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Reproduksi Ikan Kembung Lelaki *Rastreliger kanagurta* (Cuvier, 1816) di Perairan Morodemak Kabupaten Demak

Reproduction of Indian Mackerel *Rastreliger kanagurta* (Cuvier, 1816) in Morodemak Coast Demak Regency

Dwi Rachmanto[1], Djumanto Djumanto[*2] & Eko Setyobudi[2]
[1]Department of Maritime and Fisheries Service, Central Java, Indonesia
[2]Department of Fisheries, Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta, Indonesia
[*]Corresponding author, email: lely4192@yahoo.com

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Abstrak Ikan kembung lelaki merupakan salah satu jenis ikan pelagis kecil yang memiliki nilai ekonomis dan ekologis. Hasil tangkapan ikan kembung lelaki di Pelabuhan Perikanan Pantai Morodemak Jawa Tengah mengalami penurunan dari tahun 2016-2018 sehingga diduga telah mengalami eksploitasi berlebih. Penelitian ini bertujuan untuk mengamati reproduksi ikan kembung lelaki. Contoh ikan dikumpulkan dari hasil tangkapan nelayan mini purse seine pada bulan April-Juni 2019. Sampel ikan diukur panjang dan bobot individu, dibedah bagian perut untuk diambil gonadnya, dan jumlah telur dihitung dalam sub sampel gonad. Analisis data dilakukan untuk mengetahui hubungan panjang-berat, nisbah kelamin, tingkat kematangan gonad (TKG), indeks kematangan gonad (IKG), ukuran pertama kali matang gonad, dan jumlah telur tiap gonad pada TKG III dan IV. Hasil penelitian menujukkan hubungan panjang berat bersifat alometrik negatif, pada ikan betina dengan persamaan $W = 0{,}038\ L^{2{,}59}$ dan pada ikan jantan dengan persamaan $W = 0{,}178\ L^{2{,}03}$. Nilai faktor kondisi ikan baik jantan dan betina didapatkan nilai berkisar antara 1-2. Ikan pada TKG III berkisar 27,2-82,5 %, sedangkan TKG IV berkisar 3,6-33,8%. IKG ikan berkisar 0,17-4,75. Jumlah telur ikan kembung lelaki berkisar antara 11,235-40,878 butir. Ikan kembung lelaki pertama kali matang gonad pada ukuran panjang 15,2 cm.

Kata kunci: Fekunditas; gonad; kembung lelaki; Laut Jawa

Abstract Indian mackerel is a group of small pelagic fish that has high economic value and is ecologically important. The catch of Indian mackerel in the Morodemak Coastal Fishing Port of Central Java has decreased within 2016-2018, which is suspected by overexploitation. This study aims to observe the reproduction of Indian mackerel. Fish samples were collected from the catches of the mini purse seine operated by fishermen in April-June 2019. The fish samples were measured their length and weight individually, then the abdomen dissected to collect gonad, and counted in sub-sample of the egg number. Data were analyzed to determine the length-weight relationship of fish, sex ratio, gonad maturity level (GML), gonad maturity index (GMI), the size of the first gonad matured, and the egg number in each gonad brood fish. The results showed a negative allometric length relationship, and the length-weight relation equation in female fish was $W = 0.038\ L^{2.59}$ and in male was $W = 0.178\ L^{2.03}$. The value of fish condition factors in males, and females obtained values ranging from 1-2. The proportion of fish in GML III ranges from 27.2 to 82.5%, while GML IV ranges from 3.6 to 33.8%. Fish GMI ranged from 0.17 to 4.75%. The eggs number ranged from 11.235 to 40.878 grain. The female Indian mackerel get the first gonad matured at the size of 15.2 cm.

Key Words: Fecundity; gonad; indian mackerel; Java Sea

INTRODUCTION

The potential of small pelagic fish resources in the Java Sea reaches 450.400 tons/year from small coastal pelagic fish and small oceanic pelagic fish. Small oceanic pelagic fish consist of *Dusumieria russelli*, *D. macrosoma*, *Selar crumenophthalmus*, *Rastrelliger kanagurta*, *Amblygaster sirm*, *Megalaspis cordyla*. Small pelagic fish are dominated by *Exocoetidae* sp. (50%), then *Scomber* sp. (15%) and *Sardinella* sp. (11%), while the rest are other types of fish (Suman *et al*., 2014). Indian mackerel (*Rastreliger kanagurta*) is one of the small pelagic fish that many fishers catch in Morodemak coast. According to Atmaja *et al*. (2000), Indian mackerel was mostly caught with purse seine in the waters of western Indonesia, the Malacca Strait, the Java Sea, and the Bali Strait.

Many researchers have researched the reproduction of Indian mackerel for a few years ago. The first gonad matures for mackerel male and female in the Malacca Strait waters occurred after the fish reached a total length of 17 cm (Hariati *et al*., 2005). In Calicut waters of India after the fish reached a total length of 17.3 cm (Sivadas *et al*., 2006), and in the coastal waters of the Mahout Arabian Sea after male fish reached a total length of 25.2 cm, and females at a size of 25.7 cm (Zaki *et al*., 2016). The Indian mackerel fecundity varies according to its habitat. The northern waters of Aceh range from 300.000 to 520.000

grains (Hariati & Fauzi, 2011), on the Mahout coast of the Arabian Sea, which ranges from 64,024-151,844 items (Zaki *et al*., 2016). Gonadal maturity index (GMI) of Indian mackerel in Rembang and Pekalongan ranges from 0.49 to 6.98% (Zamroni *et al*., 2008).

Information on the reproductive biology of Indian mackerel landed at PPP Morodemak is scarce or has never been done by the previous researchers. Therefore, studies on the biological aspects of Indian mackerel are critical to managing, so the level of Indian mackerel exploitation is sustainable.

MATERIAL AND METHODS

Indian mackerel was collected from the fishermen catch who operated *purse seine* in Morodemak waters and landed at the Morodemak Coastal Fisheries Port (PPP). The purse seine ship, which has a landing base at PPP Morodemak was operated one day trip so that the fishing ground is in the waters of the Demak district (Figure 1).

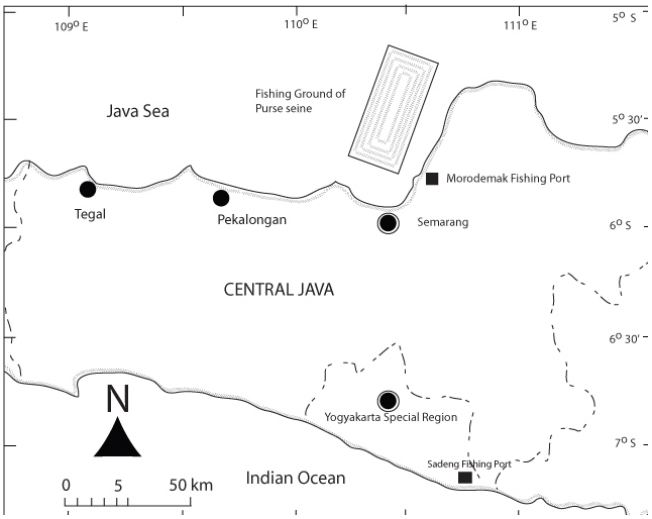

Figure 1. Map showing the location of fishing ground of purse seine in the Morodemak waters of Demak Regency.

Fish samples were collected from April to June 2019, twice a month in the first and third weeks. Fish sampling was done randomly on ships that were landing the catches at the Morodemak fishing port. The number of fish samples collected per sample was at least 50 individuals.

The fish sample was transferred to the laboratory for measurement and data recording. The sample was measured in total length, body weight, and then dissected its stomach to collect the gonad. Total length was measured using a scale board with a precision of 0.5 cm, while the individual weight was measured using a digital scale with 0.01 g accuracy. The gonad weight was measured using a digital scale with an accuracy of 0.01 g. The development of the fish gonad maturity level (GML) was determined based on the morphological character of the gonads. The eggs number was counted from the gonads of fish in GML III and IV by the gravimetric method (Effendi, 2002). The criteria for the development of gonadal maturity (GML) are presented in Table 1.

Data collected, namely were total length (cm), individual weight (g), GML for individual fish, and the number of eggs. The data obtained were then analyzed descriptively and statistically. Descriptive analysis by presenting pictures and graphs was the distribution of the length and weight of the fish caught, the length-weight relationship, fish condition factors, distribution of gonad maturity index (GMI), the relationship of length or weight to GMI, the number of eggs per gonad at GML III and IV. Statistical analysis was performed on the sex ratio and length-weight relationship. Genital ratios were measured by comparing the number of females and males caught each month during sampling.

Table 1. Morphological characteristics of female and male fish gonad maturity (Effendie, 2002).

Gonad Maturity Level	Female	Male
Immature(GML I)	Ovaries were small, and their length could reach less than half of the body cavity length. The ovary was bright red. Egg grains have not been seen yet.	Small testicles, the length can reach half of the body cavity length and whitish.
Development (GML II)	The ovaries filled up half of the body's length. The ovary was red orange. Egg grains were invisible if they were observed with the naked eye.	The testicles filled up half of the body cavity and were white, in a symmetrical shape.
Maturation (GML III)	The ovaries filled two-thirds of the body length. Ovaries were yellow-orange, egg granules were visible. Blood vessels have appeared on the surface of the ovary. Egg granules looked dark.	The testes filled two-thirds of the body's length and were creamy white.
Mature (GML IV)	The ovaries fill two-thirds of the body cavity. The color of the ovary is pink, and blood vessels are already visible on the surface. The size of the egg granules looks bigger, transparent, and mature.	The testicles fill two-thirds of the body cavity and are creamy-white with a soft texture.
Spawn (GML V)	The ovaries shrink to half of the body cavity—thick ovarian wall. The eggs in the ovaries were dark in color, and the remaining mature eggs began to disintegrate and were reabsorbed.	The testicles shrink to half of the body cavity. Soft testicular texture

The sex ratio was tested using chi-squared (χ2) with the formula:

$$\chi = \frac{M}{F} \quad \text{.....(1)}$$

Note: χ = sex ratio, M = male and F = female

The value of the relative condition factor (K) was obtained by using a formula based on observations the weight divided by weight based on the estimated weight of its length (Biswas, 1993).

$$K = \frac{W}{aL^b} \quad \text{.....(2)}$$

Note: K = Conditions factor; W = weight (g); L = length (mm); a and b are constants

The condition factors of fish between 2-4 if the body is slightly flat, while fish whose body is widened between 1-3.

Gonad maturity index was calculated using the following formula (Effendie, 2002)

$$IKG = \left(\frac{WG}{WT}\right) * 100 \quad \text{.....(3)}$$

Note: GMI = gonad maturity index; WG = gonad weight (g); WT = body weight (g).

The size of the first gonad maturity or Lm50% value is calculated by plotting the proportion between the mature gonad fish and the total gonad in each length class. The size of the first gonad is calculated using the following formula:

$$LM50\% = \frac{1}{(1 * e^{(a-b*L)})} \quad \text{.....(4)}$$

The formula can be reconstructed into a linear regression equation as the following formula:

$$Ln\left(\frac{1}{LM50\%} - 1\right) = a - bl \quad \text{.....(5)}$$

Note: LM50% = the size of the first gonad matured; L = total fish length (cm); a = intercept exponent; b = slope

The number of eggs in gonad fish GML III and IV was calculated by the gravimetric method (Effendie, 2002). Subsamples were taken from the anterior, ventral, and posterior gonads, then the number of eggs is calculated using the following formula:

$$N = \frac{Q}{q} x\, n \quad \text{.....(6)}$$

Note: N = total number of eggs (eggs), Q = total weight of the gonads (g), q = weight of the gonad subsample (g), n = number of eggs in the gonad subsample (items).

RESULTS AND DISCUSSION

Result

The number of fish samples collected amounted to 316 individuals consisting of 173 females, 87 males, and 60 not classified sex. The length and weight distribution of fish are presented in Figure 2.

Some fish samples were not identified by sex because the gonads have not yet grown, so it is difficult to distinguish between gonads and testes. Another cause was damage during hauling on fishing boats. The length and weight of female fish ranged from 15.0-18.5 cm and 39.4-82.3 g, while the length and male fish weighted around 14.5-17 cm and 36.3-56.2 g. Fish that cannot be identified based on sex are 13-13-15.5 cm long and weigh 45.3-49.3 g. The average length of a female fish (16.4 cm) and weight (55.3 g) was greater than that of a male fish with an average length (15.6 cm) and weight (47.6 g).

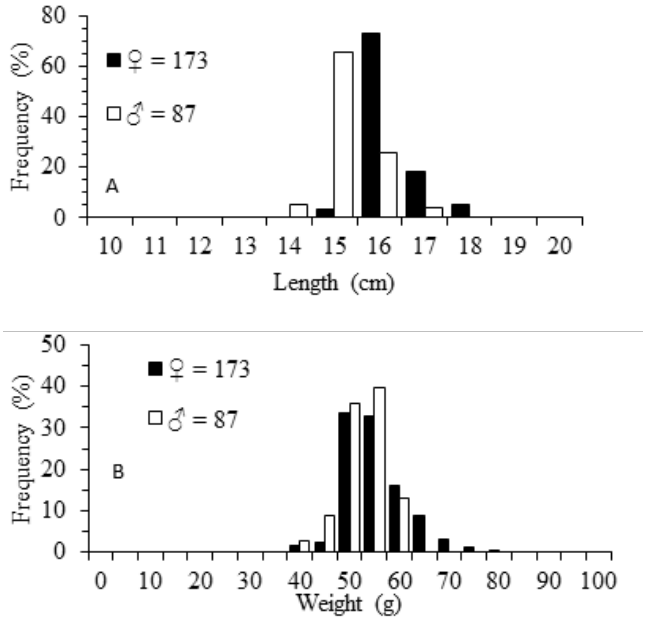

Figure 2. Length distribution of male and female mackerel (panel a) and weight of male and female mackerel (panel b).

Based on the analysis of the length-weight relationship of female Indian mackerel, the equation $W = 0.038\ L^{2.59}$ with a determination value $R^2 = 0.72$. In male mackerel, the length-weight relationship obtained by the equation $W = 0.178\ L^{2.02}$ with a determination value $R^2 = 0.52$. The correlation between length and weight in Indian mackerel shows that females were tighter and stronger than males. The length-weight relationship between male and female mackerel is shown in Figure 3.

Based on the graph of the length-weight relationship of females (b = 2.59) and male (b = 2.03), both values of b ≠ 3 indicating male and female mackerel had a negative allometric growth pattern. The length growth rate in female and male mackerel was not proportional to the weight; the growth of the length was faster than the weight.

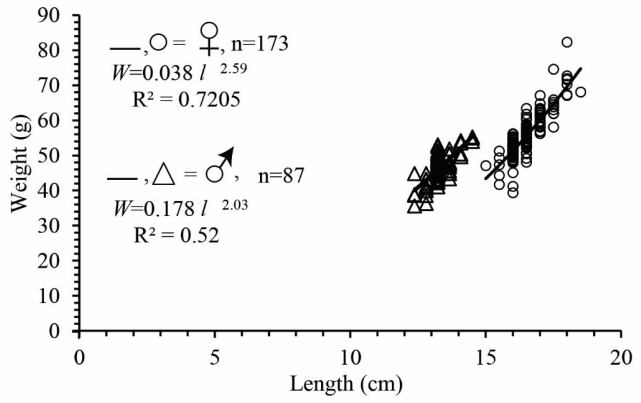

Figure 3. Length-weight relation of male and female Indian mackerel.

The condition factor values obtained from the analysis are presented in Table 2.

Table 2. The values of condition factor for male and female mackerel.

Length	Female	Male
14.5	-	0.992
15.0	1.114	1.042
15.5	1.017	1.031
16.0	1.029	1.06
16.5	1.023	1.011
17.0	1.037	0.994
17.5	1.031	-
18.0	1.052	-

The condition factors of Indian mackerel, for both male and female, were in the range of 1-2, which means Indian mackerel have a less flat body. Variations in the value of the condition factor depend on food, age, sex, and gonad maturity. If there is a sudden change in the condition of the fish in water, this situation makes it possible to investigate. If the conditions are not suitable, maybe the population is too dense, and vice versa. If the conditions are good and the food source is abundant, there is a tendency for fish to inhabit the habitat/plump. The sex ratio of female and male Indian mackerel each month of sampling is presented in Table 3. The results of the chi-square test showed that the sex ratio between females and males was overall unbalanced (P> 0.05). Overall, the number of female Indian mackerel reached 2x more (68.9%) than male Indian mackerel (31.1%). Each month the number of female mackerel caught was higher than that of male mackerel.

Table 3. Female and male sex ratio of Indian mackerel monthly sampling in the waters of Demak Regency. Sign * shows significantly different (P> 0.05).

Sex	April	May	June	Total
Female	54	57	62	173
Male	27	19	32	78
Total	81	76	94	251
*X*count	9.00	19.00	9.57	35.96
*X*table	3.84	3.84	3.84	3.84

The overall proportion of the maturity of the male and female Indian mackerel, stage III, has the highest percentage reached of 60.26%, followed by the second stage of 17.84%, the next stage IV of 13.67% and phase I of 8.23 % (Figure 4).

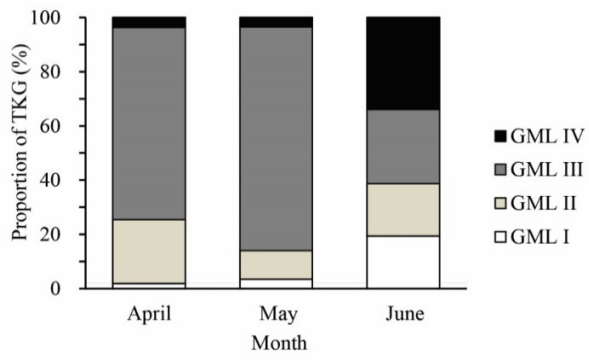

Figure 4. Composition of the gonads maturity level of Indian mackerel landed at TPI Morodemak.

Based on monthly sampling, female Indian mackerel in GML IV was found to be very few in April and May, then exposed to increase very much in June. The composition of fish in GML III was found most widely in April and May, whereas in June, the proportion of GML III and IV was almost balanced.

The gonad maturity index (GMI) of male mackerel in each sampling month is presented in Figure 5.

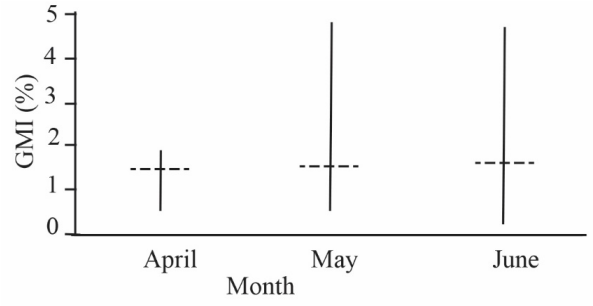

Figure 5. Average gonads maturity index of Indian mackerel landed at TPI Morodemak in each sampling month. Note: The bar line is the maximum and minimum value, the dash line is the average value.

The overall mean GMI of female gonads was 1.55%, while the average GMI per month ranged from 1.42-1.64%. The highest GMI value of 4.75% was in May and June, and the lowest was 0.17 in June. The average GMI per month tends to be the same.

The relationship between the number of eggs for individual fish with the length of Indian mackerel is shown in Figure 6.

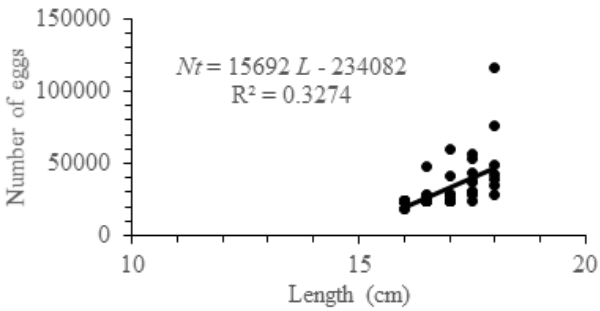

Figure 6. The relationship between egg number in the gonads and the total length of individual Indian mackerel.

Gonad Indian mackerel at a length of 16.0 cm contained at least 18.584 eggs, whereas fish at a length of 18.0 cm contained at most 116.800 eggs. The number of Indian mackerel eggs per individual was 30.317. The same length, there were variations number eggs, the longer the size of the fish, the higher the variation. The relationship between the number of eggs with length forms the regression equation Nt = 15.692 L – 234.082 (R^2 = 0.327). The egg content in the gonads tended to increase with length, but the relationship was weak, as indicated by the low correlation value. Indian mackerel brood stock of the same length contained eggs with varying amounts, so the relationship between egg content and length of each fish was weak.

The first prediction of Indian mackerel gonads during sampling in Demak district waters is presented in Figure 7.

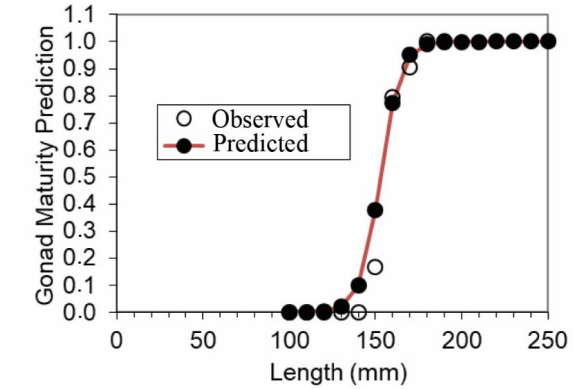

Figure 7. Prediction of the total length of female Indian mackerel reaching the first gonadal maturity.

Female Indian mackerel was estimated to have first gonad mature at a size of 15.2 cm long. The shortest female Indian mackerel caught was 15.0 cm in size, while the longest found was 18.5 cm so that more than 95% of the fish caught have reached the mature gonad.

DISCUSSION

Indian mackerel caught in mini purse seine in Demak Regency waters has a narrower range of length than those found in Aceh (Arrafi *et al.*, 2016) and Raja Ampat waters (Oktaviani *et al.*, 2014). The length and weight distribution were influenced by the fishing gear used, the frequency of capture, and the fishing season. The size of fish caught is closely related to fishing time, fishing ground, fishing gear size, and type of fishing gear (Kantun *et al.*, 2014). The frequency of fishing in Java sea waters is generally higher than in the waters of Aceh, Raja Ampat, and other Indonesian waters. Indians mackerel caught in the waters of Demak Regency tend to be smaller and of uniform size. In contrast, in waters where the fishing frequency is low, the available fish stocks tend to be diverse and sizable. Variations result in length-weight analysis in several different locations can be caused by a combination of one or several factors, including the selectivity of the fishing gear used to catch sample fish (Soykan *et al.*, 2010), season, habitat, food availability, and sex.

The capture fish size also influenced by the biological nature of the fish, which is related to group behavior. Indian mackerel are small pelagic fish that live on the surface of the water in search of food, avoid predators, and spawn (Spare & Venema, 1998). Pelagic fish in the same group will generally form a horde to find food and generate efficiently. Clustered fish are fish populations of the same size, age, and stage that work together for mutual benefit (Soria & Dagorn, 1992) and always synergize in the swimming motion. The purse seine operated by confining the fish swimming on the surface so that the catch is uniform.

In general, the sex ratio of males and females is comparable, but the results of sampling every month show the composition of the number of females doubling than males. Pelagic fish respond to water conditions by regulating the sex ratio. When the water conditions are very good with adequate food availability and low environmental pressure, the proportion of females and males is balanced. Conversely, when the water conditions are adverse, the fish population will increase the number of females. It is intended to guarantee the genetic preservation of the offspring. In Regency of Demak waters, high fishing pressure may as trigger of Indian mackerel fish populations to increase the number of female fish.

During monthly sampling, fish was in the stage of GML IV, but the proportion of GML IV was highest in June. The composition of fish GML every month is dominated by GML III, except in June, the dominant GML IV. The dominance of fish that has reached GML III and IV can be an indicator of fish spawning in waters (Suhendra & Merta, 1986). Fish spawn when environmental conditions are suitable to support the spawning success and survival of larvae (Moyle & Cech, 1982). The proportion of gonad maturity level IV is most dominant in the spawning season (Effendie, 2002). It is the highest composition of GML IV in June, so it is estimated as a spawning season. The spawning season for Indian mackerel fish varies depending on location, for example, in Aceh waters taking place in January-March and July-October (Arrafi *et al.*, 2016), in the Java sea in June-August and southern Sulawesi waters in July-August (Kasmi *et al.*, 2017). Differences in spawning seasons affected by environmental conditions related to feeding availability, water quality, and the influence of seasons (Effendie, 2002) and the availability of spawning facilities. Changes or shifts in spawning seasons occur when environmental conditions cannot support spawning.

The GMI value of Indian mackerel in the waters of the Demak Regency is relatively the same as that of Zamroni *et al.* (2008) on the north coast of Java. The same pattern is also found in Aceh's western waters (Arrafi *et al.*, 2016). Variations in GMI values in Indian mackerel are caused by environmental factors directly related to the availability of food as an energy source for somatic growth and reproduction. Increasing the GMI value of fish is an indicator of the spawning season. GMI value will be high in the spawning season because, in the spawning season, most of the fish are in ready-to-spawning conditions so that the size of the egg diameter is large and abundant (Effendie, 2002). Based on the GMI value every month, the peak spawning of Indian mackerel occurs immediately after the highest GMI value. Spawning usually occurs after the peak maturity of the gonads, so that in the next stage there is a decrease in GMI. The gonad's weight will reach its maximum when the fish lay eggs, so the gonad's weight will decrease when spawning is in progress until completion.

The gonad maturity size for the first time in this study was smaller compared with reviews on the coast of the Arabian Sea Mahout (Zaki *et al.*, 2016) and in Arafura waters (Arrafi *et al.*, 2016). The size of the first gonad mature fish caused by several factors, such as the environment pressure, age, and other factors. The suitable climate is related to the abundance of natural food and good water quality, so the size of the first gonad maturity will be larger than the poor environmental conditions with limited feed. Fishing pressure affects the stock size of fishes and the average size of the fish. Fish populations that get high fishing pressure will respond to spawn

quickly on a small average fish size (Spare & Venema, 1998). The fish size of the mature gonad caught from each study location is due to overfishing, so the fish are small but attained gonadal maturity (Kantun *et al.*, 2015). The original size of gonad maturity in each fish species achieved in varied sized. Fish spawning that occurs in smaller length sizes is a reproduction tactic to restore the balance of its population caused by changing conditions, abiotic factors, and overfishing (Siby *et al.*, 2009). Several factors can cause variations in the size of the first time the gonad maturity, namely the genetic characteristics of the population, differences in the location of the area, water quality, and the magnitude of the fishing pressure (Rahardjo & Charles, 2007).

The number of Indian mackerel eggs in the waters of the Demak Regency was lower than the fecundity of Indian mackerel in the western waters of Aceh (Arrafiet *et al.*, 2016). The number of eggs per gonad fish influenced by several factors, including the length and weight of the fish, the size of the egg diameter (Suzuki *et al*., 2000), and environmental factors (Abidin, 1986). Large fish produce abundant fecundity. At the same size, female fish in the right conditions provide higher fertility. Referring to the number of eggs produced by the female broodfish, Indian mackerel shows a high level of productivity. Small pelagic fish generally have very high fecundity. Other factors that influence the number of female fish eggs are fertility, frequency of spawning, parental protection, egg size, environmental conditions, and population density (Rochmatin *et al*., 2014). Brood fish that provide parental care to eggs and their progeny have low fecundity to improve their survival.

CONCLUSION

Indian mackerel captured in the waters of Demak Regency is relatively small, the length-weight relationship is negative allometric, dominated by females, spawning occurs every month with peak spawning in June. The number of eggs produced is low, the longer the parent size, the more eggs are produced. There is a diversity of GML, GMI, and the number of eggs caused by environmental factors, catch pressure, season, and local conditions. The size of the first adult is relatively small, which is caused by a high catch effect.

Indian mackerel fish management needs to be done by increasing the size of the net opening so that the fish caught are more extended than 15.2 cm. Besides, conservation efforts are carried out by regulating the fishing ground locations of each fishing gear, setting the level of effort, and controlling the fishing season.

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