Biology of Indian Mackerel, *Rastrelliger kanagurta* (Cuvier,1817) in the Western Waters of Aceh

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Abstract

A study of the biology of Indian mackerel, *Rastrelliger kanagurta* (Cuvier, 1817) in the Western Waters of Aceh, Indonesia was carried out from January to December 2014 and a total of 1343 Indian mackerels were collected randomly twice a month. The allometric coefficients (b) in the present study were between 2.625 and 3.449 with coefficient of determination (R^2) values that range between 0.612 and 0.984. The condition factor (*K*) ranged from 0.9176 - 1.4509. Asymptotic length ($L\infty$) and growth coefficient (K) and t_0 were estimated at 27.3 cm (TL) 0.56 y-1 and - 0.526 y, respectively. The sex ratio of male to female was 1 : 1.02. Overall, the sex ratios were not different significantly (χ^2 = 26.757; df = 11 ; p<0.05). The data suggest that there are two spawning seasons, the first is from January to March and the second is from August to October. The monthly mean GSI values ranged from 0.32 to 3.37. The observation of length at first maturity of female was estimated as 19.58 cm (TL). The fecundity of *R. kanagurta* varied from 28,542 to 123,760 with an average of 56,635 eggs.

Keywords : Biology, *Rastrelliger kanagurta*, Aceh

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Introduction

The Indian mackerel, *Rastrelliger kanagurta* (Cuvier, 1817) is a small pelagic schooling scombroid fish widely distributed in the Indian Ocean and Indo-West Pacific region. Indian mackerel is a very important species of commercial fisheries for the countries bordered with Indian Ocean, Indonesia, Pakistan, India, Sri Lanka, Bangladesh, Myanmar, Thailand (Collete and Nauen, 1983; Devaraj *et al*., 1997; Al-Mahdawi and Mehanna, 2010; Jayabalan *et al*., 2014).

Indian mackerel as a type of small pelagic fish resource has an important role in the production of marine fisheries in Western Aceh, which is known locally as “Kembung” or “Jenara”. This species supports a rich commercial fishery a contribution to the total production of Western Aceh varying from 4.68 to 7.15% between 2003 – 2012 (MFAA, 2013).

Studies on the biology and population characteristics of Indian mackerel have been conducted from different regions of the Indian Ocean, including reports by Gopakumar *et al*. (1991), Noble *et al*. (1992), Mehanna (2001), Rohit and Gupta (2004), Sivadas *et al*. (2006), Abdussamad *et al*. (2006) ; Abdussamad *et al*. (2010), Al-Mahdawi and Mehanna (2010), Ganga (2010) and Al-Mamry *et al.* (2011). Unfortunately, information on the biology and population characteristic of *R. kanagurta* from the waters of Aceh areas especially in the western waters of Aceh region bordering the Indian Ocean is very poor. There was only one study by Hariati and Fauzi (2011) in northern waters of Aceh and it was limited to fecundity and length at first maturity parameters.

An understanding of the reproductive biology and population dynamics of a species is important for future management of fisheries resources (Morgan, 2008; Amin *et al*., 2014). The present study aimed at investigating the length-weight relationship and condition factor, age and growth parameters, reproductive biological aspects i. e. sex ratio, gonad maturity level, gonadosomatic index (GSI), length at first maturity and fecundity of the Indian mackerel.

Materials and methods

Fishes were collected twice a month at Ujong Baroh fishing port, Meulaboh, Aceh from January to December 2013, where all the catches from the western waters of Aceh were landed. All fish samples were captured mainly by fishing vessel using boat seine with one day fishing trip around latitudes 04°00.349' - 04°05.461' N and longitudes 95°58.312' - 96°04.005' E, in a depth range of 5 to 30 m in fish aggregating areas shown on device. Also, purse seine with more than one day fishing was used in the process. Fish were randomly chosen from different buckets on boats. Samples were collected prior to sorting by fishermen to avoid bias on size.

After collection the fish were immediately put in ice box and transported to the laboratory. A total of

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1343 Indian mackerels were sampled in this study (24 - 312 fishes were used monthly).

Parameters a and b of the length (L) - weight (W) relationships is expressed by equation, $W=aL^b$ (Jennings *et al*., 2001) and estimated from the intercept and slope of the linear regression analysis on the log-transformed weight and length data, i.e. : ln (W) = ln a + b ln L. where, (W) is the total weight (g), (L) is the total length (cm), (a) the intercept and (b) the slope coefficients. Total lengths of individuals were measured using a ruler to the nearest 0.1 cm and total weight was taken by an electronic balance of 0.001 g accuracy.

The condition factor which indicates the condition of fish was calculated by the following formula (Pauly, 1983) :

$$K = \frac{W}{L^3} x100$$

Where K = condition factor; W = weight of fish (g) ; L = length of fish (cm)

The lengths were grouped into 1 cm class intervals to estimate the von Bertalanffy growth function (VBGF) parameters $L\infty$, K and t_0

$$L_t = L\infty\left(1-e^{-K(t-t_0)}\right)$$

Where Lt=predicted length at age t

$L\infty$=an asymptotic length

K= growth constant

t_0= the age of fish at length zero

The von Bertalanffy growth parameters were determined for the data set for each year separately using the ELEFAN program available in FiSAT FAO-ICLARM Stock Assessment Tools (FiSAT) II.

The study of reproductive biology included sex ratio, gonad maturity level, gonadosomatic index (GSI), length at first maturity (L_m) and fecundity. Sexual characteristic of fish was identified internally by observing their gonad. From the total samples, we were able to determine the sex for only 618 specimens of which 310 (50.16%) were females. The proportion of the two sexes relative to one another was used to calculate the sex ratio. Monthly sex ratio that departured from the expected 1:1 ratio was tested. The Chi square test was used to assess sex ratio deviation from a 50 : 50 (Wooton, 1998). Maturity stage (immature, maturing, ripe and spent) was recorded based on macroscopic observations of the gonad such as the size of ovary in relation to abdominal cavity and its appearance (whether bulging, half shrink or flaccid; the presence of blood vessels on the ovary and colouration of the gonads) primarily based on the maturity stages developed by Ganga (2010) for Indian mackerel. Gonadosomatic Index (GSI) were estimated based on females. This was calculated for each maturity stage of female using gonads in fresh condition. The GSI and its variation over the 12 months sampling period was calculated following the equation given by Wooton (1998) as :

$$\text{GSI} = \frac{\text{Gonad weight (g)}}{\text{Somatic weight (g)}} \text{ x } 100$$

Where somatic weight = body weight - gonad weight

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Only females of *R. kanagurta* in stage III and above were considered as mature to determine the length at first maturity. The size of maturity was analyzed using the equation below (King, 2007):

$$P = 1 / (1 + \exp[-r (L-Lm)])$$

Which:

P = probability (%)

r = slope of the curve

L = length of the fish

Lm = length of fish at specific gonad maturity Q

The fecundity of *R. kanagurta* was determined in the present study from the examination of 75 fishes with a total length range of 18.7- 26.0 cm. Ovaries of the stages III and IV (ripe and spent) were only used for fecundity estimation. Estimates of the fecundity of each individual female was obtained from the average of the three sub-samples of eggs from different parts of the ovary (Murua *et al*., 2003) :

$$Fecundity = \frac{\sum CnO / Wn}{n}$$

Cn = counted number of eggs in sub-sample n, O = ovary weight, Wn = sub-sample weight and n = number of sub-samples.

Results

The allometric coefficients (b) in the present study were between 2.625 and 3.449. The lowest b-values were found in June and September (2.631 and 2.625, respectively), whereas the highest values were found in January and May (3.416 and 3.449 respectively). The LWRs were observed with R^2 values that range between 0.612 and 0.984. The condition factor (*K*) ranged from 0.9176 - 1.4509. The lowest K value was found in November and the highest was in August.

The size of frequency distribution of *R. kanagurta* in the commercial catches ranged from 7 to 26 cm of TL during 2013 (Fig. 2). Fishes in the size class of 15.00-15.99 cm dominated the catches which accounted for about 13.48% of the catch. Fishes in the size higher than 19.50 cm collectively formed about 30.19% of the catch.

Asymptotic length ($L\infty$) and growth coefficient (K) and t_0 were estimated at 27.3 cm (TL) 0.56 $year^{-1}$ and - 0.526 y respectively (Fig. 3). The lengths of *R. kanagurta* in western waters of Aceh which are converted into age using the growth parameters (Fig. 4) showed growth at the end of first, second, third and fourth years as 15.68, 20.67, 23.51 and 25.14cm, respectively.

The observed sex ratio was not different from the expected ratio of 1:1 (male : female). From the total samples, 308 (49.84%) were males and 310 (50.16%) were females showing aratio of 1 : 1.02. The overall the sex ratio was not different significantly ($\chi^2 = 26.757$; df = 11 ; $p<0.05$).

The data suggest that there are two spawning seasons of *R. kanagurta*, the first is from January to March and the second is from August to October (Fig. 5).

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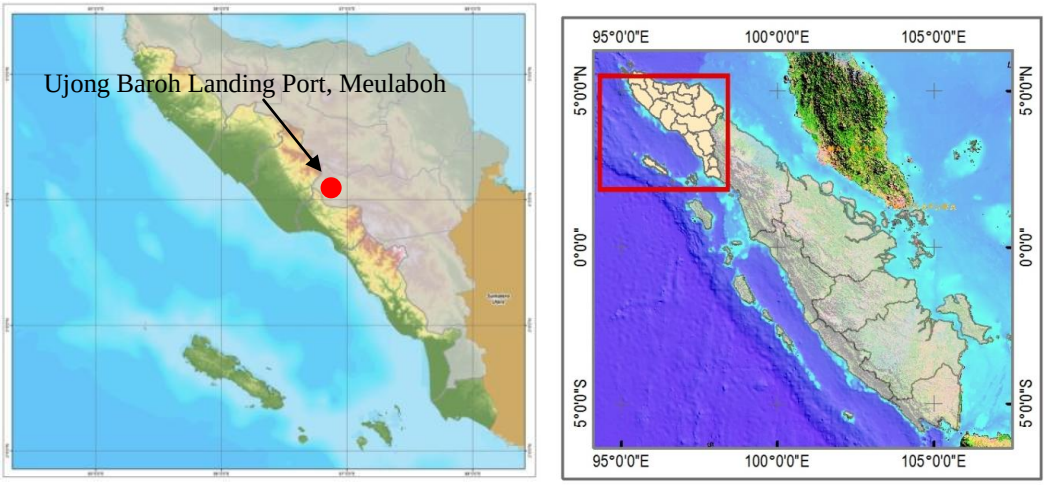

Figure 1: Research location in the Ujong Baroh Landing Port of Aceh, Indonesia.

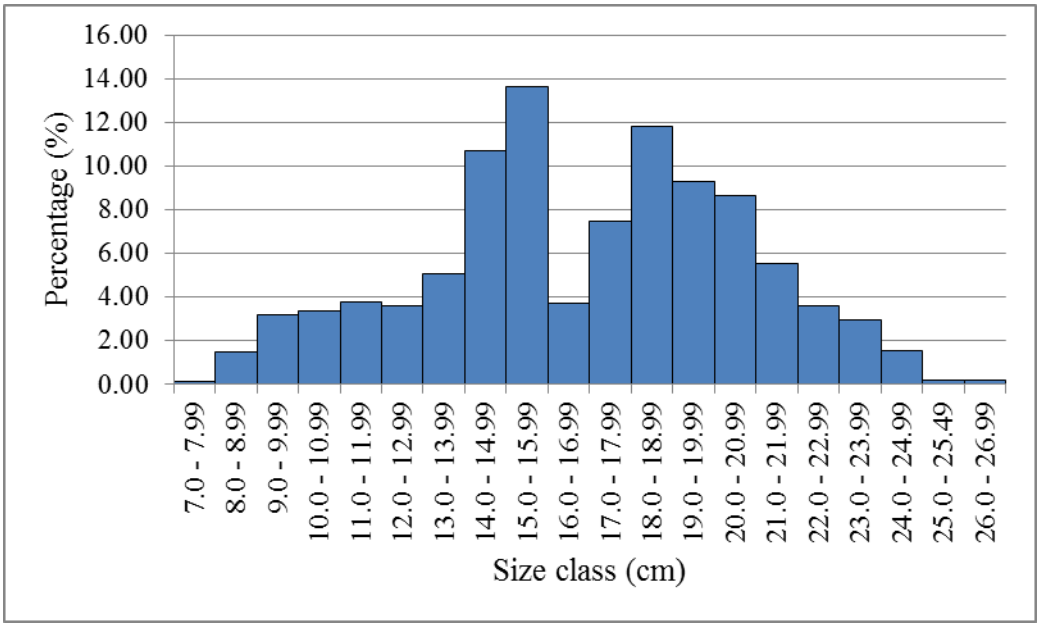

Figure 2 : Length frequency distribution of *R. kanagurta* of total catch in western waters of Aceh, Indonesia during 2013 (n = 1343).

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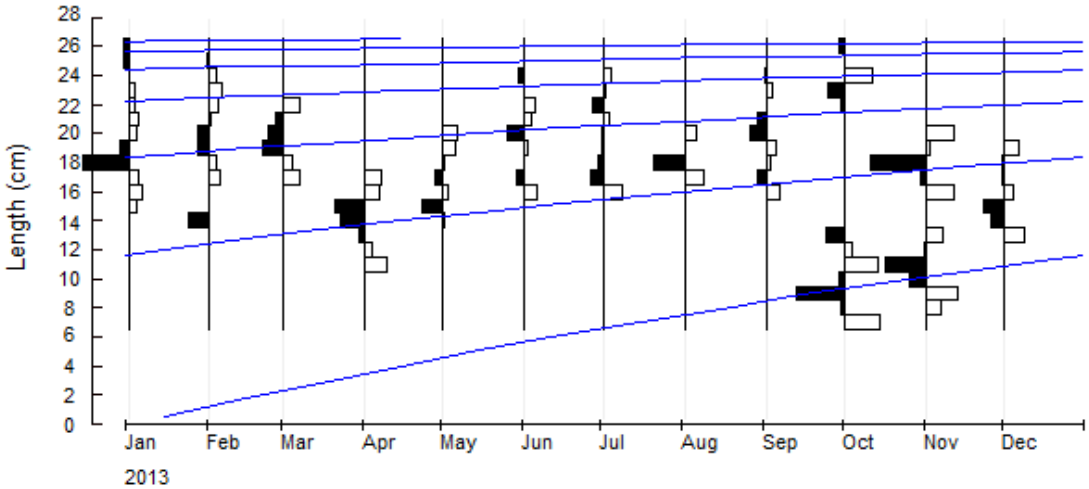

Figure 3 : Growth parameter estimates (L∞=27.3 cm and K=0.56 year^{-1}) for *R. kanagurta* in western waters of Aceh (2013).

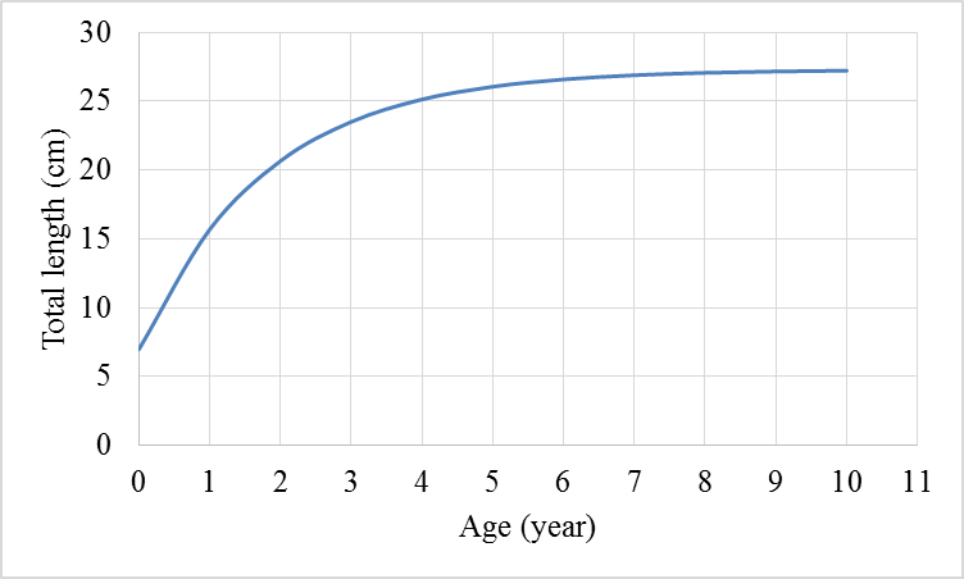

Figure 4 : The von Bartalanffy growth curve fitted to length at age data for *R. kanagurta* in western waters of Aceh (2013).

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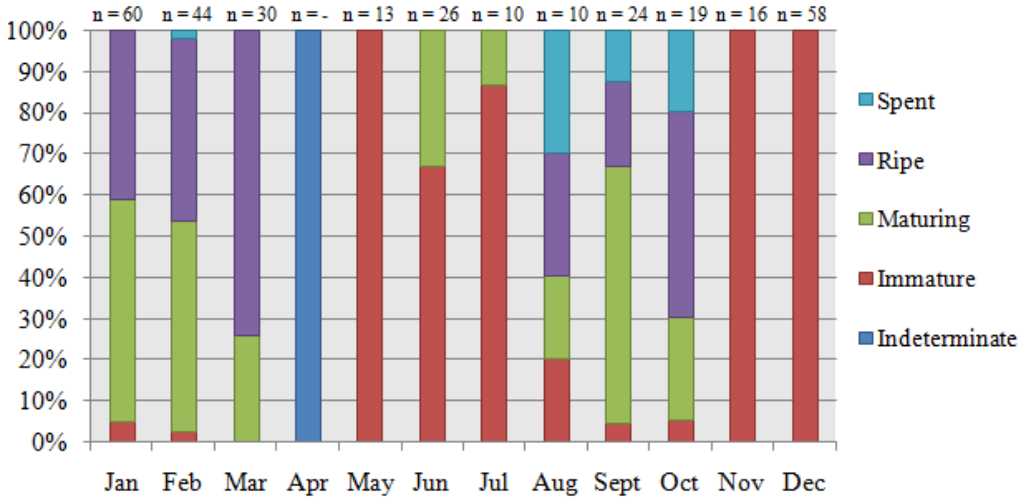

Figure 5: Monthly distribution of different maturity stages of ovary of *R. kanagurta* in western waters of Aceh.

The monthly mean GSI values ranged from 0.32 to 3.37. The lowest GSI value was recorded in November, while the highest was in March. There were no gonads available or undeterminated condition for April. GSI values of *R. kanagurta* ovary showed correlation with the maturation of gonads (Fig. 6).

The observation of length at first maturity was estimated as 19.58 cm (TL), while the length of mature female was observed to be between 18.7 and 26.0 cm. The fecundity of *R. kanagurta* varied from 28,542 - 123,760 with an average of 56,635±SD eggs. The fecundity was correlated with the fish length, weight and gonad weight. The results indicated that the number of eggs per female increased with the increasing of length, body weight and ovary weight.

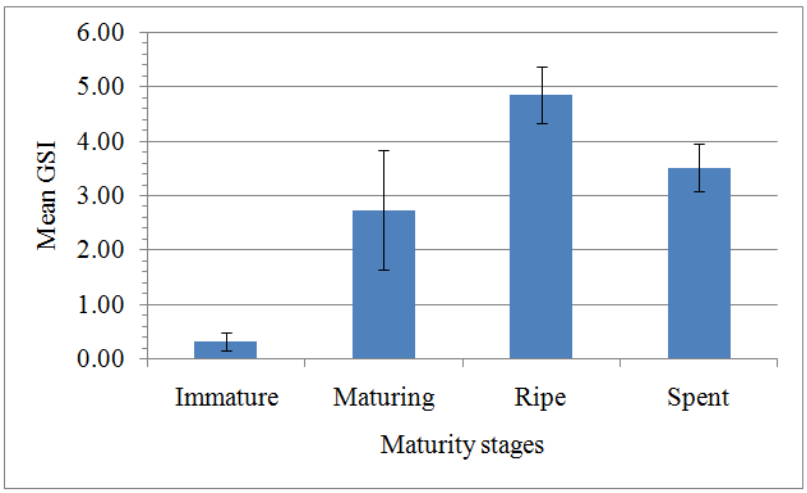

Figure 6: Trends GSI of various maturity stages of female *R. kanagurta* (Mean ± SD).

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Discussion

The observed length-weight relationship (LWRs) was with R^2 values ranging between 0.612-0.984. These results clearly shows that coefficient of determination for LWRs was high which indicated an increase in length with increase in weight. According to Biswas (1993) if the value of 'R^2' is higher than 0.5, then the length-weight relationship is positively correlated. The *b* value is close to 3 in this study, indicating that fish grow isometrically. Compared to the results from previous studies from different water bodies, the power equation describing the length-weight relationship of *R. kanagurta* in the western waters of Aceh shows a b value between theose found in the pervious studies (Edwards and Shaher, 1991; Mehanna, 2001; Sivadas *et al*., 2006Rahman and Hafzath, 2012; Jayabalan *et al*., 2014). Difference in *b* values in each month can be attributed to the combination of one or more factors such as : number of specimens examined, effect of area/season; habitat; degree of stomach fullness; gonad maturity; sex; health and general fish condition; preservation technique; and differences in the observed length ranges of the specimens caught (Wootton, 1998). Gayanilo and Pauly (1997) reported that certain factors often affect the condition factor of a fish. These include pulling data, sorting into classes, sex, stages of maturity and state of the stomach. The *K* may also be attributed to different ecological conditions.

The length range of fishes in this study was similar to those found in other studies. Hulkoti *et al*. (2013) and Amin *et al*. (2014) have observed *R. kanagurta* from Mangalore, India and Sabah, Malaysia respectively with the size ranging between 11 and 26 cm (TL), while Oktaviani *et al.* (2014) estimated that the range was between 6.3 and 26.0 cm (FL) from Mayalibit Bay, Indonesia, which is the same range size found in this present study. Fishes in the size lower than 19.50 cm collectively formed about 67.98% of the catches. while fishes in the size higher than 19.50 cm collectively formed about 32.02%. This showed that proportion of immature fish in the catch was dominant. Indian mackerel caught around western waters of Aceh tend to be smaller than those from other studies. In comparison, the study from Andaman Islands by Luther (1973), showed that more than 50 % of the fish are mature at the total length range of 25.0-25.9 cm. Abundance of fish was highest in April and lowest in August. In the present study, there was a large proportion of small fish (Juvenile) in the length range of 7.00 - 150 mm and formed about 44.97% of the total catch (Fig. 2), observed during April - May and October - December. We found juveniles mainly in April-May and October - December. New recruitment appearing in April was characterized by the arrival of juveniles in the fishery; and we guess these are coming from another sites.

The VBGF parameters estimated from different areas indicated variations

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in the parameter values. Several studies on growth paramaters have been conducted in the Indian Ocean. Abdussamad *et al.* (2010) estimated the VBG parameters, $L\infty$, K and t_0 at 33.28 cm and 1.634 $year^{-1}$ respectively and for t_0 as -0.0018 years of *R. kanagurta* exploited along the Tuticorin coast, India. This showed that *R. kanagurta* grew relatively faster and attained 105, 176, 223, 254 and 303 mm, respectively by the end of 3, 6, 9, 12 and 24 months. Jayabalan and Zaki (2014) showed growth of *R. kanagurta* from Sohar, Oman at the end of first, second, third and fourth years of age as 19.7 cm, 27.4, 30.6 and 32.0 cm respectively. Mehanna (2001) using the otolith analysis of age determination found that the *R. kanagurta* attains lengths of 15.59, 22.92, 27.26 and 29.27 cm by the end of the first, second, third and fourth year of life respectively for *R. kanagurta* from Gulf of Suez, Egypt. From Yemeni Coast of the Red Sea Al-Mahdawi and Mehanna (2010) estimated *R. kanagurta* growth as 16.15, 23.29, 27.54 and 29.61 cm at the end of the first, second, third and fourth year of life, respectively.

The sex ratio of *R. kanagurta* obtained in this study tended to be similar with other studies. Sudjastani (1974) observed the sex-ratio of Indian mackerel from Java sea, Indonesia to be 1 : 1.1. Also, in similar location, Potier and Nurhakim (1995) concluded that the sex composition of the commercial catches was 55% male and 45% female, while a recent study by Oktaviani *et al*. (2014) found proportion of M:F to be 49.76 % : 50.24%. The sex ratio of *R. kanagurta* in the Indian waters, was approximately 1:1. Based on the annual reports of the Central Marine Fisheries Research Institute, in 2010-2011 season, the sex ratio during the fishing season varied though in some landing centres was almost equal (CMFRI, 2011). The sex-ratio of a sample analyzed at Karnataka and Andra Pradesh showed the males were slightly higher than females with 1 : 0.94 in Karnataka and 1.04 in Andra Pradesh, but in Gujarat females were higher than males (0.6). During 2011-2012, the sex ratio studies indicated that the proportion of males was slightly higher than females, and the sex ratio was 1 : 0.9 in Karnataka, 1 : 0.9 in Gujarat and 1: 0.97 at Andra Pradesh (CMFRI, 2012). Hulkoti *et al*. (2013) observed the sex ratio M:F from mangalore as 1 : 0.9. From Kuantan, Malaysia, Hafaz and Rahman (2012) found that the proportion of males was slightly higher than females with a percentage 57.75% : 42.25%. According to Rahardjo *et al*. (2011) it can be concluded that the sex ratio of fish in nature is good. Observations of the fish sex ratio is important for population structure studies. The sex ratio can be predicted at equilibrium existing in population with the assumption that the ratio of male fish and females stock in nature is 1 : 1 so the population is in a balanced state.

The variations in maturity stages and gonadosomatic index were used for discrimination between the different

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conditions of the gonads in different periods, in order to identify the spawning season. The spawning season was determined on the basis of occurrence of individuals in maturing, mature, and spent stages. Higher values of GSI are frequently regarded as indicative of spawning season . The present study indicated that *R. kanagurta* spawns during all the year, with an intensive spawning in January, February, March, August, September and October. The data suggest that there are two spawning seasons, the first from January to March and then from August to October. Seasonal variations in the values of GSI were reported by different researchers for different areas. However, peaks in spawning confined to a few months in the year, a major peak during June-August and a minor one during March-April (Rohit, 2004). Mature gonads were observed throughout the year (Mosse and Hutubessy, 1996; Yohannan and Abdurahiman, 1998) Potier and Nurhakim (1995) reported spawning peak of *R. kanagurta* from Java Sea during March, May and October/November. Mansor and Isa (1995) reported that *R. kanagurta* from off the east coast of Peninsular Malaysia spawning in May - June, September - October (1993) and April - May (1994).

The results indicate the mackerel found with varying gonadal maturity level indicating that these fish tend to spawn as partial spawner and do so continuously. As suggested by Abdussamad *et al*. (2010), mature fishes with gonads at various stages of development observed throughout the year, so they assumed that an individual fish might breed several times during the year. Rao (1967) reported the Indian mackerel might be spawning throughout the year, though there might be peaks in its spawning activity.

The GSI of *R. kanagurta* showed two peaks, one during January - March and other during August - October. The GSI values ranged from 0.33 to 4.04. The lowest GSI value was recorded in December, while the highest was in March. In the present study, the values of GSI for *R. kanagurta* showed increasing trend from immature (0.34) to ripe stage (4.90), and decreasing at spent stage (3.54) with the maturation of gonads in *R. kanagurta* (Fig. 6). The GSI obtained in the present study was similar with values observed by Ganga (2010) that indicated the GSI values increased from 0.38 to 5.10 and decreased at spent stage (4.00). Atmaja *et al*. (2000) observed the mean GSI as 1.22 - 3.51 in the waters of the southern part of Sunda Shelf.

Rahman and Hafzath reported GSI from Kuantan waters, Malaysia with the lowest GSI observed in December and January. GSI of Indian mackerel in February was higher than March and April and followed by May. Hafzath and Rahman (2012) observed GSI rapidly increased after January and reached a peak in February (1.1958). After February GSI was declining again. A positive relationship was observed between GSI and condition factor of mackerel. From Mangalore,

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India, Hulkoti *et al*. (2013) obtained GSI values between 1.95 and 5.86, and the minimum value was in January and the highest was in July.

The length at first maturity (L_m) was estimated as 19.58 cm (TL) and the smallest female was 18.7 cm (TL), ranging between 18.7 and 26.0 cm (TL). The values of L_m in the present study showed similar results for the L_m as those reported in previous studies. The estimates of L_m of *R. kanagurta* appeared to be around 20 cm. Information on the length at first maturity of *R. kanagurta* is available from Indonesian waters. Sudjastani (1974) found the L_m in Java Sea waters at 19 cm (TL). Hariati and Fauzi (2011) estimated L_m of Indian mackerel female in the waters of northern Aceh as 19.97 cm (FL). Oktaviani *et al*. (2014) reported 20.71 cm (FL) from Raja Ampat. From Indian waters, Pradhan (1956) suggested 22.4 cm (TL) at maturity. The length at first maturity (L_m) of Indian mackerel exploited along the Tuticorin coast was 18.8 cm for females during 1997-2007 (Abdussamad *et al*., 2010). The length at first maturity (L_m) monitored at Kakinada during 1995-2000 by Abdussamad *et al.* (2006) were 18.47 cm for females. Recent study by Hulkoti *et al.* (2013) estimated Lm as 21.00 cm (TL) for females from Mangalore, India. Ganga (2010) reported the L_m varied during the years 2005-2008 and ranged from 16.2 to 19.6 cm (TL). Rohit and Gupta (2004) observed the minimum size at maturity was 18.0 cm (TL). Sivadas *et al*. (2006) reported TL for females at 17.34 cm with a confidence limit of L_m 17.21 and 17.47 cm.

In the present study, the total fecundity of *R. kanagurta* ranged between 28,542 and 123,760 with a mean 57,364 ± 17,897 (SD). Absolute fecundity was determined on 75 (ripe and spent) females caught in January, February, March, August, September and October 2013. The minimum and maximum value of eggs was calculated at 28,542 and 123,760 eggs, respectively. Analysis of regression showed that there were significant relationship between the fecundity with the fish length (Fig. 7), body weight (Fig. 8) and ovary weight (Fig. 9). The results indicated that the number of eggs per female increased with increasing length, body weight and ovary weight. The length-fecundity relationship showed coefficient of determination (R^2 = 0.564). Analysis of regression also showed that there were a significant relationship with body weight and ovary weight of the fish. High coefficient of determination as R^2=0.659 and 0.887 respectively compared to the body length were observed.

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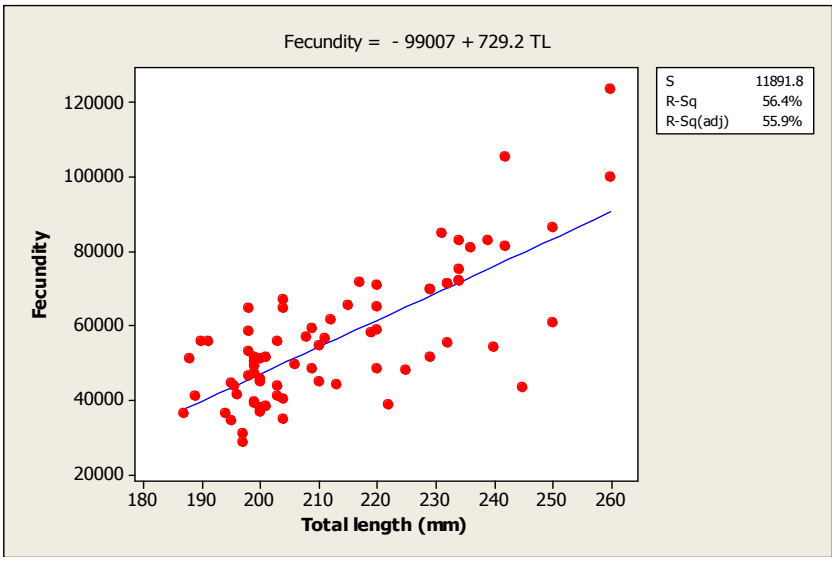

Figure 7 : Relationship between fecundity and total length in *R. kanagurta* in western waters of Aceh (2013).

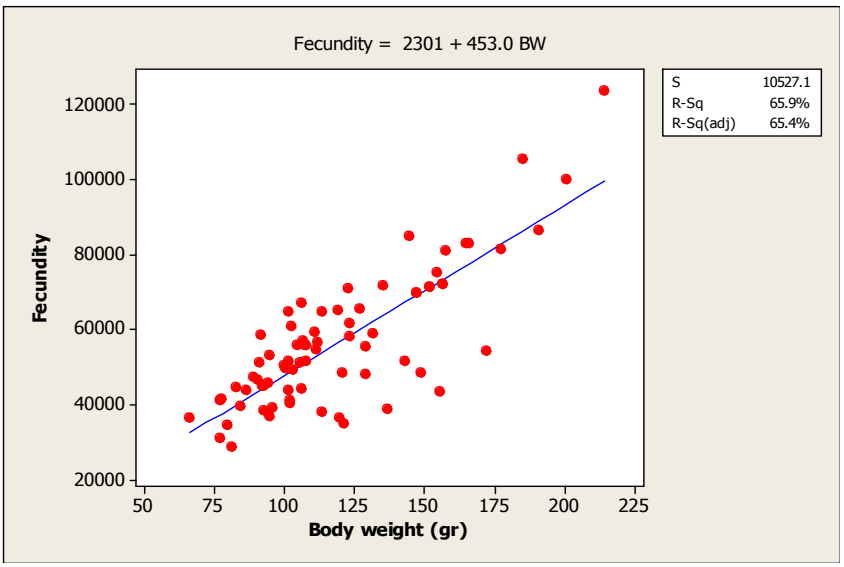

Figure 8 : Relationship between fecundity and body weight in *R. kanagurta* in western waters of Aceh (2013).

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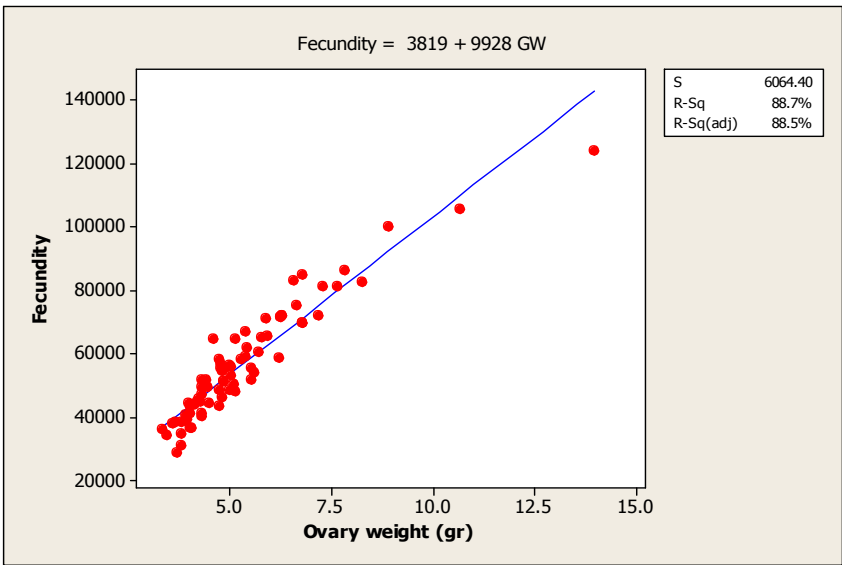

Figure 9 : Relationship between fecundity and ovary weight in *R. kanagurta* in western waters of Aceh (2013).

Similar findings of fecundity was also reported by several authors who conducted studies in Indian waters. The earlier study by Rao (1967) calculated an average of 110,000 eggs in three size groups in mackerel ranging from 228-232 mm. Ganga (2010) reported that the fecundity of *R. kanagurta* ranged from 39,600 eggs to 73,781. Gopakumar *et al*. (1991) estimated 198 to 515 eggs per gram of body weight of a mature mackerel. Abdussamad *et al*. (2010) calculated the *R. kanagurta* along tuticorin coast as 68,500 eggs. Tge recent study by Hulkoti *et al*. (2013) obtained fecundity between 86,744 and 94,376 eggs with a mean of 91,258±SD.

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