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REPRODUCTIVE BIOLOGY OF SKIPJACK TUNA (*Katsuwonus pelamis*) IN EASTERN INDIAN OCEAN

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ABSTRACT

Skipjack tuna (*Katsuwonus pelamis*) is the one of the important catch for fishermen in the Indian Ocean. The objectives of this research are to investigate gonad maturity and length at first maturity for female cakalang in Indian Ocean. Skipjack tuna were sampled from several places in South Coast of Java i.e.: Palabuhanratu, Cilacap, Pacitan, Sendang Biru, Kedonganan, Tanjung Luar, Labuhan Lombok and Oeba from April 2012 to November 2013. Fork length of the sampled 136 fish ranged from 35 to 68 cm. Gonadal maturity stages were investigated using histological analysis and Gonadosomatic index (GSI) calculation. The results showed that maturity stage of skipjack tuna dominated by stage IV with 43%, followed by stage III (21%), stage I (17%),stage II (16%) and stage V (2%). Length at first maturity occurred at 42.9 cm.

KEYWORDS: Skipjack tuna, maturity stage, GSI, Eastern Indian Ocean.

INTRODUCTION

Skipjack tuna production was the largest among the other tunas in Indonesia. Tuna catches reached 933 815 tons from 2001 to 2010. The total catches consist of skipjack production 52%, followed by yellow fin (20%), bigeye tuna (15%), albacore (11%) and southern bluefin tuna (1%) (FAO, 2012).

Skipjack was a highly migratory species and distributed from tropical to temperate waters (Collette and Nauen, 1983). This species spawned several times in areas where the sea surface temperature was higher than 24^{o}C (Matsumoto et al., 1984). Gonadal maturity stage research using histologycal analysis was still rare in Indonesia.

One of the supporting aspects for fisheries resources management is a basic knowledge about the reproductive biology. Fish reproductive biology research can provide important data and information about the spawning frequency, spawning success, spawning period, and the length of first maturity

(Mardlijah & Patria, 2012). Gonadal maturity stage determination, in addition to describing the reproductive cycle, was also associated with the age estimation, the length of fish reaching the maturity and spawning season (Abidin, 1986). Observations via histological analysis were widely used to determine the reproductive biology of tuna. This method gives accurate results on the reproductive status of tuna (Schaefer, 2001).

The aims of this study were to determine the reproductive biology aspect of skipjack tuna, includes gonadal maturity stage, spawning season estimation, and the length at first maturity (Lm).

METHODS

The gonad samples of skipjack tuna were obtained from the catch of hand line and troll line armada which were operated in eastern Indian Ocean. Skipjack tuna were sampled from several places in South Coast of Java i.e.: Palabuhanratu, Cilacap, Pacitan, Sendang Biru, Kedonganan, Tanjung Luar, Labuhan Lombok and Oeba from April 2012 to November 2013 (Figure 1). Gonad samples were preserved and analyzed in Histology Laboratorium of Research Institute of Tuna Fisheries. Other data collecting included fork length and weight of the whole body measurement. Gonadal maturity stage was observed histologically based on the oocyte development criteria by Davis *et al.* (1996), which is classified the maturity of female gonad into five stages. (Appendix 1).

Gonado somatic index (GSI) was analyzed using the equation from Afonso-Dias *et al*. (2005):

$$GSI = \frac{Gw}{Bw}\ X\ 100\%$$

where: GSI: Gonadosomatic index; Gw: the weight of the gonad (gram); W: total weight (gram)

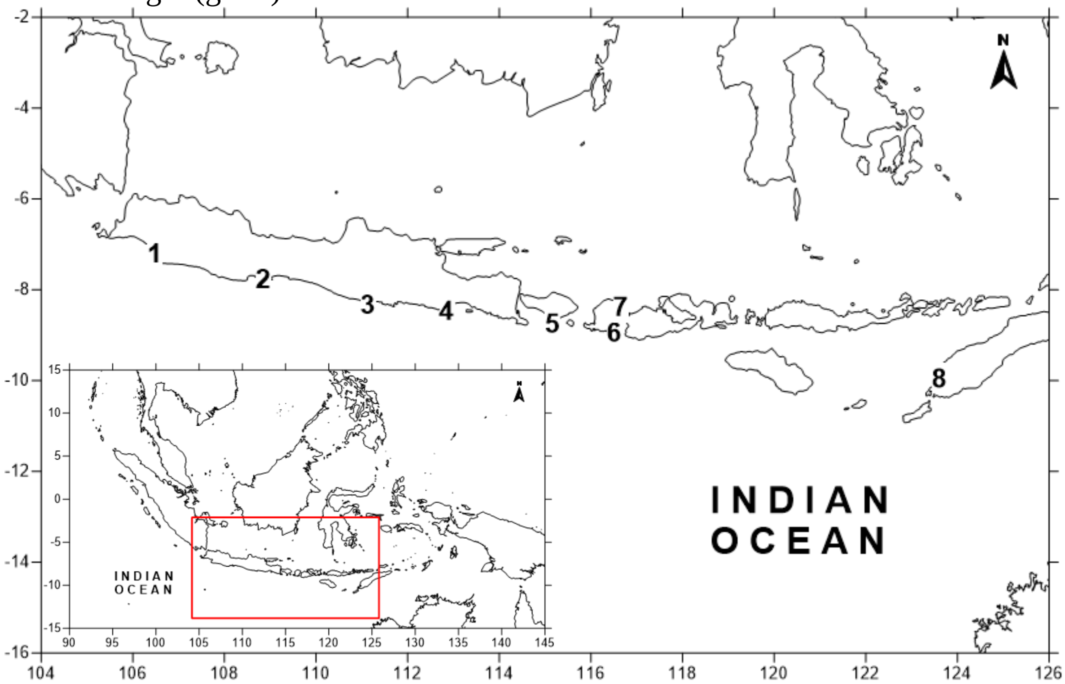

Figure 1. Gonad of skipjack sampling sites in Palabuhanratu (1), Cilacap (2), Pacitan (3), Sendang Biru (4), Kedonganan (5), Tanjung Luar (6), Labuhan Lombok (7) and Oeba (8).

Length at first maturity (Lm) was analyzed using Spearman – Karber method (Udupa, 1986):

$$m = xk + X/2 - (X\Sigma pi)$$

where: m: the log size at first maturity; xk: last log size at which 100% of fish are fully mature; x: log size increment; pi: proportion of mature fish for each size group

$$CL = antilog[m \pm 1.96\sqrt{x^2\Sigma\left\{\frac{pi\ x\ qi}{ni-1}\right\}}$$

where: CL: Confidence limit; m: length at the first maturity; ni: number of fish on length class-i; qi: 1 – *pi*

RESULT

The samples were collected in 13 months, from April 2012 until November 2013. One hundred and thirty six skipjack tuna were collected and distributed between 35-68 cm fork length. The mean length of the collected sample was dominated by 50 cm FL (Figure 2).

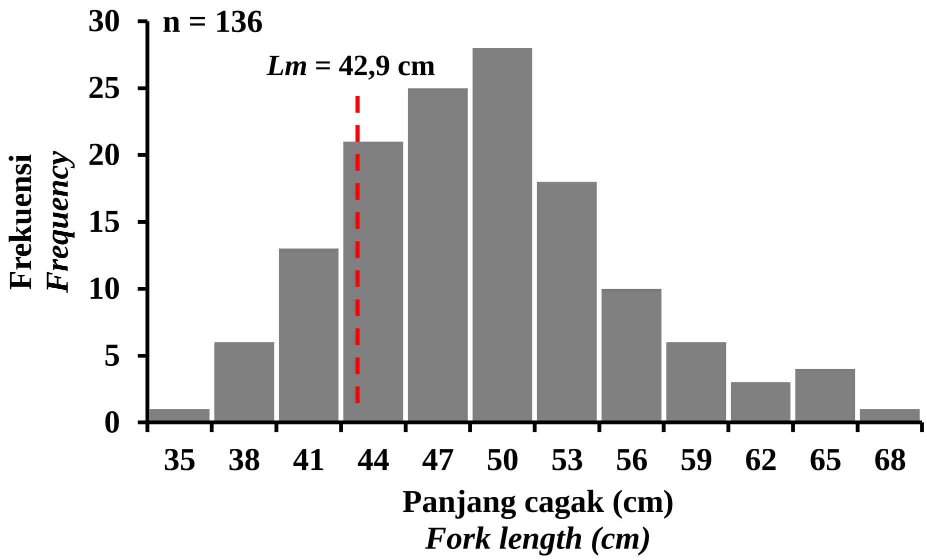

Figure 2. Length frequency of skipjack tuna (Katsuwonus pelamis) in Indian Ocean. Fork length is mid-length with 3 cm intervals.

Histological observation showed that the skipjack gonads were in complete stage of gonadal maturity stage, from stage I until stage V. Stage I was the stage of oogenesis. The oosit is still small and the nucleus was round or oval with a thicker cytoplasm. At stage II, the oocyte began to develop and entering the initial phase of vitellogenesis which was the yolk deposition process on each egg. The oocyte diameter and the nucleus were bigger. The yolks were scattered around the oocyte and the nucleus.

Stage III, also known as advanced yolked stage or early stage of mature gonad. At this stage, the number and size of the yolk granules were increased and clearly visible in all areas of the oocyte. Oil droplets began to appear in the cytoplasm, the nucleus was concentrated in the central of the oocyte and zona radiata was wider.

Stage IV is the maturation stage. A lot of yolk granules had reached fully yolked oocytes, the oil droplets were more more distributed from around the nucleus to the periphery of the oocyte. The nucleus migrated around the oocyte and commonly replaced by some oil droplets. Stage V was the final mature stage or hydrated stage. The yolks were incorporated into one and looked like a stain (Figure 3).

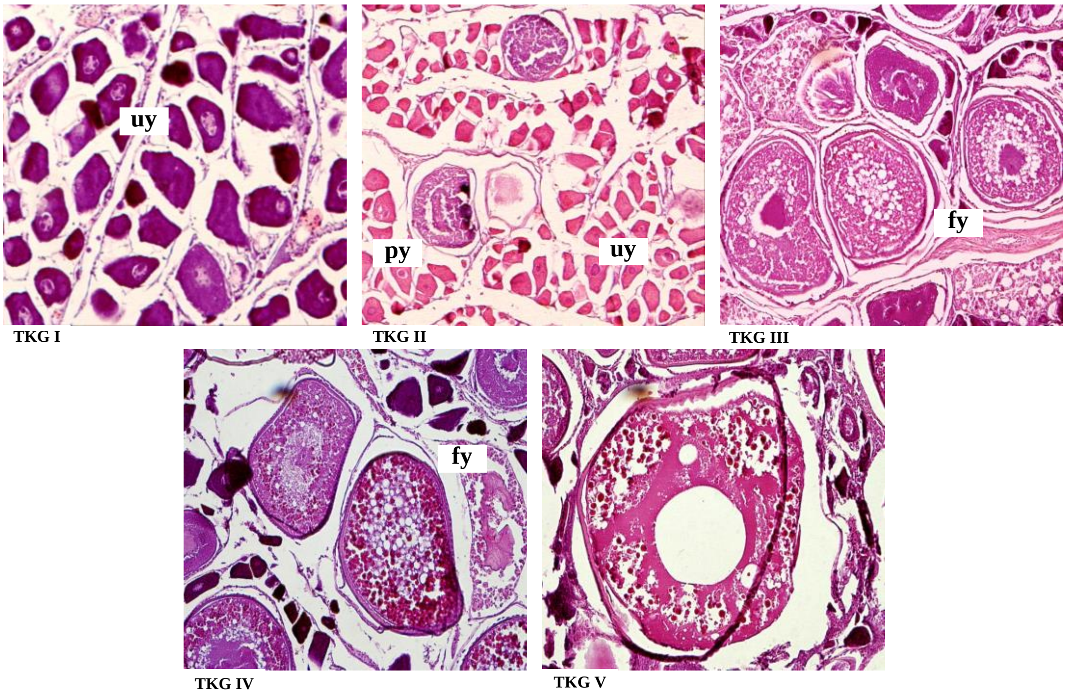

Figure 3. Histological section of skipjack tuna from TKG I to TKG V with 100x magnifications. uy = unyolked; py = partially yolked; fy = fully yolked.

The gonad maturity stage of the caught skipjack tuna were dominated by stage IV (43%), followed by stage III (21%), stage I (17%), stage II (16%) and stage V (2%) (Figure 4). Gonad maturity stage percentage in each fork length class was also dominated by stage IV. The stage IV were found in all midlength class which were larger than 41cm, ecxept 62 cm midlength. Furthermore, the stage IV were also found fully (100%) on the 65 cm and 68 midlength class. In addition, stage I and stage II were found fully on 35 cm and 38 cm midlength class (Figure 5).

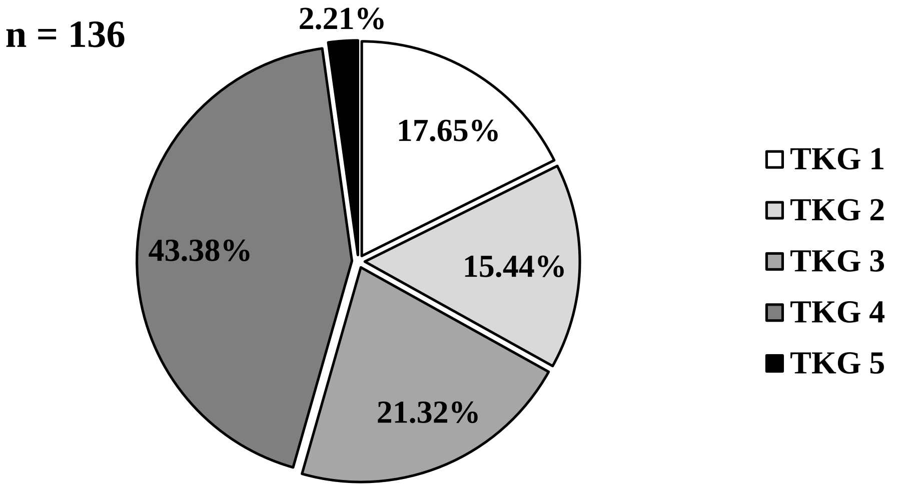

Figure 4. Percentage of maturity stage for skipjack tuna based on histological analysis.

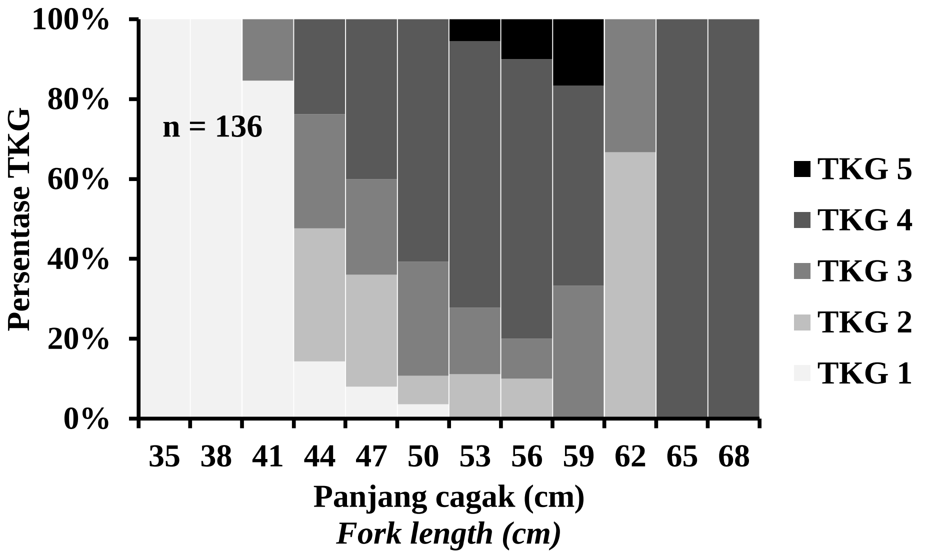

Figure 5. Maturity stage for skipjack tuna based on length class. Fork length is mid-length with 3 cm intervals.

The skipjack tuna Gonadosomatic Index (GSI) was 1.44 (0.71 to 2.56). The monthly distribution GSI showed that the highest value occurred in October 2013, while the lowest in August 2012 (Figure 6). The calculation of the first maturity size of the fish began at stage IV where the fish were categorized as mature (Farley & Davis, 1999), in Mardijah and Patria (2012). The first size of mature skipjack tuna in Indian Ocean was 42.9 cm with a range from 41.6 to 44.3 cm using Spearman-Karber methods (Appendix 2).

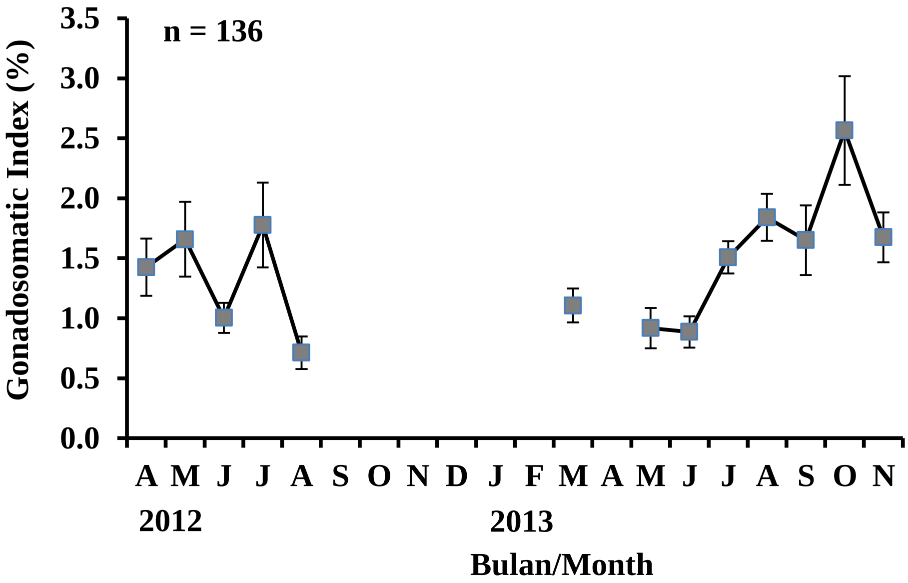

Figure 6. Monthly GSI distributions of skipjack tuna in Indian Ocean from April 2012 to November 2013.

DISCUSSION

Skipjack tuna was asynchronous spawner, there are several size of oocytes in a section of a gonad. Same condition was also happened in yellow find tuna which was landed in Benoa Port – Bali (Andamari et al., 2012; Faizah & Prisantoso, 2010). This was consistent with the study by Matsumoto *et al.* (1984)

which stated that skipjack tuna spawned year-around and the eggs were released partially over a long period (partial spawner) (Effendie, 2002).

From the analysis of GSI, the highest percentage was occured in October and spawning was predicted occurred on November. According to Widodo (1986) in Mardijah dan Patria (2012) stated that the spawning season occured approximately one month after the highest percentage of mature fish. However, a proven was still required by doing some full year skipjack tuna researchs to determine its spawning season in Indian Ocean. Moreover, the spawning time of skipjack tuna was on November until Desember which affected by warm waters (Froese & Pauly, 2011).

The length at first maturity (Lm) of skipjack tuna in this study (42.9 cm) was similar to the first size of skipjack tuna maturity which was captured in western Indian Ocean (Mauritius waters), 43 cm for female and 44 cm for male (Norungee and Kawol, 2011). *Indian Ocean Tuna Commission (IOTC)* reported that the first size of skipjack tuna maturity (L_m) was 38 cm, while the the fully mature was on 44 cm (IOTC, 2013).

The first length of skipjack tuna maturity from this study was smaller than the skipjack tuna which was captured in Bone Bay, South Sulawesi. The size was 46,5 cm which was reached in 6 months (Jamal, 2011). Nevertheless, the result of this study was larger than the skipjack tuna which was captured in western Indian Ocean (37,8 cm) (Grande *et al.*, 2010). The difference in result could occur because the same species probably have different first length of maturity (Udupa, 1986).

CONCLUSION

This research concluded that the gonads of skipjack tuna were dominated by stage IV. The spawning season was on November and the length at first maturity was 42.9 with a range from 41.6 to 44.3 cm.

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Appendix 1. The criteria of gonad maturity stage

Maturity Stage	Condition	Remarks
1	Immature	Small perinuclear oocytes with purple stained cytoplasm and a spherical nucleus. Peripheral nucleoli (small black dots) may be seen in the nucleus, along with differential staining of the cytoplasm, which might be precursors of yolk Vesicles
2	Early mature	An accumulation of pale purple stained yolk vesicles begins in the cytoplasm. These yolk vesicles initially concentrate at the periphery of the oocyte and spread inwards towards the nucleus. Peripheral nuclei are present.
3	Late maturing	Pink stained yolk granules (spheres) are present throughout the oocyte. The zona radiata is wide, turns pink and shows radial striations. The nucleus is centrally located.
4	Ripe	The nucleus migrates to the periphery of the oocyte and is usually replaced by a few large oil droplets. Sometimes you can see the yolk granules fusing to form yolk plates
5	Spent	The yolk coalesces completely (uniform pink stain). The oocyte significantly increases in size and appears irregular in shape (probably due to a loss of fluid during histological preparation)

Appendix 2. Calculations of length at first maturity (Lm) of skipjack tuna in Indian Ocean.

Length group (cm)	Mid length (cm)	Log mid length (Xi)	Number of fish (ni)	Im-mature	Mature (ri)	Proportion of mature fish (pi)	Xi+1 - Xi=X	qi=1-pi	(pixqi)/(ni-1)
34-36	35	1.5441	1	1	0	0.000	0.0357	1.0000	0.0000
37-39	38	1.5798	6	6	0	0.000	0.0330	1.0000	0.0000
40-42	41	1.6128	13	11	2	0.154	**0.0307**	0.8462	0.0108
43-45	44	1.6435	21	10	11	0.524	0.0286	0.4762	0.0125
46-48	47	1.6721	25	9	16	0.640	0.0269	0.3600	0.0096
49-51	50	1.6990	28	3	25	0.893	0.0253	0.1071	0.0035
52-54	53	1.7243	18	2	16	0.889	0.0239	0.1111	0.0058
55-57	56	1.7482	10	1	9	0.900	0.0227	0.1000	0.0100
58-60	59	**1.7709***	6	0	6	**1.000**	0.0215	0.0000	0.0000
61-63	62	1.7924	3	2	1	0.000	0.0205	1.0000	0.0000
64-66	65	1.8129	4	**0**	4	0.000	0.0196	1.0000	0.0000
67-69	68	1.8325	1	**0**	1	0.000	0.0000	1.0000	0.0000
			136	**45**	**91**	**4.9994**			**0.0523**

*) Last log size at which 100% fully mature

m = Xi + X/2 - (X x "pi)	***CL = Antilog ((m ± 1.96 "X² x "(pi x qi)/(ni - 1))***
m = 1.7709 + (0.03/2)-(0.03 x 4.99)	Upper limit: Antilog (1.6328 + 1.96 "(0.03² x 0.052) = 44.3
m = 1.6328	Lower limit: Antilog (1.6328 - 1.96 "(0.03² x 0.052) = 41.6
Antilog(1.6328) = 42.9 cm	**Lm = 42.9 cm (41.6 - 44.3 cm)**