Preliminary Analysis on Biological Features of Yellowfin Tuna, *Thunnus albacares*, Based on Observer's data in the West-central Indian Ocean

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Abstract: Based on the catch data of Yellowfin tuna captured by tuna longline fishery in the West-central Indian Ocean from January to June in 2003 and 2004, the basic biological characteristics of catch composition of Yellowfin tuna captured were investigated. The result indicated that the processed body weight of Yellowfin tuna captured varied between 7- 81 kg (2003) and 20- 78 kg (2004) respectively, and the dominant processed body weight varied between 20-50kg (2003) and 30-60kg (2004) respectively. The fork length of Yellowfin tuna captured varied between 70- 180 cm and 110- 170 cm in 2003 and 2004 respectively. Mean sex ratio remained some 0.71 and 1.00 in all months in 2003 and 2004. Monthly sex ratio had an insignificant difference among all months in 2003, however, the ratio varied remarkably during 2004. To frequency of monthly feed fullness, grade 1 and 2 dominant in every month of 2003 and insignificant difference existed among all months. Grade 1 dominant in every month of 2004, and large differences existed in 2004. The sex ratio fluctuates remarkably at a LJFL of less than 100 cm. The variation on sex ratio is insignificant and maintain to some 0.5 when LJFL fall into 100-150 cm. all samples are males at LJFLs larger than 160 cm. The processed body weight and fork length of Yellowfin tuna captured had the relationship curves $W=2.000\times10^{-5}L^{2.9269}$ between them.

Key words: *Thunnus albacares*; Fishery biology; West-central Indian Ocean

Yellowfin tuna is one of the important tuna species targeted by tuna purse seines and longlines in the Indian Ocean[1-3]. The catch of yellowfin tuna is the second for Chinese tuna longline fleet in the Indian Ocean, just after the catch of bigeye tuna. Many authors reported the biological features of yellowfin tuna[4-13]. But it seems that size composition of the yellowfin tuna catch varied with the time and areas studied (see table 1).

China began to carry out the national tuna observer program in the Indian Ocean in 2003. The paper will give the result of preliminary analysis on biological features of yellowfin tuna based on observer's data in the Indian Ocean.

2. Materials and methods

2.1 Periods and areas investigated

Data used in the paper come from the two data sets collected by observer program. The first data set on the deep frozen tuna longliner was collected in the west Indian Ocean (40° 26′ E, 08° 05′ S~69° 00′ E, 08° 20′ N) between January and June 2003, and the second data set was from the ice tuna longliner operated in Maldives' waters (69° 21′ E, 02° 19′ S~76° 43′ E, 06° 57′ N) between January and June, 2004 (see Figure 1) respectively.

2.2 Methods

The processed weight (gutted and gilled weight, kg) and fork length (LJFL, lower jaw fork length,

cm), are directed measured. Sex of each sample was identified based on the appearance of the gonads. Feed fillness in stomach is divided into following five grades[14,15]:

Grade 0 - no food in stomach and intestines;

Grade 1 - some food in stomach;

Grade 2 - right amount food in stomach;

Grade 3 - food is filled with stomach, but coat of the stomach does not expand;

Grade 4 - food is filled with stomach, and coat of the stomach expands.

The analysis on sex ratio of yellowfin tuna is based on fork length class in 5 cm interval by month. The expression of sex ratio of yellowfin tuna is as follow:

$$\text{sex ratio} = \frac{FN}{FN + MN}$$

Where, FN, sampling number of male; MN, sampling number of female.

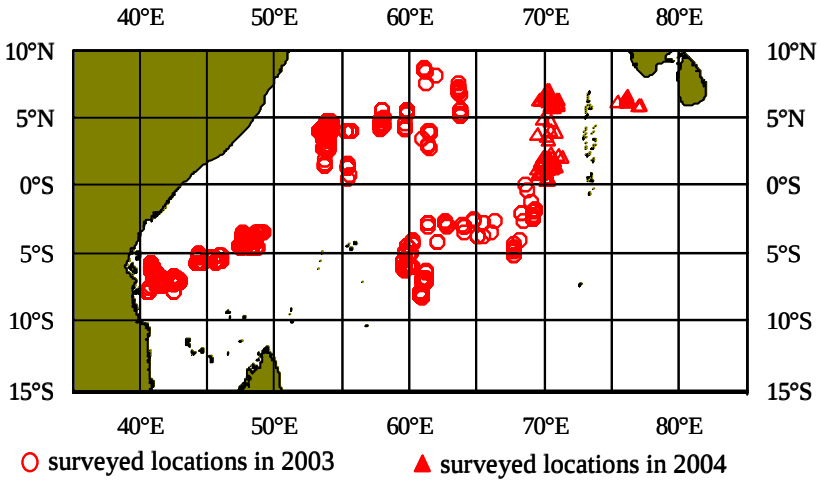

Fig. 1 Locations where the data was collected (2003 and 2004)

3. Results

3.1. Processed weight

A total number of 746 yellowfin tuna have been sampled in 2003 and 2004, among which 668 specimens in 2003 and 78 specimens were sampled in 2004 respectively. Sampling results in 2003 show that processed weight of yellowfin tuna varied from 7- 81 kg (SD= 15.00, SE= 0.58), with dominant weight between 20- 50 kg (account to 82.19%). Frequency distribution of the processed weight indicates a significant monthly difference between January and June 2003 (see Figure 2). The results from 2004's sampling indicates that processed weight of yellowfin tuna varied from 20- 78 kg (SD= 13.38, SE= 1.63), with individual weight of 30- 60 kg as dominancy (account to 92.21%), and its frequency distribution indicates an insignificant difference in the processed weight between January to June, 2004 (see Figure 3). ANOVA analysis shows a remarkably difference (F= 16.63, sig. = 0.000) in processed weight distribution between 2003 and 2004.

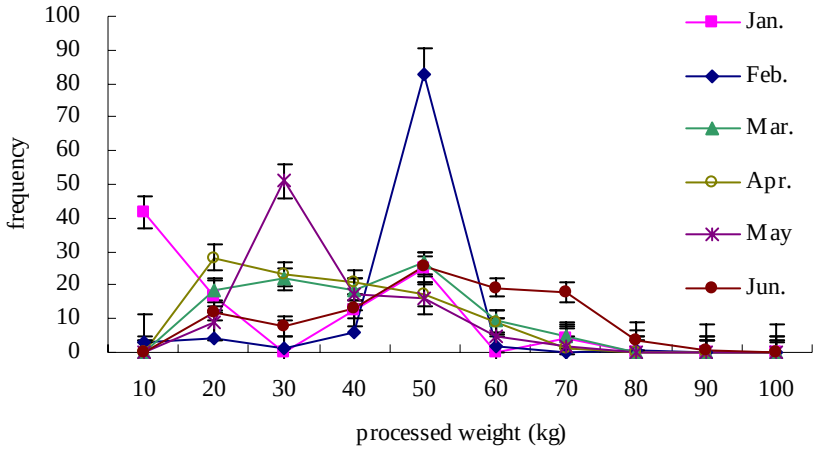

Fig. 2 Frequency distribution of yellowfin tuna (processed weight) captured by Chinese tuna longliner in the Indian Ocean (January to June, 2003) (Vertical bars indicate positive S.E.)

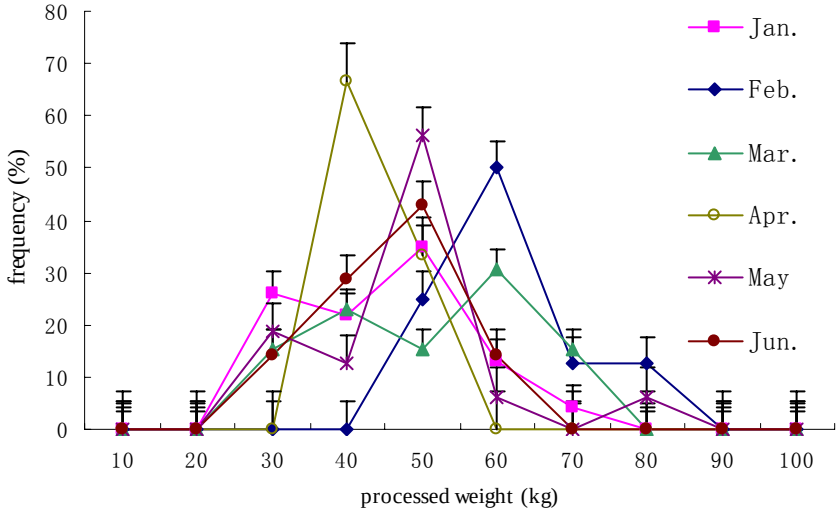

Fig. 3 Frequency distribution of yellowfin tuna (processed weight) captured by Chinese tuna longliner in the Indian Ocean (January to June, 2004) (Vertical bars indicate positive S.E.)

3.2. Fork length

Figure 4 shows that fork length of yollowfin tuna sampled in 2003 varied from 70- 180 cm (SD= 19.44, SE= 0.75), with the dominant fork length between 110- 120cm and the fork length sampled in 2004 varied from 110- 170cm (SD= 13.69, SE= 1.67), with the dominant fork length between 130-160cm. ANOVA analysis indicates a significant difference in fork length distribution between 2003 and 2004 (F=25.91, a = 0.00).

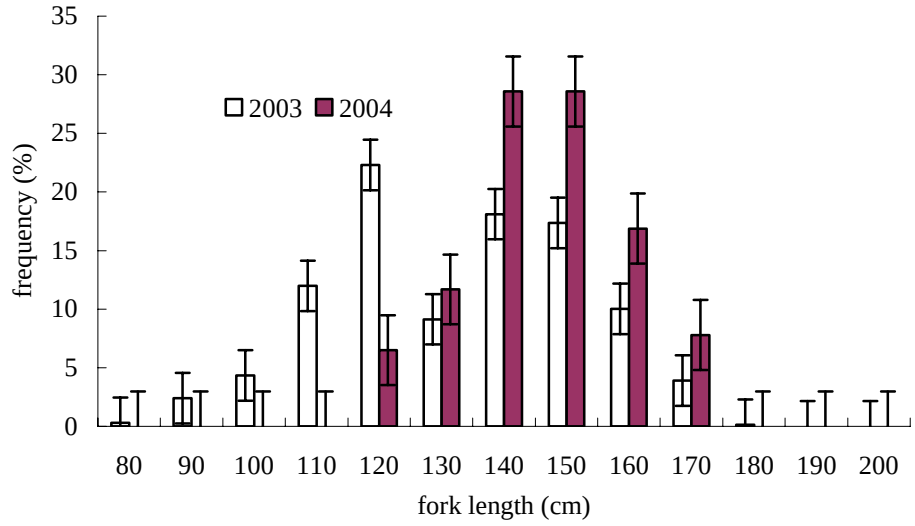

Fig. 4 Length-frequency distributions of yellowfin tuna based on sampling data from Chinese tuna longliners in the Indian Ocean (January to June in 2003, 2004) (Vertical bars indicate S.E.)

3.3. Sex ratio

Change in sex ratio of yellowfin tuna between January and June in 2003 and 2004 is showed in figure 5. The female accounts for about 40% (mean 41.18%, SD 4.52), ratio of female to male is less 1 in 2003. But, sex ratio of yellowfin tuna varied remarkably based on the sampling data in 2004 (average= 44.99%, SD= 17.81).

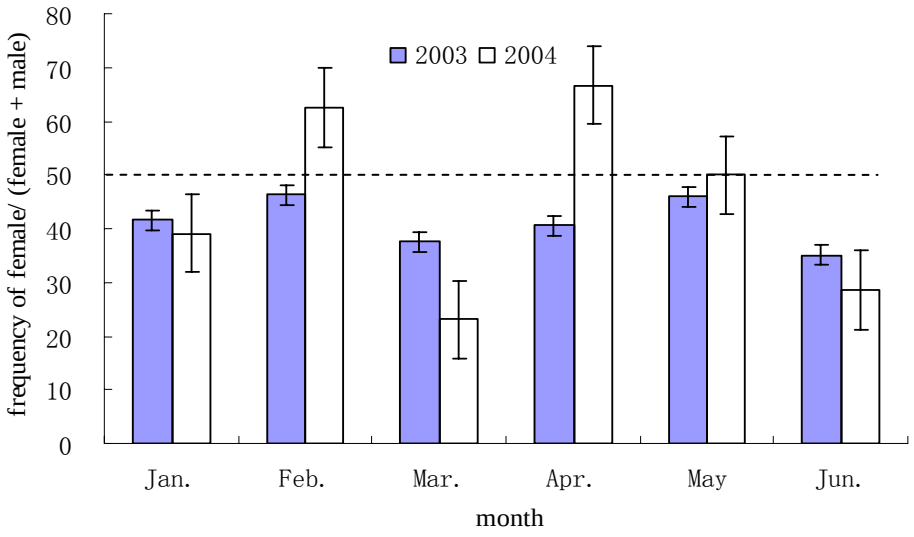

Fig. 5 Monthly percentage of female yellowfin tuna based on the sampling data from Chinese tuna longliners in the Indian Ocean (January to June in 2003, 2004) (Vertical bars indicate S.E.)

3.4. Feed fillness in stomach

Figure 6 and 7 shows the frequency distribution of feed fillness of yellowfin tuna. As seen in figure 6, high proportion of grade I feed fillness of stomach is indicated between January and June in 2003. After that time, the grade of feed fillness increases with the month. However, a big difference in the feed fillness of the yellowfin tuna is indicated after checking the stomach of the fish sampled between January to June in 2004.

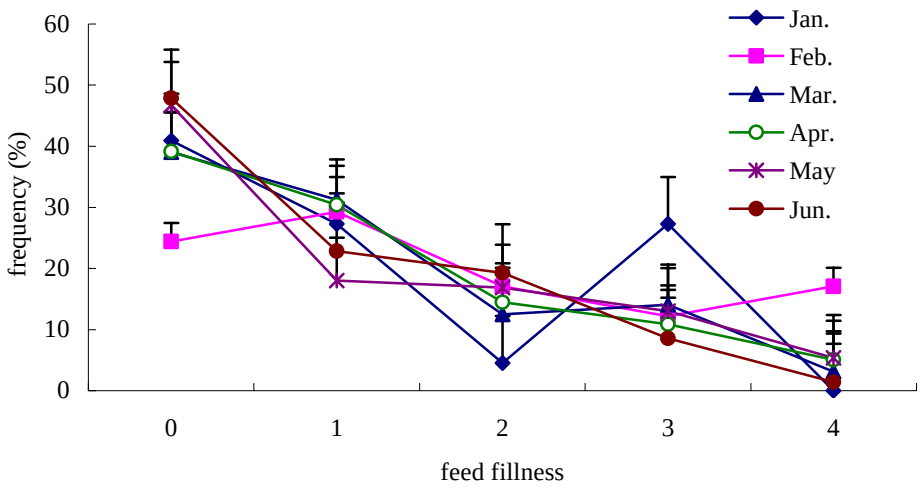

Fig. 6 Monthly frequency distribution of feed fillness in yellowfin tuna sampled from the catch of Chinese tuna longliners in the Indian Ocean (January to June, 2003) (Vertical bars indicate positive S.E.)

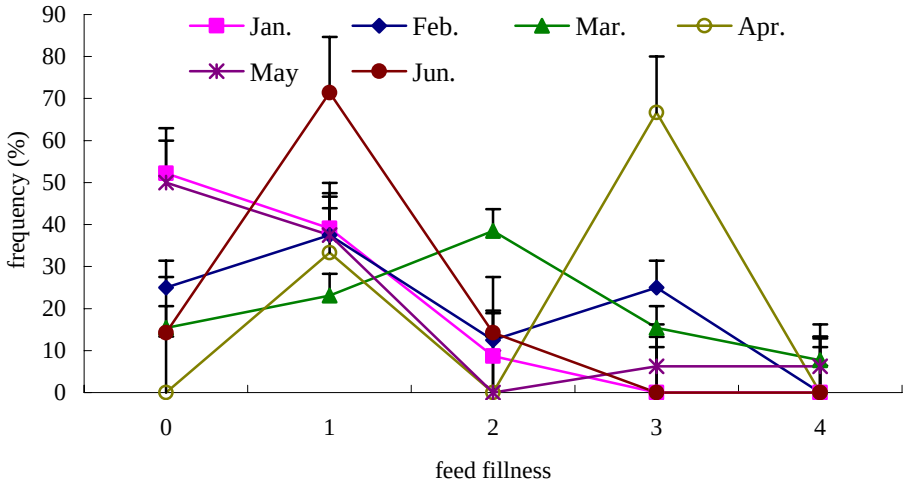

Fig. 7 Monthly frequency distribution of feed fillness in yellowfin tuna sampled from the catch of Chinese tuna longliners in the Indian Ocean (January to June, 2004) (Vertical bars indicate positive S.E.)

3.5. Relationship on fork length and sex ratio

Fig. 8 shows that relationship on fork length and sex ratio of yellowfin tuna. The sex ratio fluctuates remarkably at a LJFL of less than 100 cm. The variation on sex ratio is insignificant and maintain to some 0.5 when LJFL fall into 100-150 cm. all samples are males (i.e., a sex ratio of 1) at LJFLs larger than 160 cm.

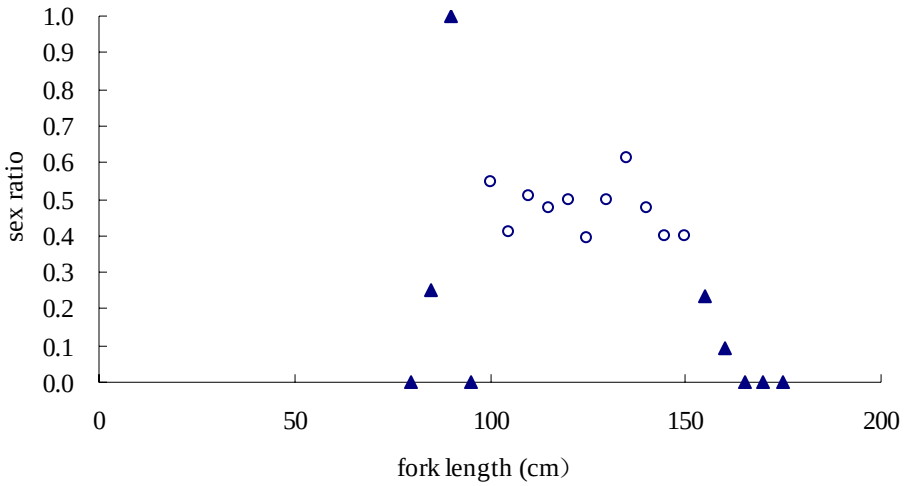

Fig. 8 Relationship on fork length and sex ratio of Yellowfin tuna captured by tuna longline fishery in the Indian Ocean (January to June in 2003, 2004)

3.6. Length – Weight relationship

Figure 9 indicates the relationship between the processed weight and fork length of yellowfin tuna sampled from Chinese tuna longline boats between January to June in 2003 and 2004. The relationship can be described by the following equation:

$$W = 2 \times 10^{-5} L^{2.9269}$$

Where, W is the processed weight (kg);

L is the fork length (cm).

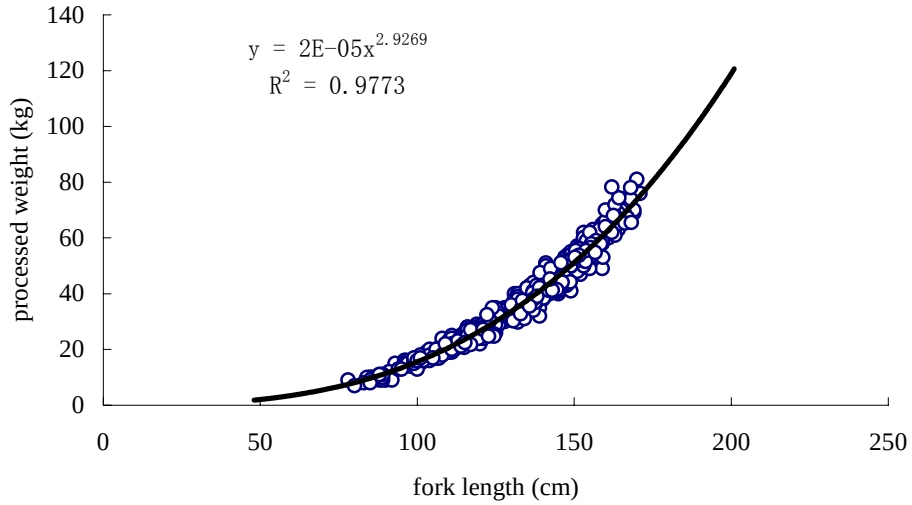

Fig. 9 Relationship between processed weight and fork length of yellowfin tuna based on the samplings from Chinese tuna longliners in the Indian Ocean (January to June in 2003 , 2004).

3.7 Gonad maturity rate

Gonad maturity rate of the yellowfin tuna sampled in 2003 is indicated as in table 2. It is showed that most of the yellowfin tuna reached stage 2 and 3 in the gonad maturity in January. Between Feb and June, majority of yellowfin tuna reached the stage 6 in the gonad maturity. It was

observed that yellowfin tuna began to spawn in February.

Table 2 Gonad maturity rate of yellowfin tuna (in percentage)

Month	Gonad maturity rate in percentage					
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
January	4.2	41.7	33.3	8.3	8.3	4.2
February	0	34.1	12.2	12.2	0	41.5
March	0	20.3	6.3	7.8	1.6	64.0
April	0	5.1	8.7	4.3	0.7	81.2
May	0	10.0	1.1	0	0.8	88.1
June	0	10.0	0.7	0	2.1	87.2

4. Discussion

4.1 Age composition

With the limit of conditions, the present paper uses the result of Stequert B. et al on the growth of yellowfin tuna in the Western Indian Ocean to calculate Von Bertanlanffy growth equation with the data collected by Chinese tuna longline fisheries from January to June in 2003 and 2004[5]. The growth equation expresses below:

$$L = 272.7(1 - e^{-0.176(t+0.266)})$$

So age composition is domain in age 2- 5 in 2003, and age 3- 5. Figure 10 indicates that Age frequency distribution of yellowfin tuna captured by Chinese tuna longline fishery in the Indian Ocean from January to June during 2003-2004

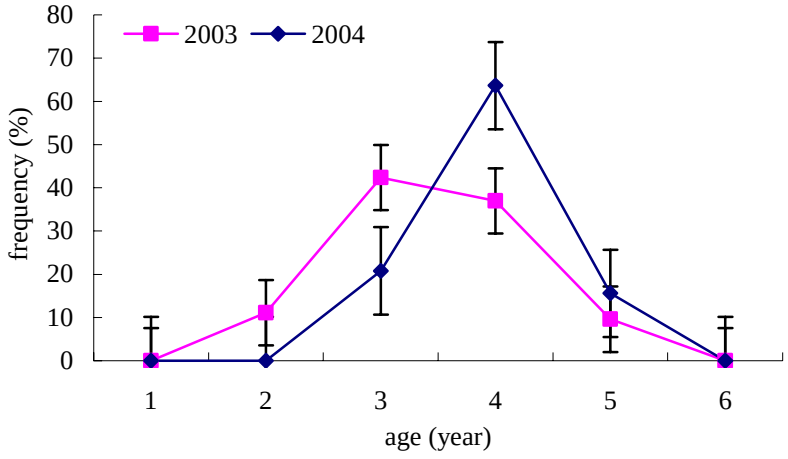

Fig. 10 Age frequency distribution of yellowfin tuna captured by Chinese tuna longline fishery in the Indian Ocean from January to June in 2003 and 2004 (Vertical bars indicate S.E.)

4.2 Size composition

4.2.1 Fork length

Fork length in 2003's and 2004's survey covers in 70- 180cm and 110- 170cm respectively. John (1989, 1993 and 1995) analyzed yellowfin tuna caught in South-west coast waters of India, Indian EEZ, and North-west coast waters of India, fork length of yellowfin tuna varied in 58-164cm，58-181cm, and 48-168cm respectively[8, 10-11]. Sudarsan et al. and Govindraj et al. analyzed yellowfin tuna captured in North-west coast waters of India, fork length of yellowfin tuna varied

in 56- 181cm and 50- 165cm[7, 9]. Obviously, some differences exist in those results, the main reason, maybe, is the quantity of data, particularly in 2004's survey.

4.2.2 Length – weight relationship

Our sampling showed a bigger yellowfin tuna with 180 cm fork length compared with other reports as indicated in table 1. Table 1 also shows that length range varies with the time and areas sampled. Comparison with 2003's survey, quantity of data in 2004 is littler; the resultant consequence is that the insignificant difference exists among every month in 2004's survey. Length - weight relationship of Yellow-fin tuna available with respect to the stock occurring in different sectors of the Indian Ocean, and the results are different[5, 7-12, 16-17]. A comparison of the length-weight relationship observed in different studies is presented below.

Table 1 A comparison of the length-weight relationship observed in different studies

Region	Gear	Sex	Sample size	Size range	Length-weight relationship	Source
Western and Central Indian Ocean	Longline	M+F	668	70-180	$W=0.0002\ L^{2.936}$	This study, 2003
Maldives' EEZ	Longline	M+F	78	110-170	$W=0.0006\ L^{3.1708}$	This study, 2004
Arabian Sea	Longline	M+F	210	50-170	$W=0.0001036\ L^{2.66410834}$	Silas et.al ., 1985
Arabian Sea	Longline	M+F	98	92-153	$W=0.000049557L^{2.8055}$	John & Reddy, 1989
Arabian Sea	Longline	M+F	133	-	$W=0.000040697L^{2.8496}$	Sudarsan et.al., 1991
Indian EEZ	Longline	M+F	243	59-155	$W=0.000039528L^{2.8318}$	John & Sudarsan, 1993
Andaman Sea	Longline	M+F	351	100-150	$W=0.000038812L^{2.8507}$	Sudarsan & John, 1993
Andaman Sea	Longline	M F M+F	304 118 422	58-163 59-147 58-163	$W=0.000034569L^{2.8653}$ $W=0.0000551847L^{2.7565}$ $W=0.000038062L^{2.8423}$	John, 1995
Northern Arabian Sea	Longline	M+F	850	50-165	$W=0.00004626L^{2.8012}$	Govindraj et.al., 2000
Western Indian Ocean	Purse Seine	M+F		> 64	$W=0.00005313L^{2.7536}$	Stequert et al., 1996
Western Indian Ocean	Purse Seine	M+F		=> 64	$W=0.00001585L^{3.0449}$	Stequert et al., 1996
Eastern Ocean Indian	Longline	M+F	1398	84-174	$Wx=0.000018L^{2.9841}$ $Wy=0.000691L^{2.7396}$	Morita, 1973
Indian Coastal	P. Seine & G.net	M+F	628	32-118	$W=0.00003852L^{2.7443}$	Pilllai, et. al, 1993

Source: V. S. Somvanshi, 2002

4.3 Relationship on fork length and sex ratio

Data of yellowfin sex ratio by size obtained on purse seine catches taken in various oceans were compared: Indian Ocean, Atlantic and Eastern Pacific Ocean[18-21]. The same sex ratio pattern, males being dominant at larger sizes, appears to be dominant world wide. Figure 11 indicates that the relationship on fork length and sex ratio of yellowfin tuna in different areas of the Indian Ocean[22-23]. The sex ratio fluctuates remarkably without a significant pattern at a fork length of

less than 90. The sex ratio of yellowfin tuna is almost more than 0.5 at fork length of 90-139 cm. All samples are females (i.e., a sex ratio of 1) at fork lengths larger than 160 cm in the West-central Indian Ocean (This study) and 150 cm in the Eastern Indian Ocean [23].

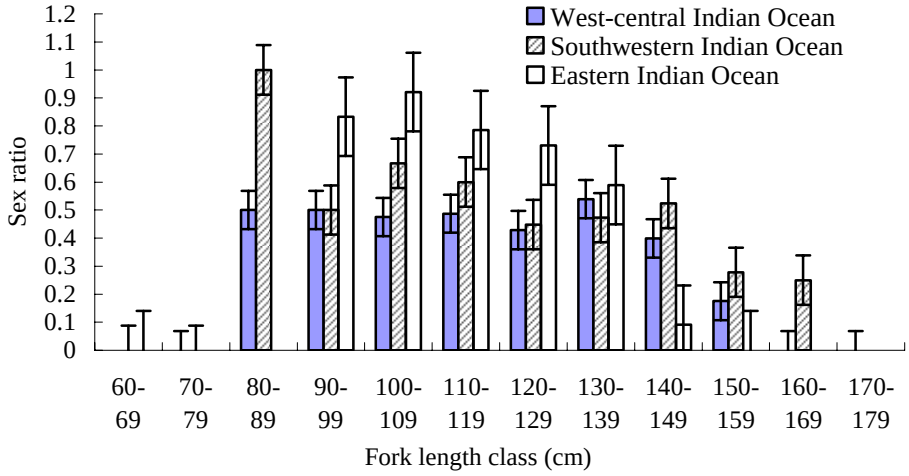

Fig. 11 Relationship on fork length and sex ratio of yellowfin tuna in the Indian Ocean

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