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ANALYSIS OF SEX RATIO BY LENGTH CLASS OF YELLOWFIN (*Thunnus albacares*) AND BIGEYE TUNA (*Thunnus obesus*) CAUGHT BY INDONESIAN LONGLINERS IN THE EASTERN INDIAN OCEAN

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ABSTRACT

This paper present the sex ratio results corresponding to yellowfin tuna-YFT (*Thunnus albacares*, Bonaterre 1788) and bigeye tuna-BET (*Thunnus obesus*, Lowe 1839) obtained by scientific observer program courtesy of Research Institute for Tuna Fisheries (RITF). Data collection was conducted from August 2005 to December 2014 following Indonesian longliners based in Benoa, Palabuhanratu, and Padang fishing port. Chi square analysis also used to determine sex ratio. YFT size ranging from 30 and 179 cmFL, however 81,19% of them had been eligible to be captured. While 69,21% of BET had been eligible with size ranged from 30 to 192 cmFL. Sex ratio of (F:M) 1:1,45 was observed for YFT and 1:1,32 for BET respectively indicated that male was dominant than female. Correlation between sex ratio and length proved to be significant with different pattern for YFT and BET. However, both of those correlation could be described as linear regression equation.

***KEYWORDS**: sex ratio, length distribution, yellowfin tuna, bigeye tuna, eastern Indian Ocean*

INTRODUCTION

Yellowfin and bigeye tunas are two of the most important tuna species distributed widely from tropical and subtropical waters (FAO, 1994), including Indonesian waters (Uktolseja *et al.*, 1991; Wudianto and Nikijuluw, 2004). Both of these fishes also have economically valuable and dominate catches of tuna with the percentage of 69% and 24% respectively of the total national catch (DGCF, 2012). Total catch of these species landed in domestic ports of Indonesia, in particular in Benoa fishing port which was contributed 60% of national catch, has reached about 25,913 ton in 2013 (RITF, 2013).

Biological information such as length, weight, age, growth, sex ratio, etc. were important for not only understanding life history, but also for the stock assessment of the species. Thus, collection of biological information became the first step on studying fishery

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biology of the species. These information also are required for consideration of management measures of the species in the future. In this study, we reported biological information of these two most dominant tuna species caught by Indonesian tuna longline fishery operating in the eastern Indian Ocean. The information consisting length distribution and sex ratio due to poor data issues was occurred in this fishery. Several authors have conducted studies on sex ratio by length class of YFT and BET in the Indian Ocean. However, knowing that given information is still limited, thus similar research covered more areas in Indian Ocean are imminently needed, either as a comparison or adding existing information.

MATERIAL AND METHODS

Data consisting of setting position, length of caudal fork (LCF) in centimeter, and sex were obtained from scientific observer program conducted by Research Institute for Tuna Fisheries (RITF). Data was collected from August 2005 to December 2014 which was following commercial logline vessel operation comprising 93 trip (Table 1) mainly based in Benoa, Palabuhanratu and Bungus fishing port. The length data was aggregated into 5 cm of length interval and also compared with length at first maturity (L_{50}) for YFT and BET = 100 cm (IOTC, 2013) to determine proportion of fish which eligible to captured. Chi Square analysis with 95% of confidence also implemented to determine sex ratio between female and male. Hypothesis in this study that sex ratio of male and female is equal (1:1). Then, correlation between length and sex ratio was calculated using regression formula following Nootmorn *et al.* (2005).

RESULT AND DISCUSSION

Yellowfin Tuna

Total of YFT which were caught by Indonesian longliner during 2005-2014 were 2,343 fish, but only 2,318 of them could be measure due to several reason i.e. those fish had been preyed partially by predator during towing process or had been measured using different method and unit. Length distribution ranged from 30 to 179 cm, with mode size ranged from 106 to 110 cm and the average was 117.59 cm (Table 2). However, if we compared with size of first maturiry (L_{50}) there were 81.19% or 1,882 fish of YFT had been eligible to be captured. Meanwhile, 18.81% or 436 fish were not eligible (Figure 1).

Sex ratio, the monthly proportion of male and female was used to expect the spawning capability of fish (Hamano & Matsuura, 1987 *cited* in Nootmorn, 2005). Sex ratio of YFT between female and male was 1:1,45 and significantly different with equal condition (1:1) ($X^2_{value} = 52.89 > X^2_{(0.05)} = 3.84$; freedom degree = 1). Female was 675 fish ranged from 30 to 170 cm, while male was 978 fish ranged from 43 to 179 cm. However, if we compared with size at first maturity (L_{50}), there were 94.37% of female and 82.31% of male had been sexually matured (Figure 2). Similar result also gathered from previous study i.e. Rohit & Rammohan (2009) in Andhra waters (India); Kar et.al (2012) in Andaman and Nicobar waters; Zhu et al. (2008) in Central and Western Indian Ocean; and Marsac et.al (2006) whose reported that male was predominantly than female. Female ratio fluctuated with irregular pattern, in particular at size below than 120 cm. Meanwhile, there was decreased female ratio indicating between 136 and 180 cm as described as linear regresion equation (Female ratio = 2.1636 – 0.073FL; $R^2 = 0.9523$; n = 9). Even, female was not found at size larger than 170 cm (Figure 3). Fonteneau (2005) also concluded that male are increasingly dominant at sizes greater than 140 cm, reaching levels close or over 80% of male at 160 cm in every ocean (Fonteneau, 2005).

Bigeye Tuna

Total of BET which were caught by Indonesian longliner during 2005-2014 were 5,933 fish and 5,930 of them could be measured. Length distribution ranged from 30 to 192 cm, with mode size ranged from 96 to 100 cm and the average was 111.70 cm (Table 3). However, if we compared with size of first maturiry (L_{50}) there were 69.21% or 4,104 BET had been eligible to be captured where their size were larger than L_{50}. Meanwhile, 30.79% or 1,826 fish were not (Figure 4). Maximum size of BET were caught by in the Eastern Indian Ocean had smaller size than previous study. Ariz *et al.* (2006) reported that BET has been caught in southwestern Indian Ocean obtained through scientific observer

program ranging from 25 to 208 cm. While Zhu *et al.* (2009) reported that BET caught in the central Atlantic Ocean ranging from 50 to 206 cm.

Sex ratio of YFT between female and male was 1:1,32 and significantly different with equal condition (1:1) (X^2_{value} = 79.42 > $X^2_{(0.05)}$ = 3.84; freedom degree = 1). Total of female was 1,767 fish ranged from 42 to 192 cm, while male was 2,338 fish ranged from 56 to 184 cm. However, if we compared with size at first maturity (L_{50}), there were 84.10% of female and 80.37% of male had been sexually matured (Figure 5). These results are similar to previous studies by Anrose & Kar (2010) in the Andaman Sea and Nicobar; Farley *et al*. (2004) in the Coral Sea (Zone Fishing Australia); and Xu *et al.* (2006) in the western part of the Atlantic Ocean reported that male was more dominant than female. Meanwhile, different results also reported by Nootmorn (2004) in the eastern Indian Ocean; and Wang *et al.* (2002) in Taiwan waters, where female was more dominant than male. Differences in sex ratio is often influenced by three factors i.e. differences in reproductive behavior, environmental conditions and pressure of fishing activities (Bal & Rao, 1984). Female ratio fluctuated with irregular pattern, in particular at size below than 120 cm. Meanwhile, female ratio was increased and nearly equal (1:1) between 96 and 145 cm as described as linear regresion equation on Figure 6 (Female ratio = 0.0589+0.0031 FL; R^2 = 0.8151; n = 10). However, males tend to be slightly dominant for larger BET mainly at size more than 175 cm where female was no longer found. The 100% levels of males that are often observed for large yellowfin are never seen for bigeye (Fonteneau *et al.*, 2005). Xu *et al.* (2006) reported that BET were found in western central Atlantic Ocean which had size larger than 191 cm all is male. The information concerning sex ratio-at-size of bigeye has been collected to variable degrees in the three oceans. This information is abundant in the Atlantic and Pacific oceans, and primarily comes from

samples taken on large bigeye fished by Japanese longliners. But, this information is not available for the Indian Ocean (Fonteneau *et al.*, 2005).

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Appendix

Table 1. Summary of number of trip, day at sea and position observed by scientific observer program from 2005 to 2014

Year	Trip	Day at sea	Latitude (S)	Longitude (E)
2005	9	117	12-16	107-116
2006	13	401	4-31	103-128
2007	13	258	9-33	79-115
2008	16	404	9-18	76-119
2009	13	288	0-14	95-119
2010	5	152	9-15	110-120
2011	4	111	12-15	115-120
2012	8	192	1-32	85-117
2013	6	198	9-13	100-121
2014	6	265	6-13	100-120

Table 2. Number of sample, mean, and variance of YFT length distribution

Year	n	Length of Caudal Fork (cm)				
		Min	Average	Max	SD	SE
2005	12	69	111.8	148	30.6	8.8
2006	579	54	117.1	162	21.6	0.9
2007	208	53	122.5	161	18.3	1.3
2008	448	45	131.9	172	28.4	1.3
2009	333	56	143.8	178	27.4	1.5
2010	184	30	131.9	178	28.4	2.1
2011	64	45	123.3	160	28.9	2.8
2012	197	61	104.4	179	21.5	1.5
2013	205	30	116.5	172	26.8	1.9
2014	88	54	129.2	170	27.4	2.9
Total	**2.230**	**30**	**117.6**	**179**	**27.4**	**0.6**

Table 3. Number of sample, mean, and variance of BET length distribution

Year	n	Length of Caudal Fork (cm)				
		Min	Average	Max	SD	SE
2005	419	42	110.4654	186	21.80406	1.065198
2006	852	40	108.4108	192	22.51967	0.771511
2007	582	52	114.4794	183	21.269	0.881629
2008	826	45	117.5182	180	23.29568	0.81056
2009	678	47	119.0487	183	25.71349	0.987521
2010	489	40	111.90	183	23.33423	1.05521
2011	207	50	114.285	190	28.43355	1.976269
2012	770	39	115.4416	181	24.11815	0.869158
2013	433	30	112.8499	173	27.30559	1.312223
2014	674	60	116.3294	173	20.64908	0.795373
Total	**5930**	**30**	**114.2664**	**192**	**23.74939**	**0.308408**

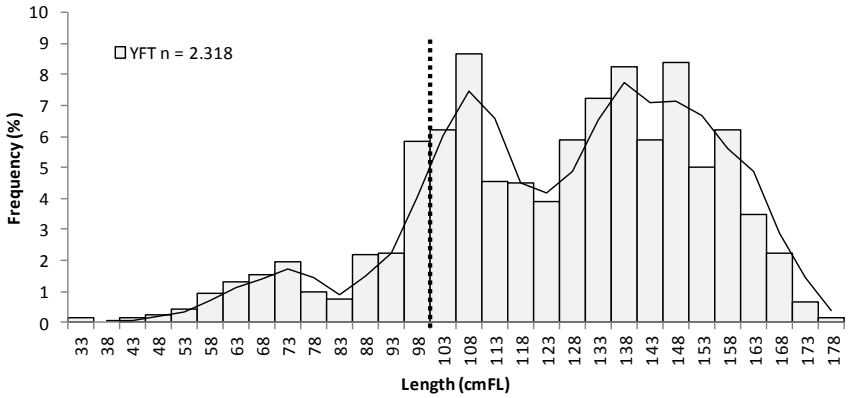

Figure 1. Length distribution of YFT caught in the eastern Indian Ocean.
Remarks: the dash line showed as size at first maturity (L_{50}) 100 cm (IOTC, 2013)

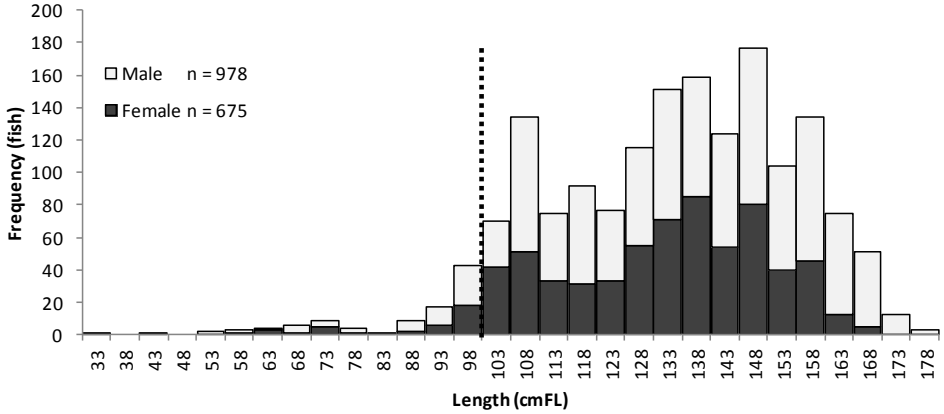

Figure 2. Sex ratio by length class of YFT caught by Indonesian longline in the eastern Indian Ocean
Remarks: the dash line showed as size at first maturity (L_{50}) 100 cm (IOTC, 2013)

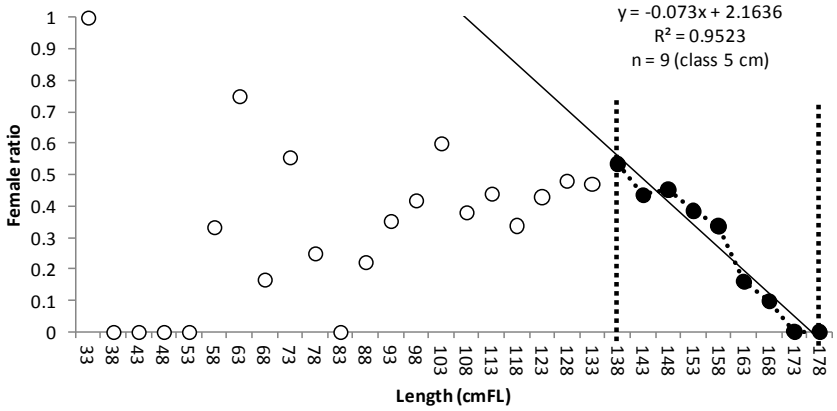

Figure 3. Correlation of female proportion and length of YFT caught by Indonesian longliner in the eastern Indian Ocean
Remarks: The dash line and black dots showed the limit of interval class used for linear regression analysis for female proportion to length size (136≤FL≤180).

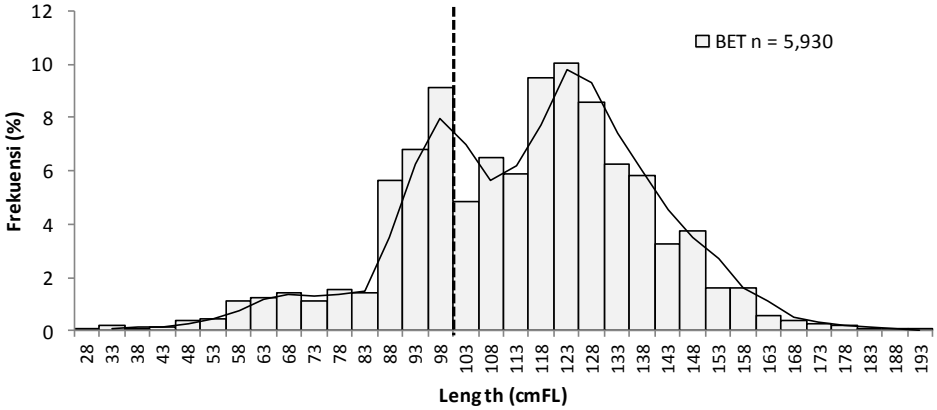

Figure 4. Length distribution of BET caught in the eastern Indian Ocean.
Remarks: the dash line showed as size at first maturity (L_{50}) 100 cm (IOTC, 2013)

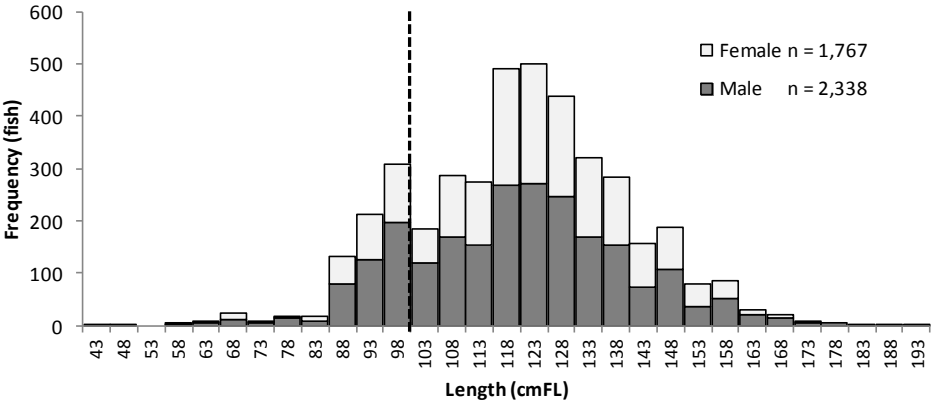

Figure 5. Sex ratio by length class of BET caught by Indonesian longline in the eastern Indian Ocean
Remarks: the dash line showed as size at first maturity (L_{50}) 100 cm (IOTC, 2013)

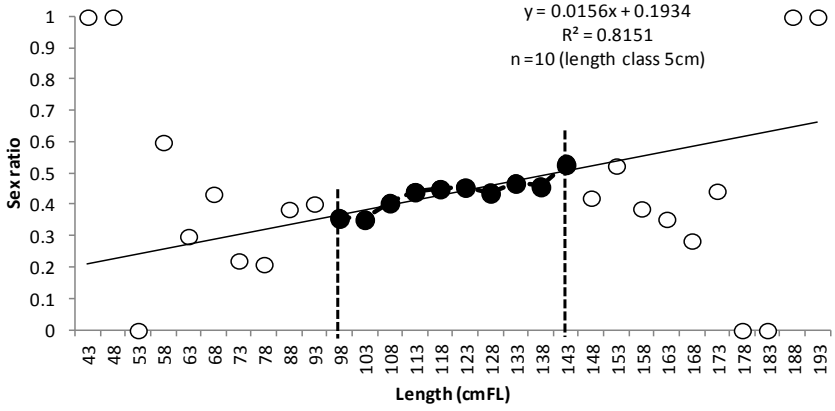

Figure 6. Correlation of female proportion and length of BET caught by Indonesian longliner in the eastern Indian Ocean
Remarks: The dash line and black dots showed the limit of interval class used for linear regression analysis for female proportion to length size ($96 \leq FL \leq 145$).