

STUDY ON THE REPRODUCTION OF "LAYANG DELES" SHORTFIN SCAD (*Decapterus macrosoma*) IN THE JAVA SEA

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ABSTRACT

Some reproduction aspects of "layang deles" (*Decapterus macrosoma*) in the Java Sea were investigated using microscope, gonado somatic index and diameter of eggs for determining the stage of maturity. The distribution of gonado somatic index by size class showed that median value is always close to zero and 75% of the index value do not reach 2.5%. According to the diameter of eggs, gonado somatic index value less than 4% was grouped into immature stage. The fish with mature stage in purse seine catches were purely coincidence, most of the time they were immature and reproductively inactive. The monthly development of gonado somatic index indicated that only single peak occurred in May and June. However, observation on the spent females indicated that spawning season occurred during the South-East monsoon (August–November). Spawning season most probably occurred within this time (May–November). Length at first maturity was 19.7 cm, FL. The batch fecundity is estimated between 43 to 88 thousands eggs. The average diameter of the mature eggs varied from 0.67 to 0.70 mm. This species seems to spawn along the continental slope of eastern part of the Java Sea.

KEYWORD: scad, *Decapterus Macrosoma*, reproduction, Java Sea

INTRODUCTION

The pelagic fisheries in the Java Sea have developed rapidly since the mid 1970's, after the introduction of the purse seine fleet and the trawl ban in 1980. This fleet became the sole semi industrial exploitation in these waters. Numerous trawlers were transformed into purse seiners. In 1982/1983, the fleet extended their fishing ground towards the eastern part of the Java Sea and the southern part of the South China Sea. This extension was made easier by the introduction of bigger vessels (80-100 GT). In 1986/1987, fishing tactic changed, light was replaced fish aggregating device (FAD, rumpon) (Atmaja & Sadhotomo, 1985; Potier & Sadhotomo, 1995a).

At least four species of scads were found in Indonesian waters, i.e., *Decapterus kurroides*, *Decapterus macarellus*, *Decapterus russelli*, dan *Decapterus macrosoma*. In the southern part of the Sunda shelf, the last two species were the main components of small pelagic resources. They represented up to 60% of the catch in eastern part of the Java Sea (Potier & Sadhotomo, 1995a). Before the introduction of the purse seiners in the Java Sea, *Decapterus russelli* was commonly caught by danish seine fishery (Potier & Sadhotomo, 1995b). Concerning with frequency of occurrence of species in the fishing zones, *Decapterus macrosoma* was grouped into the fish which like oceanic habitat (Sadhotomo & Durand, 1997). The landings increase significantly since the fishing grounds have been extended eastward. The monthly landings peaked obviously from October to April (Atmaja, 1999).

Preliminary studies on reproductive biology had been pioneered by Delsman (1926) on the early life stage and De Jong (1940) on eggs size distribution of

some pelagic species. De Jong concluded that only one batch of eggs in the ovary and after spawning the ovary resembles empty of sack. Hardenberg (1938) gave an hypothesis on the distribution of scads populations *Decapterus* spp. in the Java Sea. He stated that there were three populations of scads inhabit the Java Sea waters, one from the east entering the Java Sea from Flores Sea during the South East monsoon and the other two populations coming from the west during the North West monsoon via the Indian Ocean then enters the Java Sea through the Sunda Strait and from South China Sea one through the Karimata Strait. Part of the eastern population residents in the Java Sea and its spawning grounds were near to the Bawean Island. Venema (1996) stated that scads spawn along the continental slope of the Java Sea. Widodo (1989) stated that the increases in the exploitation rate will lead to the recruitment overfishing, the size at first capture (Lc) being longer than the size at first maturity (Lm). The individuals that inhabit the Java Sea waters were being inactive stage of reproduction (Atmaja *et al.*, 1995).

The present study described and clarified the reproduction of *Decapterus macrosoma* in Java Sea through the analysis of the scad landings by purse seine net, including stage of maturity, spawning season, size at first maturity, and fecundity.

MATERIALS AND METHODS

Materials

Data of reproduction aspects were collected at several landing places, i. e., Pekalongan, Juana, Rembang, and Sarang (Central Java), Kota Baru (South Kalimantan), Indramayu (West Java) during

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period of 1992-1995 and Labuan (West Java) from April-May 1998. This was part of the research activities of Research Institute for Marine of Fisheries and Java Sea Pelagic Fishery Assessment Project. The specimens were collected from the landings of commercial purse seine fishery and they were coming from all the main fishing grounds in the Java Sea.

Methods

The stage of maturity

The stage of maturity is adapted from several studies with differences species and ecological areas, because of inavailability of intensive investigation carried out in the Java Sea. We modified the criteria of *Sardinella longiceps* (Raja, 1967), *Clupea harengus* (Iles, 1984; Hempel, 1979), *Sardinella aurita* (Fontana, 1969) and manual of biological observation (Holden & Raitt, 1974). Then, maturity staging by Gonado Somatic Index was confirmed by microscopic examination, i. e., egg size. The index denoted as Gonado Somatic Index indicate a primary reproductive effort in fish and to reflect the development of the ova, i. e. stage of maturity. It was calculated as percentage of the gonads weight over somatic weight, as expressed in the following formula (Iles, 1984):

$$GSI = Wg/(Wb-Wg) \times 100$$

where:

W_g and W_b = the gonads and body weight respectively.

Length at first maturity

Sampling procedure, length composition of biological samples can be adjusted using length data which was regularly obtained by measuring the sampling. In each length group, for easily distinguishable fish, five individuals were chosen for a biological study. The sex was determined by dissection and examination of the gonads. The maturity stage, gonad weight, were recorded. A total of 2,250 specimens of a size longer than 13 cm was collected.

Length at first maturity was estimated by performing mean length of which the female individual considerably mature. This estimation would be analog as the length at which 50% of the fish are mature. The term of length at first maturity is commonly used in the context of population dynamics and estimated from cumulative frequency distribution. The definition of mature for various literatures were based on different criteria. In order to avoid subjectivity of staging and ambiguity of criterium used for mature fish, it is preferable to use the values of Gonado Somatic Index higher than 4%. Sadhotomo (1998) in a study on small pelagic caught by the purse seiners, determined the ovaries as mature when Gonado Somatic Index was

higher than 4%. This value of Gonado Somatic Index has showed the ovary occupy almost the whole body cavity, abdomen distended.

Fecundity

Fecundity is defined here as the total number of ripe ova present in a female immediately prior to spawning, there is only a single batch of mature eggs (translucent eggs), sharply separated with smaller eggs stock (opaque eggs) as called batch fecundity (De Jong, 1940; Fontana 1969). Fried & Walsh (1991) stated that batch fecundity is the number of hydrated oocytes released in one spawning, usually determined by counting the number of hydrated oocytes in the ovary. The estimation of the number of eggs in the last mode was calculated from subsamples of the ovary with eggs diameter larger than 0.5 mm. The subsamples were between 0.1 to 0.3 g, measured and counted with 2 or 3 replications. The subsamples were counted under a binocular microscope, with 100x. The batch fecundity was determined by gravimetric method (Bagenal, 1978a), which was estimated by the following equation:

$$F = (Wg/Ws).n$$

where:

F = batch fecundity

W_g = gonad weight (g)

W_s = weight of subsample (0.1 to 0.3 g)

n = number of ova in subsample from the last mode within the distribution of ova diameter

RESULTS

Distribution of Gonado Somatic Index

Sexual maturity

Often in fisheries work only the female ovaries are studied, because these are larger and more easily examined than male testes, it also assumed that development of both ovaries and testes are synchronous. Ovaries may be examined microscopically and classified into various developmental stage. The particular event of interest in the reproductive cycle of a species is the time spawning, when fully developed gametes are released (King, 1998).

For the sake of uniformity of staging criteria used in this study, it emphasizes on the use of for the sake of uniformity of staging criteria used in this study, it emphasizes on the use of for the sake of uniformity of staging criteria used in this study, it emphasizes on the use of Gonado Somatic Index rather than the stage of maturity. However, visual observations were done by three people (of the biology team of the Pelfish Project) and several university students that

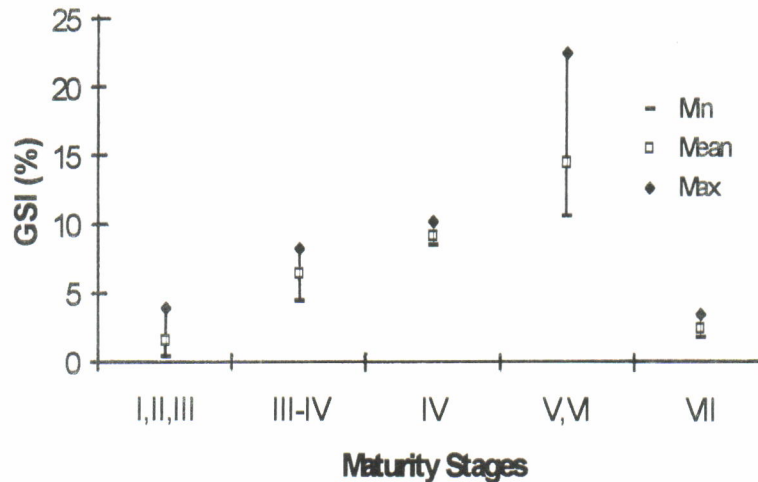


Figure 1. Relationships between Gonado Somatic Index (%) and maturity stage of *Decapterus macrosoma*, with maximum and minimum.

possibly generates a subjectivity of observation in different landing places. Structure of maturity stage of female fish was evaluated using Gonado Somatic Index and a verification for its relationship was depicted in Figure 1. The value of Gonado Somatic Index of the stages IV and V, VI were 8.5-10.2% and 10.6-22.6% respectively. Linkage between Gonado Somatic Index, macroscopic and microscopic for ripe and spawning stages (Figure 2). Ripe stage was characterized by ovaries which contain opaque eggs. According to the diameter of these eggs, Gonado Somatic Index values range from 4% to over 6%. Spawning stage was characterized by a fish with distended abdomen, a peritoneal cavity filled with ovaries where translucent eggs are visible through the ovary. This phenomenon is very common in the development of ovaries and usually most species have transparent eggs to reduce the predation (Johannes in Bailey & Houde, 1989). The weight of gonad for stage VI represent 19.8-22.9% of the weight of the fish in *Clupea harengus* (Iles, 1984). The average of Gonado Somatic Index in stage VI of *Scomber scombrus* (Morse, 1980) and *Engraulis mordax* (Laroche & Richardson, 1980) were 24.9% and 18.1%, respectively. In the current study the average of Gonado Somatic Index in stages V and VI were 14.64%.

Distribution of Gonado Somatic Index by length

More than 40% of the individuals fish of size 15 cm (FL) were sexually undetermined. At 16 cm long, this percentage decreases to only 30% of undetermined. This size corresponds to the one found by Widodo (1988; 1991a; 1997) for the first maturity (Lm) (Figure 3a). He gave a size at first maturity of 15.5 cm.

The distribution of value of Gonado Somatic Index by length class for females can be seen in the Figure 3b. Figure 3b showed the distribution of Gonado Somatic Index values by size class (Fl) through Box &

Whisker Plots (Tukey, 1977). The range of the Gonado Somatic Index increases with the size reaching a peak at 19 cm. Median value is always close to zero and 75% of the values do not reach 2.5%. It can be stated that the fishes with mature stage (GSI>4%) scarcely in sample, indicating an incidental occurring the mature stage in purse seiner catches.

Spawning season and places

Based on period of occurrence highest average value, monthly evolution of Gonado Somatic Index demonstrated only one peak a year (Figure 4). This would indicate that spawning season during the periods of observation, although some peaks that clearly shown in the figure came from few specimens only. Unfortunately, there is no information on the development of Gonado Somatic Index from immature stage to spawning stage that enable us to classify the group of spawner for the next spawning. More precisely, the occurrence of spent specimens would give a direct indication of spawning season. Prediction of spawning season based on summarizing the occurrence of spent specimens (Table 1). This showed that spawning season also occurred in most of the months between July and November.

However, based on back calculation of age of juvenile fish entering the fishery at beginning recruitments (Table 2), showing that this species also spawned in January–March.

Ripe stage specimens were found in July 1992 and May-June 1993 in the sub area Matasiri-Samber gelang Bank, while the spent ones (partly and fully) were frequently found in July-August in the more extensive sub areas i. e. Bawean-Lumu-lumu Bank in the southern most of Makassar Strait (Table 3). A preliminary conclusion can be drawn for spawning behaviour of *Decapterus macrosoma*. It appears that spawning takes place in the near slope ground or probably beyond the Java Sea.

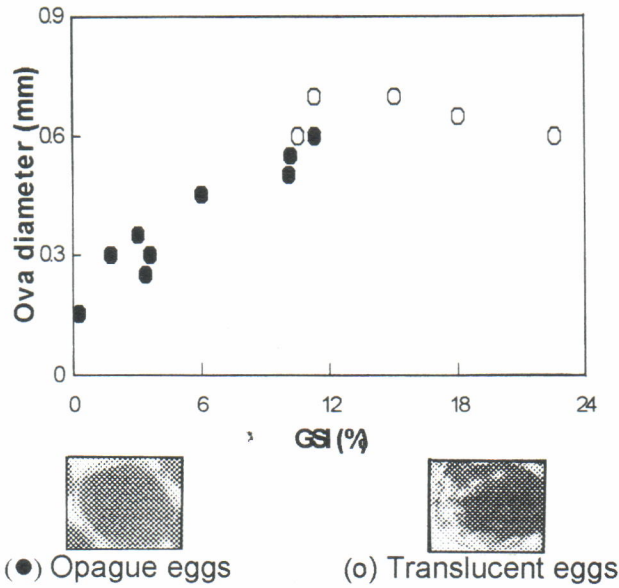


Figure 2. Plot eggs diameter and Gonado Somatic Index (%) value of scads.

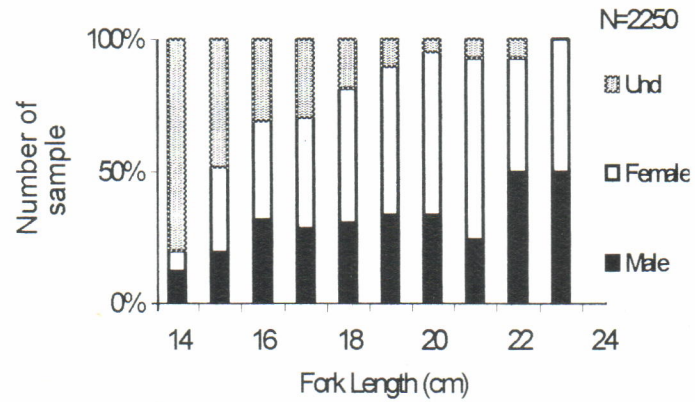


Figure 3a. Percentage of male (below), females (center), and undetermined individuals (above) by class size (cm).

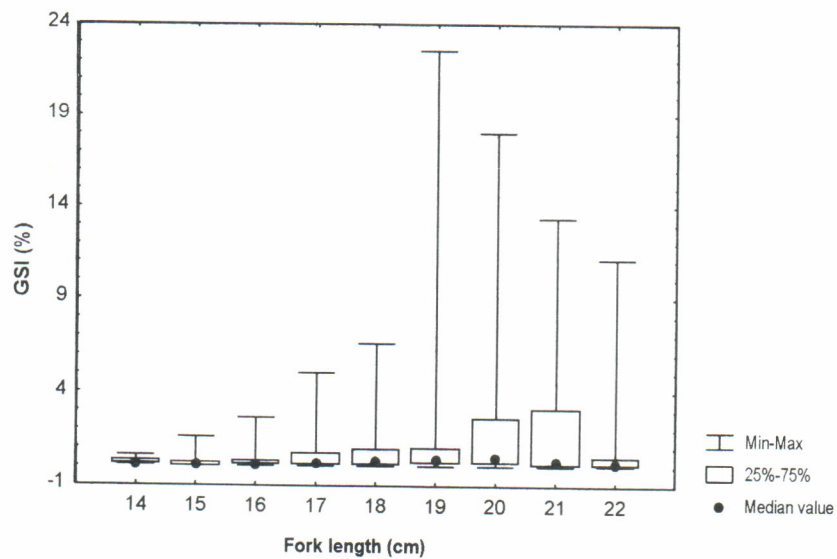


Figure 3b. Distribution of Gonado Somatic Index (%) value of *Decapterus macrosoma* by size (cm).

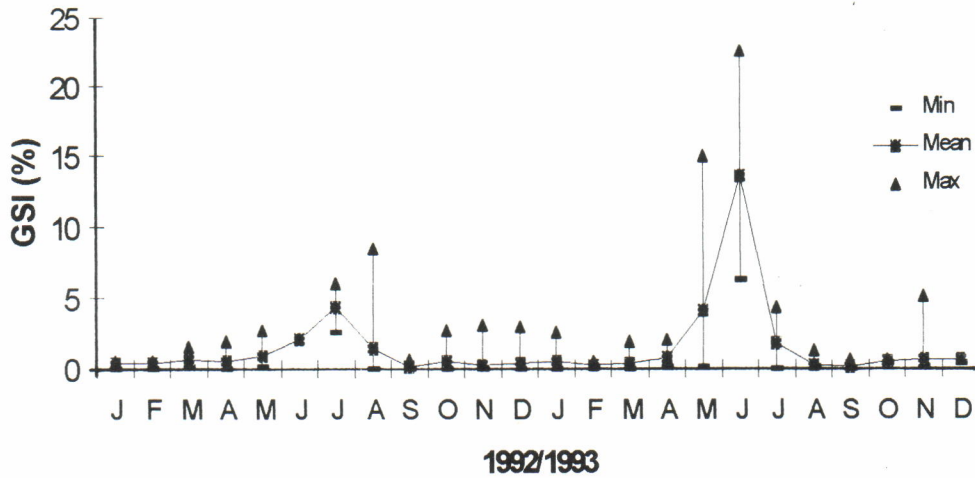


Figure 4. Monthly evolution of Gonado Somatic Index values of the main species in the Java Sea, 1992/1993.

Table 1. Monthly distribution of maturity stages (%)

Month/Stages	I, II, III	III, IV	IV	V, VI	VII	n
January	100					227
February	100					137
March	100					92
April	100					52
May	94.5			5.4		56
June	78.5	3.1	3.1	15.4		65
July	60.5	30.4			8.3	23
August	84.4	13.0	1.3		1.3	77
September	93.0				6.9	29
October	97.9	1.0			1.0	97
November	96.5	0.8			2.3	130
December	100					74

Table 2. Approximates spawning season of *Decapterus macrosoma* as back calculated from length at the first period of entering the fishery (underlined figures are derived from minor distribution) (Sadhotomo, 1998)

Approximates spawning periods	Modes of length (cm)	Periods of observation
August 1991	8.5	November 1991
January 1992	12.5	July 1992
January 1993	11.5	June 1993
February 1994	12.5	June 1994
August 1994	10.5	November 1994
March 1995	9.5	June 1995

Table 3. Maturity stages and Gonado Somatic Index (%) classification by fishing ground

Zones/Stages	I, II, III	III, IV	IV	V, VI	VII	n
Labuan	98	2				80
Indramayu	100					20
Karimunjawa	99.4	0.6	-	-	-	154
Bawean	96.9	1.1	-	-	2.1	96
Masalembo	93.8	3.4	-	1.4	1.4	208
Matasiri-Samber geleng	92.5	1.9	0.7	3.7	1.1	268
Lumu-lumu	94.8	4.3	0.5	-	0.5	211
Kangean	100	-	-	-	-	112

Size at first maturity

Estimation of the mean length of the mature female was derived from the frequency distribution of the mature female (GSI>4%). The female would reach maturity at 19.7 cm in average of fork length (Figure 5). In the Philippines waters, this species matures at length of 18-20 cm at the beginning of the third year of life (Tiews *et al.*, 1970). They also suggested that *Decapterus macrosoma* spawns only once in its life span.

Sex Ratio

The proportion of female seems to vary by month. Proportions of females of *Decapterus macrosoma* tended to pass the males almost all year (Figure 6). There is no significant conclusion to extract from this figure without evaluating reproductive behaviour and the relationship between female stock and successive recruits.

Fecundity

Due to the lack of mature sample found within current observation data, the fecundity was evaluated from a few specimens (*i. e.* only 10 specimens),

where the ovaries with eggs ready to be spent or exactly in ripe stage. In this stage, there is only single batch of mature eggs found in the ovary sharply separating from the immature ones. The mature eggs are easily differentiated from the smaller opaque ova (immature ones) and their size vary from 0.50 to 0.90 mm in diameter (Figure 7). Immediately, after spawning (spent or partly spent stages) the ovaries still contain some residual translucent and the immature eggs. These unshed eggs will be reabsorbed into ovarian tissue as shown by opaque eggs in some spent stage specimens. Pried & Walsh (1991) first point out that the fish release eggs in discrete batches rather than continuously. Is suggests that this species never spawns more than once in a year. After spawning, the fish usually do recovery that can be shown by large size (more than 21 cm) in resting stage or in inactive condition. The average of fecundity estimated to be 61,200 eggs per batch of female fish with the range values of 43,000-88,000 (Table 4 and Figure 8).

The fecundity seems to be lower than that in the Philippines waters that counted to be in the range of 68,000 to 106,000 eggs per female (Tiew, *et al.*, 1970). Unfortunately, its relation to the body size is not clear due to the narrow range of the size of the

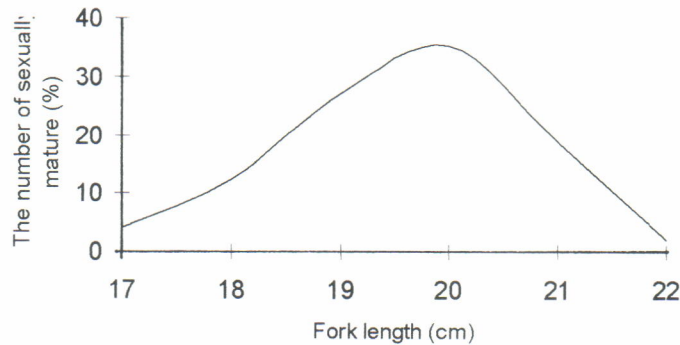


Figure 5. Length frequency of female scads by GSI value >4 %.

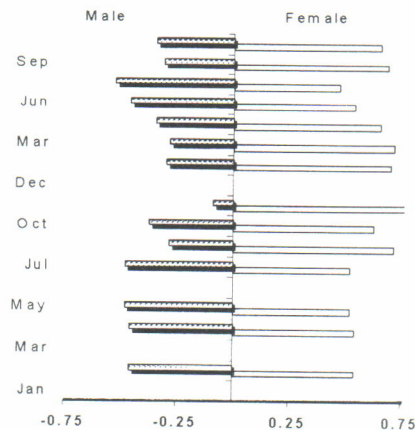


Figure 6. Proportion of sex of *Decapterus macrosoma*.

Table 4. Summary of the ten specimens (n=10) for fecundity observation

	Mean	Minimum	Maximum	Std.deviation
FL (cm)	20.06	19.3	20.5	0.45
GSI (%)	14.64	10.6	22.6	3.70
FECUNDITY	60,378	43,000	80,000	1,289

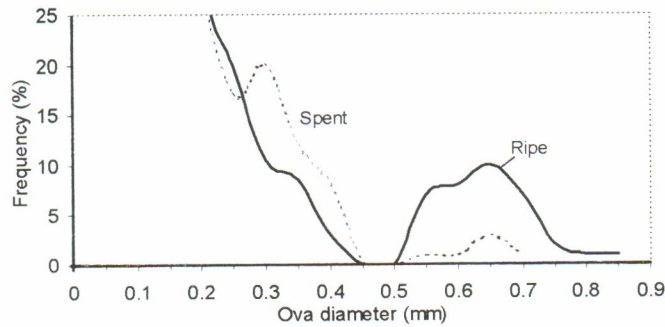


Figure 7. Eggs size distribution of mature stage of *Decapterus macrosoma*.

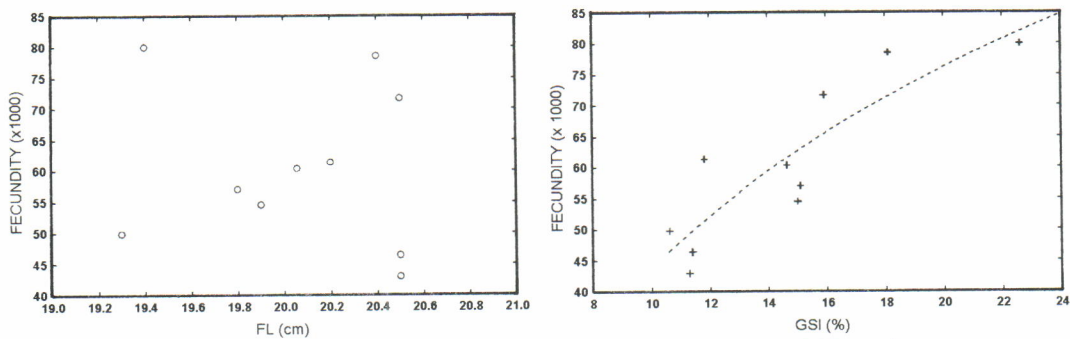


Figure 8. Plot of fecundity versus length and Gonado Somatic Index of *Decapterus macrosoma*.

specimens (*i. e.* 19.5-20.5 cm in fork length). The mature eggs (translucent eggs) were made with a diameter variation of 0.50-0.90 mm.

DISCUSSION

Staging criteria used in this study was confirmed by the relative size of the ovaries and visual performance of the ova. In stage V and VI, the ovaries occupy almost the whole of body cavity and eggs are translucent. Visual examination show an abdomen distended, the whole peritoneum cavity is filled with ovaries and translucent eggs became easily visible through the ovary wall. In this stage also part of the ova is ready to spent and the Gonado Somatic Index value will attain maximum (Figure 1) as well as the ova size (Figure 2). While the difference with the observation of Widodo (1988; 1991a) was probably due to the different visual determination. However, it could not infer that different population may have different reproductive characteristic since the criteria and the composition of samples by length (age) used are not comparable. It believes that his study was not

including the ovary with translucent eggs (stages V and VI).

The size at first maturity appear slightly lower than the result of previous studies from Atmaja *et al.* (1995)². On the other hand, Widodo (1991a; 1991b; 1997)³ estimated the length at first maturity to be much lower than others eventhough the criteria of staging are almost same. Apparently, microscopic verification is needed for determining the mature condition but this procedure is time consuming. For this reason we used translucent eggs for mature criterium of female of this species. In this case, subjectivity of observation plays an importance role in influencing the final results, more than the methods applied.

Prediction of spawning season based on summarizing three methods (monthly evolution of Gonado Somatic Index, the occurrence of spent specimens and based on back calculation of age of juvenile fish entering the fishery at begining recruitments), if these methods were mutually supplement. A conclusion can be drawn that

Decapterus macrosoma spawns all year, but juvenile fish entering the fishery at the beginning of recruitments.

Difficulty of finding the mature fish inside the Java Sea (in the area covered by this study) would immediately reveal conclusion that this area is not the spawning ground of this species, or at least this species do not spawn in the fishing ground of the purse seine. We found in our study similarly to De Jong (1940) who noted that ripe fishes are rarely found in the Java Sea even during spawning season. In relation to recruitment and migration scheme, Sadhotomo & Potier (1995) implicitly indicated a possible spawning ground of pelagic species (for the highly migrant species, such as *Decapterus macrosoma*) in the slope of eastern part of the Java Sea without giving any detail. However, this (hypothesis) means that the most likely spawning ground would be outside of the Java Sea. Delsman (1926) showed an indication of spawning ground of layang (*Decapterus russellii*) near Bawean and Madura Islands in his mission on June 1920 and October 1922. His statement of observed of fully mature fish in fishermen catch could be unreliable indication for spawning ground as there was no direct observation had been made for determining the maturity. Also, eggs and larval stages specimens found in that subarea might be misidentified as *Caranx kurra* and *Caranx macrosoma* (synonym of *Decapterus russellii* and *Decapterus macrosoma*). He speculatively used reference of *Trachurus trachurus* for the genus *Caranx* (*Decapterus*) and other genus of Carangidae (that recently identified as genus of *Caranx*, *Atule*, and *Alepes*).

However, a highly seasonal availability of samples in the period before development of purse seine could cause a difficulty in conducting a continuous observations on pelagic species in the Java Sea. However, the phenomena of simultaneous spawning season as indicated in almost the same period of the occurrence of the highest average of Gonado Somatic Index of the main species could not be used for corroborating the Delsman's specimens. But, in this case, one could say that the hydrological condition at that time was better than that of current period. Of course, it is a little bit nostalgic, but, it has been well known, there was no extractive exploitation on coral reef and destruction of the habitat before decade 1960's (Subani, 1972).

A question of possibility of occurrence of spawning ground in the Java Sea in past time would relate to disappearance of substock due to heavy exploitation and the change of reproductive behaviour. Unfortunately, we could not go any further because of the lack of information. Theoretically, an ideal condition in the past (say 30 years ago) can be said as analog with concept of optimal environmental window of Cury & Roy (1987). Adapting the theory of Gargett (1997), the Java Sea area at that time could

be regarded as an area with an optimal window during intermediate stabilities that is a range of stability value for which the associated condition of sea waters (nutrient and others) are sufficient, stimulating levels of primary production which are significantly larger than those of other period. Then, we could speculate that before the tremendously increase of fishing effort being started in the 1970's decade, the Java Sea stock might be composed by several subpopulations, more than those at recent years. Anyway, the Java Sea is not closed to other neighboring areas and migration of larval and nekton stage could be possible following seasonal circulation scheme of sea.

CONCLUSION

In general, the fish stock available for the fisheries mainly consist of young fishes. Very few specimen of adult fish indicated that *Decapterus macrosoma* was not available in the fishing ground, all year around.

Two groups of recruits were identified in the Java Sea. The major recruits enter the fisheries during the southeast monsoon (June-July) and the minor one during November. From back calculation of the age of youngest groups of the major recruits, we can conclude that these recruits were not the offsprings descended by the adult fishes stayed in this area in last year period. The peak of maturity of the fishes staying in the Java Sea occurs in June-July, and peak spawning season would be on July-November, while the approximate spawning of the major recruits was about November. The scarce of ripe and spawning stage specimens in the samples indicate that the spawning grounds of this species was not in the Java Sea (*i. e.* at least this was not in the fishing ground of the purse seine fleets).

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