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Gonad Maturity and Fecundity of Mackerel Tuna (*Euthynnus affinis* (Cantor, 1849)) in North Gorontalo Waters, Indonesia

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ABSTRACT

Mackerel Tuna (*Euthynnus affinis* (Cantor, 1849)) is one of the fish that is widely used and found in North Gorontalo Waters. Utilization of pelagic fish in Sulawesi sea waters has increased from year to year so the sustainability of fish can be threatened. Estimation of size at first maturity is one way to determine population development in water. This study aims to determine the relationship between gonad maturity stages and the fecundity of Mackerel Tuna in North Gorontalo Waters. This research was carried out in October-November 2021 at the Kwandang Archipelago Fishing Port. Gonad maturity stages were observed morphologically and the determination of fecundity was observed using volumetric and gravimetric methods. Based on the results of the research that has been done, it can be concluded that the maturity stage of Mackerel Tuna in North Gorontalo waters is dominated by stage I. The fecundity value ranges from 600-47,400 eggs. The relationship between the gonad maturity stages and the fecundity obtained is directly proportional, if the gonadal maturity value is high, the fecundity value will also be higher. The spawning season for Mackerel Tuna in North Gorontalo waters does not take place in October-December, this is characterized by low fecundity. Based on the monthly GSI value, the peak spawning of Mackerel Tuna (*Euthynnus affinis*) is thought to occur shortly after the highest GSI value.

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***Keywords*:** Gonadal Somatic Index (GSI), Kwandang Archipelago Fishing Port, maturation, spawning time, *Euthynnus affinis*

1. INTRODUCTION

North Gorontalo waters are one of the main bases for small pelagic fisheries in the Sulawesi seas [1]. Kwandang Archipelago Fishing Port is the main base for small pelagic fisheries and large pelagic fisheries [2]. One type of pelagic fish that is widely used in these waters is Mackerel Tuna (*Euthynnus affinis* (Cantor, 1849)) [3]. The use of pelagic fish in Sulawesi sea waters which has increased from year to year can threaten the sustainability of small pelagic fish in these waters [4, 5].

Mackerel Tuna (*Euthynnus affinis*) is a large pelagic fish that is a fast swimmer and lives in schools [6-8]. This fish has a distribution area on the coast and oceanic and is one of the marine biological resources that has high economic potential so it becomes a catch target for fishermen [9]. Mackerel Tuna (*Euthynnus affinis*) has a tendency to form multispecies groups based on size consisting of 100 to more than 5,000 individuals [10, 11].

Excessive fishing without regard to fish conditions, such as the gonad maturity stage, can cause a decrease in the quality and quantity of fish resources [12]. This will affect the catch and can cause the distribution of fish to decrease if fishermen do not pay attention to the sustainability of fish resources [13]. Reduced long-term fish populations can be caused by-catches of fish that are about to spawn or have never spawned [14]. Therefore, it is important to know the development of fish populations through the Gonadal Somatic Index (GSI) and understand fecundity to determine the number of fish to be produced and the number of fish in a certain age class [15, 16]. Reproductive aspects of Mackerel Tuna (*Euthynnus affinis*) in North Gorontalo Waters need to be studied to determine the relationship between the Gonad maturity stages, Fecundity, and the Gonadal Somatic Index (GSI) to ensure the sustainability of fish resources.

2. MATERIALS AND METHODS

This research was carried out in October-November 2021. The sampling location was carried out at the Kwandang Archipelago Fishery Port and the observation process was continued at the Fisheries and Maritime Laboratory of the University of Gorontalo.

The tools used in this study include; cool box, electric scales, stationery, a camera, sample paper, a petri dish, dissecting set, a microscope, a pipette, and a beaker glass [17]. The ingredients used include Mackerel Tuna (*Euthynnus affinis*) which can be seen in Figure 1, 100 ml of water, and ice cubes.

2. 1. Sex Determination and Observation of Fish Gonads

A sampling of Mackerel Tuna (*Euthynnus affinis*) at the Gorontalo Archipelago Fishing Port is carried out 3 times a month. The caught fish are grouped and counted based on the sampling station. Then the length is measured and weighed, then dissected to determine the sex by looking at the characteristics and differences found in the gonads [18]. Observation of gonad

maturity stages morphologically (Table 1) includes color, surface structure, eggs, length, and weight of gonads, followed by observations of fecundity. The parameters observed in both male and female specimens were gonad length, width, weight, and gonad colour [19]. Each specimen was also weighed and measured. Five gonad maturity stages were identified and described: Stage I (Immature or transition), Stage II (Early maturation), Stage III (maturation), stage IV (mature) and Stage V (post spawning or spent) [19-21].

Figure 1. Mackerel tuna (*Euthynnus affinis* (Cantor, 1849)) samples.

Table 1. Morphological determination of gonad maturity stages

Stages	Female	Male
I (Immature)	Gonads are clear	Gonads are clear
II (Early maturation)	Gonads are yellowish white	The gonads are milky white
III (Maturation)	The gonads fill almost half of the peritoneum, the eggs are fine granules, greenish-yellow in color	The gonads fill almost half of the peritoneum and are milky white
IV (Mature)	The gonads fill most of the peritoneum and are brownish-green in color	Gonads fill most of the peritoneum and are milky white
V (post spawning or spent)	Gonads shrink	The gonads are empty

2. 2. Fecundity

The determination of the value of Fecundity is carried out using the Effendi formula [20], which is as follows:

$$F = \frac{G \times V \times X}{Q}$$

Information:

F : Fecundity
G : Total Gonad Weight (g)
V : Dilution Volume (100 ml)
X : Number of eggs in 1 cc
Q : Egg weight (g)

2. 3. Gonadal Somatic Index (GSI)

Gonadal Somatic Index (GSI) is calculated from the percentage ratio of gonad weight and fish weight [22]. The GSI value is getting bigger until the maximum range is reached, then there will be a decrease (spawning) so that the spawning season can be predicted [23]. The GSI value is analyzed based on the following formula [20]:

$$GSI = \frac{GoW}{GW} \times 100$$

Information :
Gow : gonad weight in grams (g)
GW = gutted weight in grams (g)

3. RESULT

3. 1. Gonad Maturity Stages

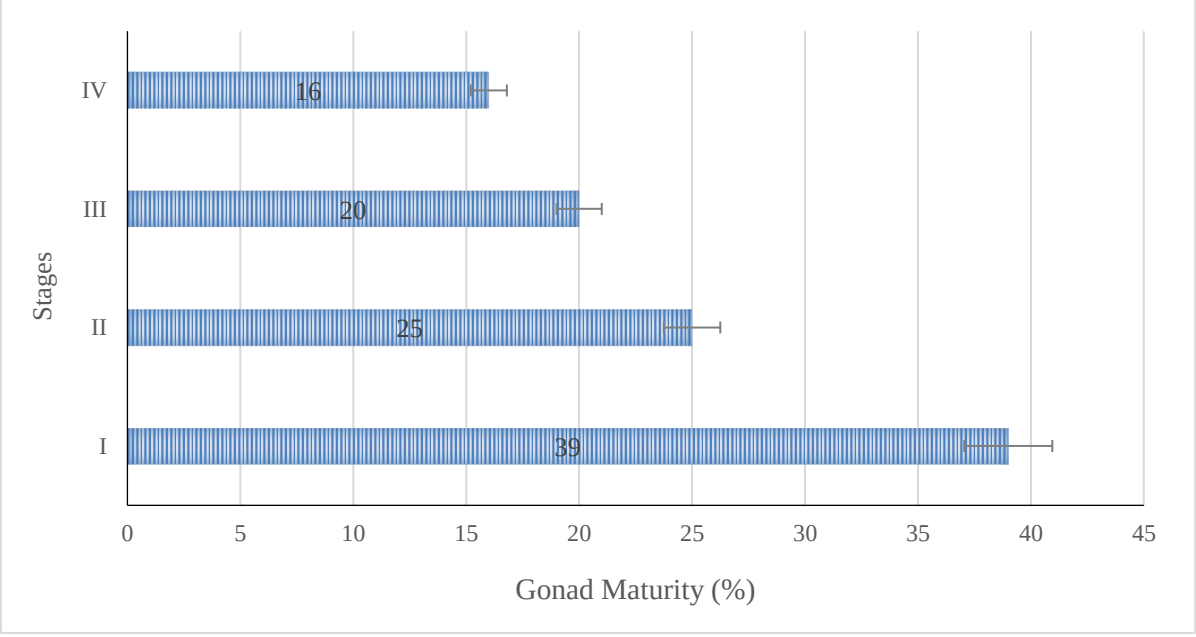

Figure 2. Gonad maturity stages mackerel tuna caught in October-December in North Gorontalo Waters

Gonad maturity stages are one of the basic knowledge of reproductive biology in fish stocks [24]. Morphological determination of the gonad maturity stage can be seen from the shape, length, weight, and color as well as the development of the contents of the gonads, while histology can be seen from the anatomy of the development of the gonads [19, 25]. According to Effendi [20] and Anjani et al. [26], gonadal weight gain generally ranges from 10-25% of the weight of female fish and 5-10% in male fish. Based on the results of the study it is known that the gonad maturity stages of Mackerel Tuna caught in October-December in North Gorontalo waters, namely Stage I are 40 individuals (39%), Stage II are 25 individuals (25%), Stage III are 20 individuals (20%), and Stage IV namely 16 individuals (16%).

Based on Figure 2, it can be said that Mackerel Tuna are not ready to spawn because the stage III and IV values for fish caught in October-December have low values. According to Effendi [20] in Auliyah & Olii [21] gonad development is part of the fish reproductive process before spawning occurs. Within one species or in different species, gonad maturity can also vary [27]. This is due to the availability of feed in certain waters, different adaptation patterns, and life strategies of fish, apart from that the growth rate of each fish also causes the fish to reach different gonad maturity stages [28, 29].

3. 2. Gonadal Somatic Index (GSI)

Gonadal Somatic Index (GSI) is a percentage value obtained by comparing gonad weight with fish body weight [30]. The GSI value indicates the percentage of total fish weight used for egg production during the reproductive process [31]. The results of observations and calculations on the Gonadal Somatic Index of Mackerel Tuna (*Euthynnus affinis*) in North Gorontalo Waters (Figure 3) in October had a GSI value of 5.36%, in November it was 1.26%, and in December it was 0.05%. Mackerel Tuna (*Euthynnus affinis*) in October has a high value of 5.36% compared to GSI in November-December.

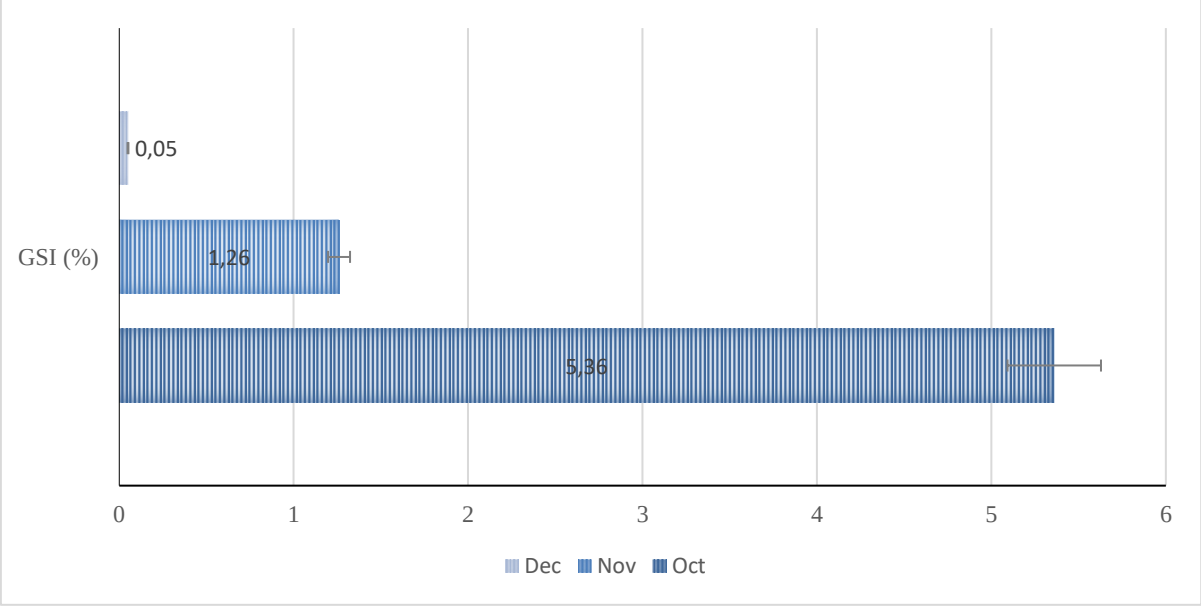

Figure 3. GSI of mackerel tuna caught in October-December in North Gorontalo Waters

The GSI value of Mackerel Tuna (Euthynnus affinis) in October has a lower value compared to November and December. This is because the fish caught from November to December are dominated by small fish. This is to the research conducted by Arifah et al. [32] who examined the biological aspects of Mackerel Tuna in TPI Tawang and obtained Gonadal Somatic Index (GSI) values ranging from 0.118% -2.004%. In another study conducted by Ardelia et al. [33] in the Sunda Strait waters, the GSI value of Mackerel Tuna ranged from 0.07% -0.68%.

Differences in gonadal maturity in each species or one species are influenced by various factors, such as differences in population genetic characteristics, differences in growth rate, water quality, area differences and fishing pressure [34]. Based on the GSI value every month in North Gorontalo Waters, the peak spawning of Mackerel Tuna (*Euthynnus affinis*) occurs shortly after the highest GSI value. This value indicates that fishing occurs during the spawning season [35]. Based on Pratama et al. [36] stated that the Gonadal Somatic Index value will be in line with the development of the gonads of fish. When the spawning season arrives, the GSI value will continue to increase up to the maximum range limit. The GSI values obtained in this study ranged from less than 20%. This value indicates that Mackerel Tuna is a fish that can spawn more than once a year [37].

3. 3. Fecundity

Fecundity is all the eggs that will be released when the fish will spawn, by knowing the fecundity it can be estimated the number of fish that will be produced and the number of fish of a certain age class can also be determined [38]. Based on the results of a study conducted in November in North Gorontalo waters, the fecundity value of Mackerel Tuna was high, ranging from 600-47400 eggs. In November, the fecundity value of Mackerel Tuna ranged from 600 eggs in stage III with a gonad weight of 0.5 g, while in stage IV Mackerel Tuna had a fecundity of 47400 grains with a gonad weight of 19.84 g. Based on Ardelia et al. [33] in the Sunda Strait waters, the fecundity value of Mackerel Tuna was in the range of 17,814 – 560,792. According to Suzuki et al. [39], the amount of fecundity in fish is influenced by factors such as feed availability, fish length and weight, egg diameter, and environmental factors. The value of Fecundity is often related to length rather than weight because length does not decrease as easily as weight does. Based on this, sampling needs to be done carefully and repeatedly because if fish are taken when the gonads are growing, the taking is not included in somatic growth. Therefore, there must be a difference between somatic growth and gonadal growth. Older and larger fish usually have relatively low fecundity.

3. 4. Sex Ratio

Sex ratio is the ratio of male and female fish in a population [40]. Based on the results of the study (Table 2) the sex ratio of Mackerel Tuna from October to December 2021 shows that the ratio between male and female fish is 1: 0.29. Based on the sex ratio, it can be seen that male fish are more dominant than female fish. Comparison of the number of male and female fish plays an important role in the balance of fish populations. If the male-fish sex ratio is greater than the female sex ratio, then the fish population can be threatened. Several factors influence this sex ratio including fish activity in waters, adaptability, genetic factors, food, fishing factors, migration, changes in new fish species in existing populations, and growth patterns [40]. Gender balance also influences the production, recruitment, and conservation of fish resources [41].

Table 2. Mackerel Tuna sex ratio.

Type of fish	Total (individuals)	Male (individuals)	Female (individuals)	Sex ratio (M : F)
Mackerel Tuna	101	78	23	1: 0,29

Extreme environmental conditions cause fish to carry out reproductive strategies by increasing egg diameter and decreasing fecundity. This can trigger excess food due to overfishing. Decreasing fish populations due to mortality can increase the availability of food for the remaining populations, thereby increasing the fertility of the population. However, when the fish population is complete or the number is high, the fertility is low. Therefore, it is important to monitor sex ratios and understand the factors that influence them to ensure the sustainability of fish populations.

3. 5. Relationship of Gonad Maturity Level and Fecundity

Based on the results of the study, the fecundity value and gonad maturity stages of Mackerel Tuna (*Euthynnus affinis*) are directly proportional, where the higher the gonad maturity stages, the greater the fecundity value obtained. Gonad maturity stages and Fecundity of Mackerel Tuna (*Euthynnus affinis*) from October to December can be seen in Table 3.

Table 3. Correlation between Gonad Maturity Level and Fecundity of Mackerel Tuna (*Euthynnus affinis)*

Gonad Maturity Stages	Fecundity		
	Oct	Nov	Dec
I	0	0	0
II	0	0	0
III	0	45,618	0
IV	0	106,533	0

Based on the table, it can be seen that the fecundity value of Mackerel Tuna depends on the gonad maturity stages. In October-December in stages I and II, Mackerel Tuna does not have a fecundity value. Whereas in stage III it was only identified in November with a fecundity of around 45,618. In stage 4, the fecundity value was only identified in November with a fecundity value of around 106,533.

The relationship between fecundity values and gonad maturity stages in Mackerel Tuna (*Euthynnus affinis*) is directly proportional, where the higher the gonad maturity stages, the

higher the fecundity value obtained [28]. In addition to gonadal maturity, the value of fecundity is also influenced by the length and body weight of the fish. Gonad maturity stages that are the same but have different weights and lengths will produce different fecundity values.

However, the fecundity value of each fish also varies because it is influenced by several factors such as the type of species, age, individual size, food, body physiology, fish characteristics, population density, and the environment in which the individual fish reside [42]. Each fish species has different fecundity due to differences in size and variations in fish fecundity caused by differences in time and location of observation resulting in different amounts of fecundity [43-46].

4. CONCLUSIONS

Based on the results of the research that has been done, it can be concluded that the gonad maturity level of Mackerel Tuna in North Gorontalo waters is dominated at stage I. The spawning season for Mackerel Tuna in North Gorontalo waters does not take place in October-December, this is characterized by low fecundity. The relationship between the gonad maturity stages and fecundity shows a directly proportional value, if the gonadal maturity value is high, the fecundity value will also be higher.

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