Method

Fish sampling was carried out by purposive sampling, namely by collecting scads landed at the TPI based on the availability of fishermen's catches. Fish samples were taken by considering size variations to obtain a more representative distribution of length and weight. The parameters measured in this study include:

- The total length of the fish (Total Length, TL) was measured using a ruler with an accuracy of 0.1 cm.
- Fish body weight (BW) was measured using a digital scale with an accuracy of 0.1 grams.
- The gonad maturity level (TKG) was determined by observing the gonad morphology based on the macroscopic classification of gonad maturity levels.

Each fish sample collected will be given an identification code to facilitate recording and further analysis.

Data Analysis

The data obtained were analyzed using descriptive statistical methods and morphometric relationship analysis. Some of the main analyses conducted include:

- Length-Weight Relationship Analysis

The relationship between fish length and weight is analyzed using the allometric equation (Le Cren, 1951):

$$W = aL^b$$

Where:
W = Fish body weight (g)
L = Total fish length (cm)
a = Growth constant
b = Growth coefficient

The value of b will determine the type of fish growth, namely:
b = 3 → Isometric (balanced growth in length and weight)
b < 3 → Negative allometric (fish tend to grow longer than they grow heavier)
b > 3 → Positive allometric (fish gain weight faster than they grow longer)
Linear regression analysis is performed using logarithmic transformation:

$$\log W = \log a + b \log L$$

- Gonad Maturity Level Analysis

The level of gonad maturity of fish is analyzed based on the macroscopic classification method commonly used in fish reproduction studies. Each individual fish will be grouped into one of the TKG categories, which reflects the development of gonads in the fish's reproductive cycle.

- Statistical Analysis
  - Regression tests were conducted to see the relationship between fish length and weight.
  - Student's t-test or ANOVA can be used to compare the average length, weight, and TKG between sample groups if necessary.
  - The distribution of length sizes was analyzed to see the population structure of trevally caught at the research location.

RESULTS

Class Range

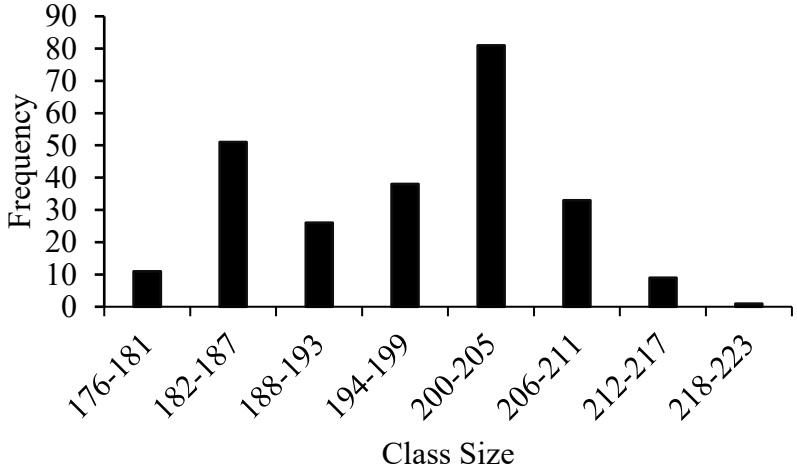

Figure 2. Class Range of Length of Bigeye Scad (*S. crumenophthalmus*)

The length distribution of bigeye scad (*S. crumenophthalmus*) landed at the TPI of South Buton Regency showed quite diverse size variations. From the total samples observed, the length range of fish ranged from 176 mm to 223 mm. The length class with the highest frequency was in the 200–205 mm interval, with 81 individuals, indicating that the majority of fish caught were in this size range.

In general, the frequency distribution of fish length tended to be a unimodal distribution, with a peak frequency in the 200–205 mm class, followed by the 182–187 mm class with 51 individuals, and the 194–199 mm class with 38 individuals. Meanwhile, the smaller (176–181 mm) and larger (218–223 mm) length classes had much fewer individuals, 11 individuals and 1 individual, respectively.

Length-weight Relationship

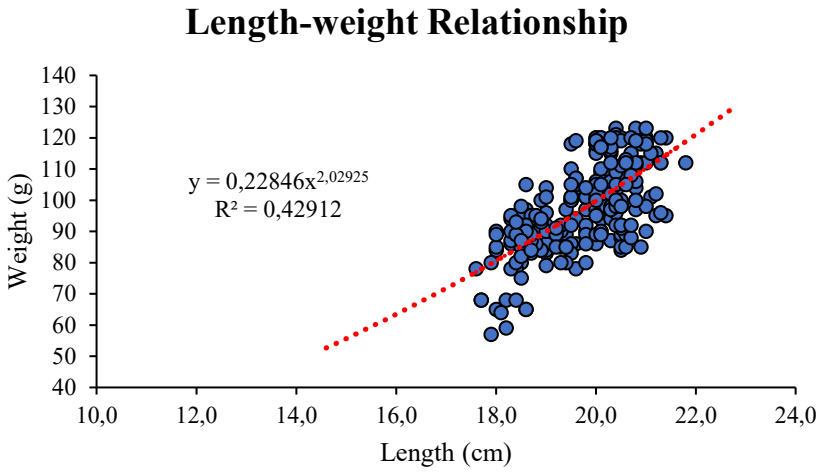

Figure 3. Length-weight Relationship of Bigeye Scad (*S. crumenophthalmus*)

The results of the analysis of the length-weight relationship in this study follow the equation: y = 2.4983x-4.0765. The R^2 value is 0.42912. This equation shows that there is a positive relationship between the length and body weight of the scad, where an increase in body length will be followed by an increase in weight.

However, the relatively low R^2 value (0.42912) indicates that body length only explains about 42.91% of the variation in body weight, while the rest is influenced by other factors such as environmental conditions, food availability, and other biological factors. This shows that the length-weight relationship in the scad population studied is not very strong and there is likely to be variability in individual growth.

Ecologically, fish growth patterns can be classified as isometric or allometric. In this case, the regression coefficient value (b = 2.02925) is less than 3, which indicates that the scad has negative allometric growth. This means that the increase in body length is not followed by a proportional increase in weight, so that the fish tends to be slimmer as its length grows.

Table 1. Size and Number of Gonad Maturity Levels of Bigeye Scad (*S. crumenophthalmus*)

Sex	Size	I	II	III	IV	V	Total
Male	176-181	-	1	4	4	2	11
	182-187	-	2	13	18	9	42
	188-193	-	2	3	7	4	16
	194-199	-	-	1	10	3	14
	200-205	-	1	8	18	8	35

Sex	Size	I	II	III	IV	V	Total
	206-211	-	-	7	7	2	16
	212-217	-	-	2	4	2	8
	218-223	-	-	-	-	-	-
Female	176-181	-	-	-	-	-	-
	182-187	-	-	3	2	4	9
	188-193	-	-	5	4	1	10
	194-199	-	-	9	10	5	24
	200-205	-	5	9	15	18	47
	206-211	-	-	4	6	6	16
	212-217	-	-	-	-	1	1
	218-223	-	-	-	-	1	1

In male fish, individuals with early gonad maturity levels (TKG I and II) were relatively rare. Most individuals were in TKG III to V, especially at sizes 182–187 mm to 200–205 mm. At a size of 182–187 mm, the number of individuals in TKG III was 13 and TKG IV was 18, indicating that fish in this size were starting to enter the gonad maturity phase. The peak of maturity occurred at a size of 200–205 mm, with 18 individuals in TKG IV and 8 in TKG V. After a size of 212 mm and above, the number of individuals decreased drastically, and no male fish were even found in the range of 218–223 mm, which may indicate that fish of this size were rarely caught or were already in the spawning phase.

In female fish, the distribution pattern of gonad maturity showed differences compared to males. No female individuals were found at a size of 176–181 mm, which may indicate that female fish require a larger size before undergoing gonadal development. At a size of 182–193 mm, most individuals were still in TKG III and IV, with a relatively smaller number compared to male fish of the same size. The peak maturity occurred at a size of 200–205 mm, where 15 individuals were in TKG IV and 18 individuals in TKG V, indicating that females tend to mature gonads at a larger size.

Gonad Maturity Level of Bigeye Scad (*S. crumenophthalmus*)

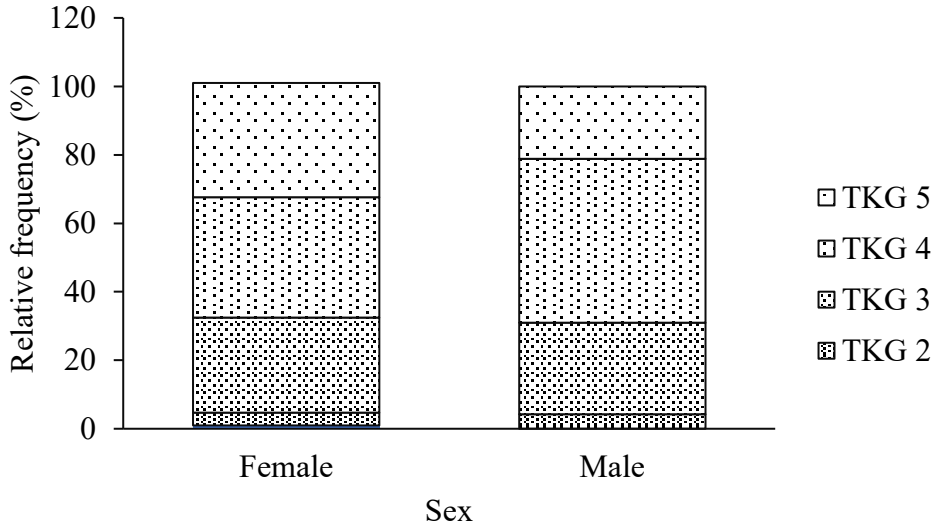

Figure 4. Gonad Maturity Level of Bigeye Scad (*S. crumenophthalmus*)

Based on data on the gonadal maturity level (TKG) of bigeye scad (*Scomber crumenophthalmus*), there are differences in gonadal development patterns between male and

female fish. The largest percentage of female fish was in TKG 4 (35.2%) and TKG 5 (33.33%), indicating that most of the observed female individuals were in the final stage of gonad maturation and ready to spawn. Meanwhile, male fish were dominated by TKG 4 (47.9%), indicating that the majority of male fish had also reached the gonad maturity stage, but the number was smaller in TKG 5 (21.13%) compared to females.

The percentage of fish in TKG 2 and TKG 3 was relatively smaller compared to the higher maturity phase. Female fish with TKG 2 were only 3.7%, while male fish were 4.2%. This indicates that most of the fish caught were already at an advanced maturity stage. In TKG 3, the number of females was 27.8%, slightly higher than males which reached 26.8%, indicating that both sexes were almost balanced in this maturation stage.

Size of First Gonad Maturity

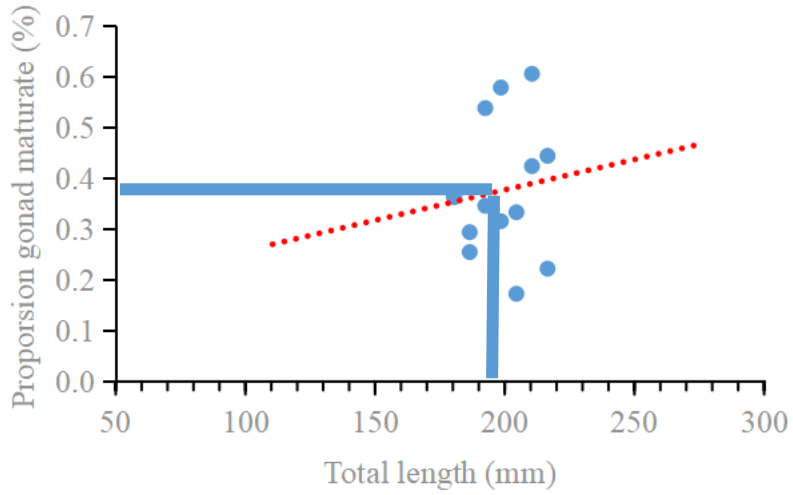

Figure 5. Size of First Gonad Maturity of Scomber Fish (*S. crumenophthalmus*)

Based on the results of the analysis, the size of scomber fish (*Scomber crumenophthalmus*) when it first reached gonad maturity was 194.455 mm. This means that at that size, some individuals in the population have reached a level of gonad maturity that allows them to reproduce.

DISCUSSION

Size Distribution

The length distribution of bigeye scad (*S. crumenophthalmus*) landed at the TPI of South Buton Regency showed quite diverse size variations. From the total samples observed, the length range of fish ranged from 176 mm to 223 mm. The length class with the highest frequency was in the 200–205 mm interval, with 81 individuals, indicating that the majority of fish caught were in this size range. In general, the frequency distribution of fish length tended to be a unimodal distribution, with a peak frequency in the 200–205 mm class, followed by the 182–187 mm class with 51 individuals, and the 194–199 mm class with 38 individuals. Meanwhile, the smaller (176–181 mm) and larger (218–223 mm) length classes had much fewer individuals, 11 individuals and 1 individual, respectively. These results are in line with research by Fitria et al. (2020) which reported that the distribution of the length of S. crumenophthalmus ranged from 155–255 mm. In addition, research by Saranga et al. (2019) at the Bitung Ocean Fisheries Port found that the total length of the bigeye trevally ranged from 9.44 mm – 203.88 mm, while the smalleye trevally had a length range of 9.66 mm – 149.14 mm. According to Musyali et al. (2022), differences in fish size distribution can be influenced

by various factors, including the observation season, natural habitat, and the fertility of the waters where the fish thrive. These factors can cause variations in the size of fish caught in each region and season.

In addition, research by Faizah et al. (2017) found that the bentong fish in the northern waters of Kwandang had a fork length range of 13.5–21 cm FL. These results indicate that there are variations in the size of scad fish in various locations that can be influenced by ecological factors, such as food availability and environmental conditions of the waters. These environmental factors greatly influence the growth and development of scad fish in their habitat. Considering the results of previous studies, the size distribution of scad fish found in South Buton is within a reasonable range and comparable to the results of studies in various other regions. However, further studies are needed related to the specific environmental factors that affect the growth of scad fish in these waters, such as temperature, food availability, and exploitation levels.

Length-Weight Relationship

The length-weight relationship of fish is one of the important parameters in fisheries biology studies because it can describe the growth pattern of fish in an ecosystem. Anto et al. (2017) explained that this relationship can be used to estimate the weight of fish based on its length or vice versa, which is important in understanding the ecological aspects and management of fish resources. In this study, the length-weight relationship of scad fish follows the equation: $y = 2.4983x - 4.0765$ with an R^2 value of 0.42912. This equation shows that there is a positive relationship between the length and body weight of the scad, where an increase in body length will be followed by an increase in weight. However, the relatively low R^2 value (0.42912) indicates that body length only explains about 42.91% of the variation in body weight, while the rest is influenced by other factors such as environmental conditions, food availability, and other biological factors (Pasisingi et al., 2021).

Ecologically, fish growth patterns can be classified as isometric or allometric. In this case, the regression coefficient value ($b = 2.02925$) is less than 3, which indicates that the scad has negative allometric growth. This means that the increase in body length is not followed by a proportional increase in weight, so that the fish tend to be slimmer as their length increases. This finding is in accordance with the research of Sapira et al. (2017) in the Sunda Strait Waters, which also found that scad has a negative allometric growth pattern in both male and female fish. Several studies have shown that fish growth patterns can vary in different locations. Siwat et al. (2016) reported that the scad in Semarang waters had a negative allometric growth pattern, while Espino-Barr et al. (2016) found a positive allometric growth pattern in the scad in Manzanillo Bay, Mexico. This variation can be influenced by environmental factors, habitat conditions, and food availability (Agista et al., 2019). Paul et al. (2015) also explained that the b value in the length-weight relationship can differ because it is influenced by environmental factors such as habitat, season, and biological factors such as sex, gonad maturity, and diet.

In addition, the condition factor of the fish can also provide an overview of the level of health and growth of the fish. Geral et al. (2022) found that the condition factor of the bentong scad in May 2021 was $K = 1.01$, which indicates that the fish are less flat. A low condition factor can indicate limited food resources or other environmental pressures that affect fish growth.

Gonad Maturity Level and First Gonad Maturity Size

Gonad maturity level (TKG) is an important parameter in the study of fish reproductive biology because it provides information on the stages of gonad development before spawning occurs (Mustofa & Setyobudiandi, 2019). Environmental factors, such as food availability,

water temperature, and spawning pressure, can affect variations in the size and age of fish when they first reach gonad maturity (Dahlan et al., 2015). In this study, the results of the analysis showed that most male scads were at TKG III to V, with peak maturity occurring at a size of 200–205 mm. At this size, 18 fish were in TKG IV and 8 fish in TKG V, indicating that male trevally tends to reach gonad maturity at this size range. Meanwhile, fish with a size larger than 212 mm experienced a significant decrease in the number of individuals, and no males were found at a size of 218–223 mm. This phenomenon can be associated with increased spawning activity or differences in the selectivity of fishermen's fishing gear. The distribution of gonad maturity levels in female fish showed a slightly different pattern compared to male fish. No females were found at a size of 176–181 mm, indicating that females tend to need a larger size to reach gonad maturity. Most female individuals were in TKG III and IV at a size of 182–193 mm, while peak maturity occurred at a size of 200–205 mm, with 15 individuals in TKG IV and 18 individuals in TKG V. This difference indicates that female fish have a different reproductive strategy than male fish, where they tend to experience greater body growth before reaching gonadal maturity.

Kadir et al. (2021) stated that if the fish caught were dominated by individuals in TKG III, this indicated that the fish population was still in the development stage and had not fully entered the peak spawning season. Jusmaldi et al. (2023) reported that the spawning season for yellow scad (*Selaroides leptolepis*) occurs in November to December, which most likely also applies to scad in the waters of South Buton. This finding is supported by research by Muharam et al. (2020), which found that the gonad maturity index (IKG) of trevally increased along with the increasing level of gonad maturity, indicating a scheduled spawning pattern in the population. Analysis of the distribution of TKG also showed that the percentage of female fish in TKG IV (35.2%) and TKG V (33.33%) was higher than male fish, which were dominated by TKG IV (47.9%) with fewer individuals in TKG V (21.13%). This difference reflects the different reproductive strategies between the two sexes, where female fish require more energy for egg production than male fish. The percentage of fish in TKG II and III is relatively lower compared to higher maturity stages. Female fish with TKG II are only 3.7%, while male fish are 4.2%. In TKG III, the number of females reached 27.8%, slightly higher than males which reached 26.8%, indicating that both sexes were almost balanced in this stage of gonad development. This may indicate that most of the fish caught were in the pre-spawning phase.

Geral et al. (2022) found that the growth of the scad follows a negative allometric pattern with a b value of 2.8057, indicating that the growth in length is faster than the growth in weight. In addition, the condition factor of the fish in the May 2021 sample showed a K value = 1.01, indicating a less flat body condition and can affect the reproductive strategy of fish in various habitats. Several studies have also reported variations in the size of the first gonad maturity in various pelagic fish species. According to Fitri et al. (2018), the size of the first gonad maturity in fish from the Carangidae family can vary between 180 mm and 220 mm depending on environmental conditions and exploitation pressure. Another study by Widodo et al. (1993) found that the size of the first gonad maturity of small pelagic fish in tropical waters ranged from 190 mm to 210 mm, which supports the results of this study. Based on the results of this study, the first mature gonad size (L_m) of bigeye scad (*Scomber crumenophthalmus*) in South Buton waters is 194.455 mm. This value is an important reference in sustainable fisheries management policies.

CONCLUSION

The following are the conclusions of the study on the morphometry and reproduction of bigeye scad (*Scomber crumenophthalmus*) landed at the TPI of South Buton Regency:

1. This study shows that bigeye scad (*Scomber crumenophthalmus*) in South Buton waters have a length range of 176–223 mm, with the majority of individuals being 200–205 mm in

size. The growth pattern of the fish is negative allometric, which means that the increase in body length is not followed by a proportional increase in weight.
2. The level of gonad maturity (TKG) shows that most fish are in TKG III–V, with the first gonad maturity size (L_m) of 194.455 mm. Based on the research time (July–September 2023), as well as the number of individuals in TKG IV and V, it is suspected that the spawning season for bigeye scad occurs in October to early the following year.
3. In fisheries management, it is recommended to set a minimum catch size above 194.455 mm and regulate the fishing season so as not to interfere with the spawning period, in order to maintain the sustainability of bigeye scad stocks in the waters of South Buton.

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