

Reproductive Biodynamics of Short Mackerel (*Rastrelliger brachyoma* Bleeker, 1851) in the Northern Waters Makassar Strait, Indonesia

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ABSTRACT Short mackerel are caught with high intensity by the fisherman and using various fishing gear. It is feared that this activity could change the reproduction habits of short mackerel in their habitat. This study aims to analyze the bio-dynamics reproduction of short mackerel, including sex ratio, maturity stage, length at first maturity, length at first spawning, and fecundity. The survey method obtained the sample collection from the fish landing sites. Samples were collected in 1320 samples consisting of 651 females (13.0-16.5 cm) and 669 males (13.3-17.4 cm). The results showed that the sex ratio was balanced (1.00:1.02), the stage of gonad maturity showed from immature gonad to spawning (I to V), and the highest gonad maturity index for males and females were found in July (1.609 and 1.794). The length at first maturity of males and females had occurred when they were 16.51 cm and 16.63 cm, and the length at first spawning for males and females was 17.12 cm and 17.03 cm in size. The fecundity of female mackerel ranges from 30.106 to 58.439 in the northern waters of Makassar Strait. Capturing fish is suggested with a length above the spawned fish (>17 cm), considering that the fish only spawn at least once from their life cycle. The fecundity of short mackerel is relatively high as an indicator of high reproductive potential.

Keywords: Biodynamic reproduction; Makassar Strait; *Rastrelliger brachyoma*; short mackerel

INTRODUCTION

Short mackerel (*Rastrelliger brachysoma* Bleeker, 1851) is a small pelagic fish that spreads from the coast to the open seas. It is often caught using various types of fishing gear. Fishing in this way causes mackerel to always be available in the market. This availability unwittingly causes pressure on nature as a result of intensive fishing. It is feared that the intensity of fishing will interfere with fish recruitment so that they do not have the opportunity to do spawning and impact decreasing population stocks.

The catch of short mackerel is generally using surface gill nets and purse seines. Both of these fishing gears are included in the less selective size. Capturing fish activities using unselective gear is not environmentally friendly and directly impacts the reproductive biodynamics of fish in waters (Reynolds *et al.*, 2001; de Graaf *et al.*, 2003). Reproductive biodynamics plays an essential role in the management of aquatic resources. It can be used as basic information in predicting the time and place of spawning and its reproductive potential, so it requires circumspection to manage it. Research on mackerel, both short and Indian, has been carried out by experts in several locations but with a specific parameter. For example, breeding season indicator (Oktaviyani & Kurniawan, 2018), species identification (Collette & Nauen, 1983), the gonad maturity stage (Suyama *et al.*, 2000), bycatch management (Noranarttragoon, 2005), reproductive biology (Sritakon *et al.*, 2011), ovary histology (Senarat *et al.*, 2017); reproduction (Kasmi *et al.*, 2017; Kantun *et al.*, 2018), population dynamics and spawning potential (Zamroni *et al.*, 2017); and reproductive biology (Sudarno *et al.*, 2020). Many of the studies mentioned above are

specific to Indian Mackerel only, but for Short Mackerel, especially in Makassar Strait is still lacks of information. Each location has different environmental characteristics and types of fishing gear, so it has implications for the reproductive conditions of short mackerel. Therefore, this research is vital to analyze the biodynamic reproductive of short mackerels in the northern waters of Makassar Strait.

MATERIALS AND METHODS

Materials

The research was conducted from March to October 2018 in the northern waters of Makassar Strait (Local Name: Maros). Measurement, sampling, and observation of samples were carried out every month for eight months. The mackerel fish samples were taken at the fish landing sites. In addition, samples were collected from fishers who knew the location of their fishing grounds. Samples were collected in a cool box for further analysis in the laboratory.

Methods

The samples were dissected to observe the male and female sex. Observation of the stage of gonad maturity is determined morphologically by referring to the criteria expressed by (Ganga, 2010) by looking at the shape, colour, and development of gonad contents. Furthermore, the gonads were removed from the fish body and weighed with a digital scale with an accuracy of 0.01 g. The gonad maturity index compares gonad weight to fish body weight (Suyama *et al.*, 2000). The size of the first sexual maturation and the first to spawn were calculated based on the Spearman Kerber method (Udupe, 1986).

Gonad maturity stage used as a cumulative percentage in determining the size of the first mature gonads were included in stage III (three) and IV (four) categories, spawning fish used for fish in stage V (five), and total fecundity; 80 samples were calculated during the study.

RESULTS AND DISCUSSION

Sex ratio

The sex ratio in this study was 1.00: 1.02 (651: 669). It is higher than previous studies in other areas. The sex ratio is the same as the sex ratio of male *R. kanagurta* to female Java Sea waters with a balance of 1.00: 0.65 (Putera & Setyobudiandi, 2019) but lower compared to research in north Java with a balance of 1: 1.09 (Zamroni *et al.*, 2017) but all show the ratio of female fish was more dominant than that of males. According to Suwarso & Hariati (2017) research, males dominate Jakarta Bay, but females dominate Belanakan, Indramayu, and Tegal. Different sex ratios at each research location and time can be caused by differences in research, environmental conditions, and catch effort in fish populations. The balance of the sex ratio shows that the opportunity to recover from the resources is still there because getting a partner while doing spawning is still high.

Gonad maturity stage

The gonad maturity stage is a particular stage of gonad development before and after spawning fish. Figures 1 and 2 below show that the immature Gonad maturity of short mackerel is 43.01%, and for males, 52.02%, while those in mature conditions are 48.39% for females and 39.31% for females male. It means that immature gonad fish dominate the fish that have been observed and analyzed.

The male and female gonads stage was found from I (first) to V (fifth). It indicated that the fish live in match conditions with their requirements, especially in the sandy ecosystem. This condition is the same as that found in the waters of Staring Bay, with good mangrove, seagrass, and coral reef ecosystems (Sudarno *et al.*, 2020). In other studies, different conditions were found, such as those found in Kendari Bay's waters, where part of the time is spent in these waters because the mangrove ecosystem has not been able to provide comfort in carrying out its reproduction sustainability (Asriyani *et al.*, 2009). However, some small pelagic fish will generally migrate as a strategy to fulfil their life cycle. In certain conditions, the waters are only used as a rearing, protection, or spawning area.

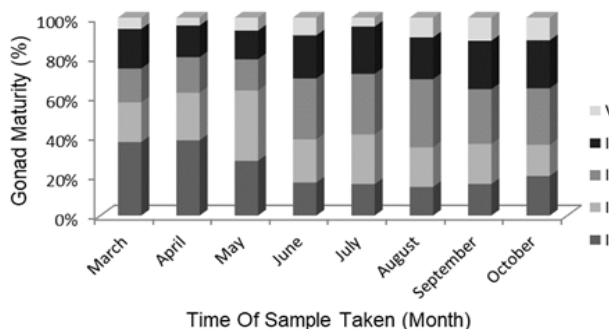


Figure 1. Gonad maturity stage of female short mackerel from the Northern Makassar Strait.

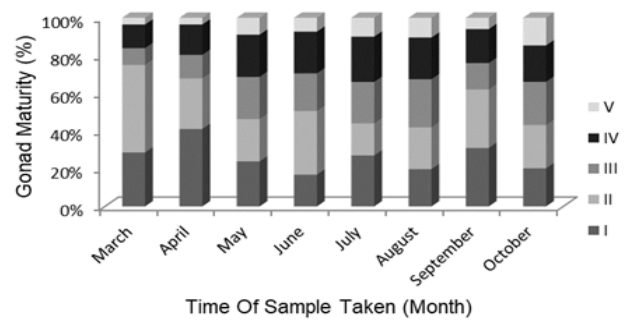


Figure 2. Gonad maturity stage of male short mackerel from the Northern Makassar Strait.

The gonad maturity stage will shift as the gonad maturity increases. This shift provides information on an ongoing spawning peak, even though spawning occurs throughout the year (Prihartini *et al.*, 2007; Oktaviani *et al.*, 2015). The various stages of gonad development of female mackerel are influenced by the growth rate of individual fish and the conditions of the aquatic environment (Suyama *et al.*, 2000; Sritakon *et al.*, 2011). Gonad development in fish occurs in two stages: the gonadal growth stage, when the fish mature until sexual maturity. The gonad maturation stage starts when the fish experiences sexual maturity and continues to develop as long as the reproductive process runs (Lagler *et al.*, 1977; Simanjuntak, 2007). Most of the energy from fish metabolism will be focused on gonad development or gonadal growth (Effendie, 2002).

Gonad maturity index

In July, the gonad maturity index of short mackerel (for males and females) peaks. The female and male have a maturity index pattern that is always in sync. When the female mackerel experiences gonad maturity, the male mackerel also follows. This synchronization is one of the reproductive strategies for small pelagic fish that experience fishing pressure to maintain their sustainability. The Gonad Maturity Index, as quantitative gonadal development information, can be an indicator in determining the occurrence of fish spawning season. Variations in short mackerel maturity index values during the study period are shown in Figure 3.

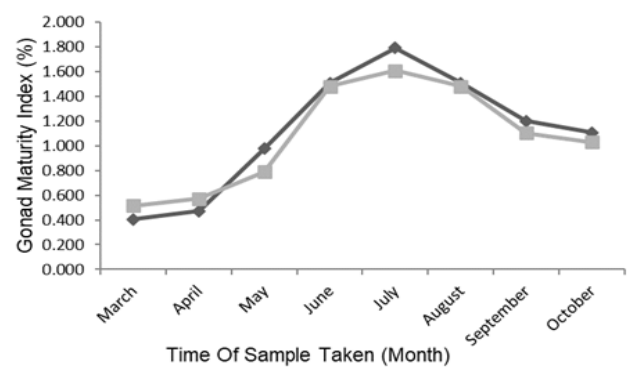


Figure 3. Gonad Maturity Index of Short Mackerel from the Northern Makassar Strait

Figure 3 shows that the short mackerel in this study area experience gonad maturity and spawning are not simultaneously. The highest value for both male and female fish occurred in July, which indicates that the peak

from female short mackerel gonad maturity happened at that time and after they were spawning. However, there were spawning fish with a low percentage of spawning every month. In Staring Bay found that spawning is likely to occur in March and May (Sudarno *et al.*, 2020), while the mackerel spawning season in Indramayu and Jakarta Bay occurs during the western season (Suwarso & Hariati, 2017) and on the northern coast of Java it occurs during the east season (Zamroni *et al.*, 2017). The difference in the mackerel spawning season at several research locations is related to the Gonad Maturity Index value variation.

The highest stage of gonad maturity is generally always followed by an increase in the Gonad Maturity Index value. The maturity index increases in size and reaches a maximum when the fish are toward spawning and decreases after the fish have spawned. The development in the Gonad Maturity Index is associated with an increase in ovarian weight due to the vitellogenesis process in gonad development. In testes, the weight increases due to the spermatogenesis process and the volume of cement in the seminiferous tubules (Asriyani *et al.*, 2009; Asriyani & Sara, 2013). The same thing was reported in mackerel fish in South Sulawesi waters (Suyama *et al.*, 2000). The same thing also happened to several different fish species such as Indian mackerel and *R. kanagurta* in Java Sea waters (Nurhakim, 1993), Takalar coast (Kasmi *et al.*, 2017), on the coast of Makassar (Kantun *et al.*, 2018), and in West Aceh (Arrafi *et al.*, 2016). The variation in the value of maturity index between male and female fish can be caused by groups of mature gonad fish that are not in the fishing area, and they have been predicted to migrate to the spawning and fishing areas which are also areas for foraging and growing for mackerels (Suwarso & Sadhotomo, 1995).

Size at first maturity

The size of the first maturity for female short mackerel at 166.3 mm, and for the male at 165.1 mm fork length. The relatively same size of the first maturity of female and male fish indicates that the reproductive process is going well. The size of the first maturity can indicate the availability of reproductive stock and the time the fish are ready to be caught using selective fishing gear (Najamuddin *et al.*, 2004).

Research results in other areas showed that male *R. kanagurta* size at first maturity ranged from 171.13-174.27 mm and 172.1-174.7 mm for females (Sivadas *et al.*, 2006), from the Java Sea at a long-range 180-205 mm (Sudjastani, 1974), in Sunda Strait with range, 193.8 mm for male and 205 mm for female sizes 160-170 mm (Putera & Setyobudiandi, 2019) and *R. kanagurta* in India 162-196 mm (Ganga, 2010).

Different sex allows for differences in the size of the first maturity of the gonads because of the growth rate due to food intake. When they first matured, the fish length when they reached their size at first maturity was relatively varied even though they came from the same species. It is related to several factors such as geographic distribution (Udupe, 1986; Effendie, 2002); environmental change (Karna *et al.*, 2011; Beyrer *et al.*, 2012); population genetic traits, size, and age of fish that cause differences

in growth rates (Lowe-McConnell, 1990); fish and food habitat (Asriyani *et al.*, 2009; Sara, 2013) and differences in area and fishing pressure (de Graaf *et al.*, 2003; Reynolds *et al.*, 2001; Kasmi *et al.*, 2017; Kantun *et al.*, 2018).

Individuals from one length class do not always reach the same length when ripe for the same gonad because the size varies significantly between and within the types of fish themselves (Udupe, 1986). The first size at first maturity of short mackerel that caught on the northern waters of Makassar Strait was smaller than that of other researchers. It is assumed that because of the intensive fishing in the northern waters of Makassar Strait. The fishing method is related to catching and the fishing gear used. Fish will respond to the above consequences by maturing the gonads early to maintain their existence and continue their generation.

The first length of spawning

The first length spawning of short mackerel in northern waters of Makassar Strait for the female sex was obtained at 170.3 mm and for a male at 171.2 mm. The first length of spawning size is relatively the same as when it reaches the size at first maturity. This similarity is related to the fishing gear used to catch the same size, with low selectivity. The short mackerel that was found spawning was relatively low, ranging from 8.60-8.67%. This information confirms that short mackerel fish were constantly spawning during the study but with a low percentage. It indicates that mackerel, when spawning, will migrate to another place looking for a safe and comfortable place, while the fishing area is used to look for food.

Fecundity

Total fecundity ranges from 30.106 to 58.439. The total amount of fecundity was highly correlated with the size of the first maturity of the gonads. The mackerel caught in the northern waters of Makassar Strait has a smaller gonad size but can produce higher fecundity. It proves that there has been catchment pressure. Fish under catchment pressure will produce more eggs with a smaller diameter. Short mackerel can produce about 2314-96924 eggs (Putera & Setyobudiandi, 2019). A fully mature female *R. kanagurta* with a gonad weight of 24.3 g has 5.930. Meanwhile, another research obtained the relative fecundity of *R. kanagurta* in the range of 476±163 eggs per g of body weight (Suwarso & Hariati, 2017).

CONCLUSIONS AND RECOMMENDATION

Conclusions

The sex ratio of short mackerel is balanced, making it easier to carry out fertilization in the reproductive process. The development of gonad maturity level was obtained from I (First) to V (Fifth) level but dominated by the immature stage of the gonads. The size of the first maturity of the gonad is an indicator of the availability of reproductive stock, the time the fish are ready to be caught, and the size of the mackerel spawning or fit to catch. In the northern waters of Makassar Strait, capturing fish is suggested with a length above the spawned fish (>170 mm), considering that the fish has released the egg at least once in its life cycle. The fecundity of short

mackerel is relatively high, and this is also an indicator of high reproductive potential for the short mackerel fish in the study area to recover from capturing intense.

Recommendation

Capturing fish is suggested with a length above the spawned fish (>17 cm), considering that the fish have spawned their egg at least once in their life cycle. The fecundity of short mackerel is relatively high as an indicator of high reproductive potential.

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AUTHORS' CONTRIBUTIONS

All authors are well contributing to this manuscript. WK is responsible for all aspects, starting with an idea, collected and measured in the field and data analysis. H is responsible for funding the stationary and manuscript production, and AEM is responsible for translating the manuscript.

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