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Preliminary analysis on biological features of *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 Chinese tuna longline fleet 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- 50 kg (2003) and 30- 60 kg (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 respectively. 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 maintaining to some 0.5 when LJFL falls 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 $W = 2\times 10^{-5} L^{2.9269}$ between them.

Key words: *Thunnus albacares*; biological feature; west-central Indian Ocean
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1 Introduction

Yellowfin tuna (*Thunnus albacares*) is one of the important tuna species targeted by tuna purse seines and longlines in the Indian Ocean[1- 3]. yellowfin tuna is in the second position of the catch list of Chinese tuna longline fleet in the Indian Ocean, just after bigeye tuna. The biological features of yellowfin tuna have been reported[4- 13] and shown that size composition of the yellowfin tuna catch varied with the time and areas studied (See Tab. 1). The paper will give the result of preliminary analysis on biological features of yellowfin tuna based on data collected from the national tuna observer program which started in 2003.

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. One 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 other 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 Fig. 1) respectively.

2.2 Methods

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

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cm), are directly measured. Sex of each sample was identified based on the appearance of the gonads. Feed fullness 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 – stomach is filled with food, but coat of the stomach does not expand;

Grade 4 – stomach is filled with food, 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 follows:

$$\text{sex ratio} = \frac{N_F}{N_F + N_M}$$

Where, N_M, sampling number of male; N_F, sampling number of female.

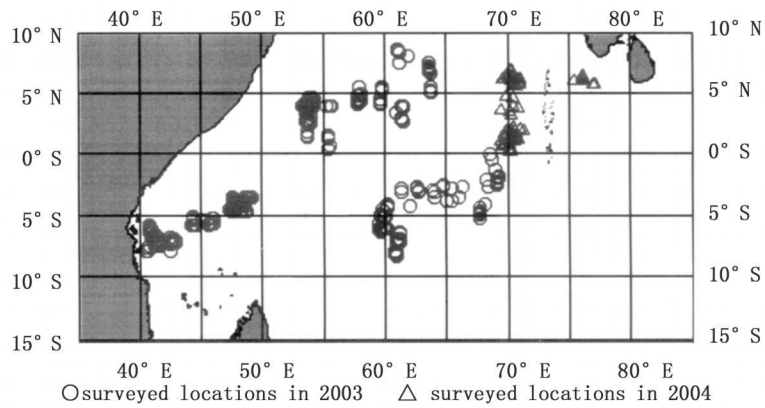

Fig. 1 Locations where the data were collected (2003 and 2004)

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 Fig. 2).

The results from 2004's sampling indicate 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 (accounting to 92.21%), and its frequency distribution indicates an insignificant difference in the processed weight between January and June, 2004 (See Fig. 2). ANOVA analysis shows a remarkable difference (F= 16.63, sig. = 0.000) in processed weight distribution between 2003 and 2004.

3.2 Fork length

Fig. 3 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 110– 120 cm and the fork length sampled in 2004 varied from 110 – 170 cm (SD= 13.69, SE= 1.67), with the dominant fork length 130– 160 cm. ANOVA analysis indicates a significant difference in fork length distribution between 2003 and 2004 (F= 25.91, a= 0.00).

3.3 Sex ratio

Change in sex ratio of yellowfin tuna between January and June in 2003 and 2004 is showed in Fig. 4. The female accounts for about 40% (mean= 41.18%, SD= 4.52), ratio of female to male is less than 1 in

2003. But, sex ratio of yellowfin tuna varied remarkably based on the sampling data in 2004 (mean= 44.99%, SD= 17.81).

3.4 Feed fullness in stomach

Fig. 5 shows the frequency distribution of feed fullness of yellowfin tuna. As seen in Fig. 5, high proportion of grade I feed fullness of stomach is indicated between January and June in 2003. After that time, the grade of feed fullness increases with the month. However, a big difference in the feed fullness of the yellowfin tuna is indicated after checking the stomach of the fish sampled between January to June in 2004.

3.5 Relationship on fork length and sex ratio

Fig. 6 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 maintains at some 0.5 when LJFL falls into 100- 150 cm. All samples are males (i.e., a sex ratio of 1) at LJFLs larger than 160 cm.

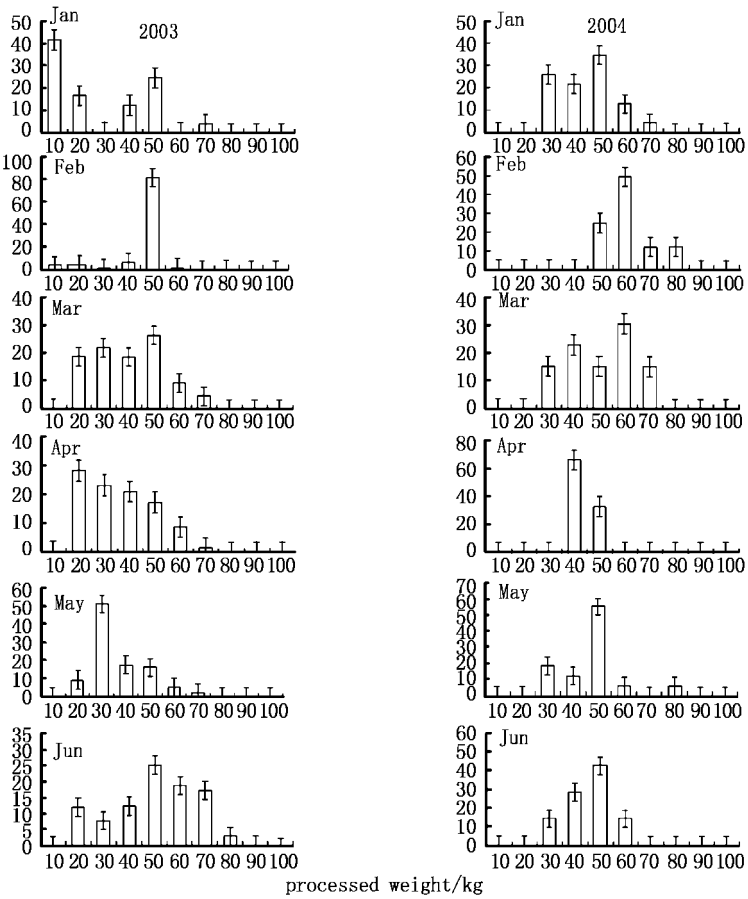

Fig. 2　Frequency distribution of yellowfin tuna (processed weight) captured by Chinese tuna longliner in the Indian Ocean (January to June in 2003 and 2004)
(Vertical bars indicate positive S.E.)

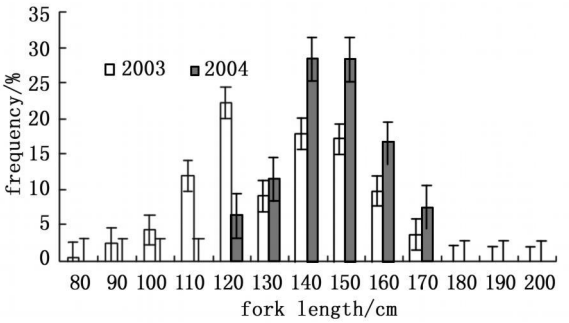

Fig. 3 Length-frequency distributions of yellowfin tuna based on sampling data from Chinese tuna longliners in the Indian Ocean (January to June in 2003, 2004) (Vertical bars indicate S. E.)

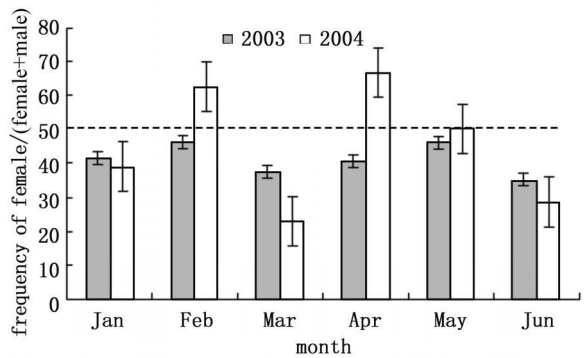

Fig. 4 Monthly percentage of female yellowfin tuna based on the sampling data from Chinese tuna longliners in the Indian Ocean (January to June in 2003, 2004) (Vertical bars indicate S. E.)

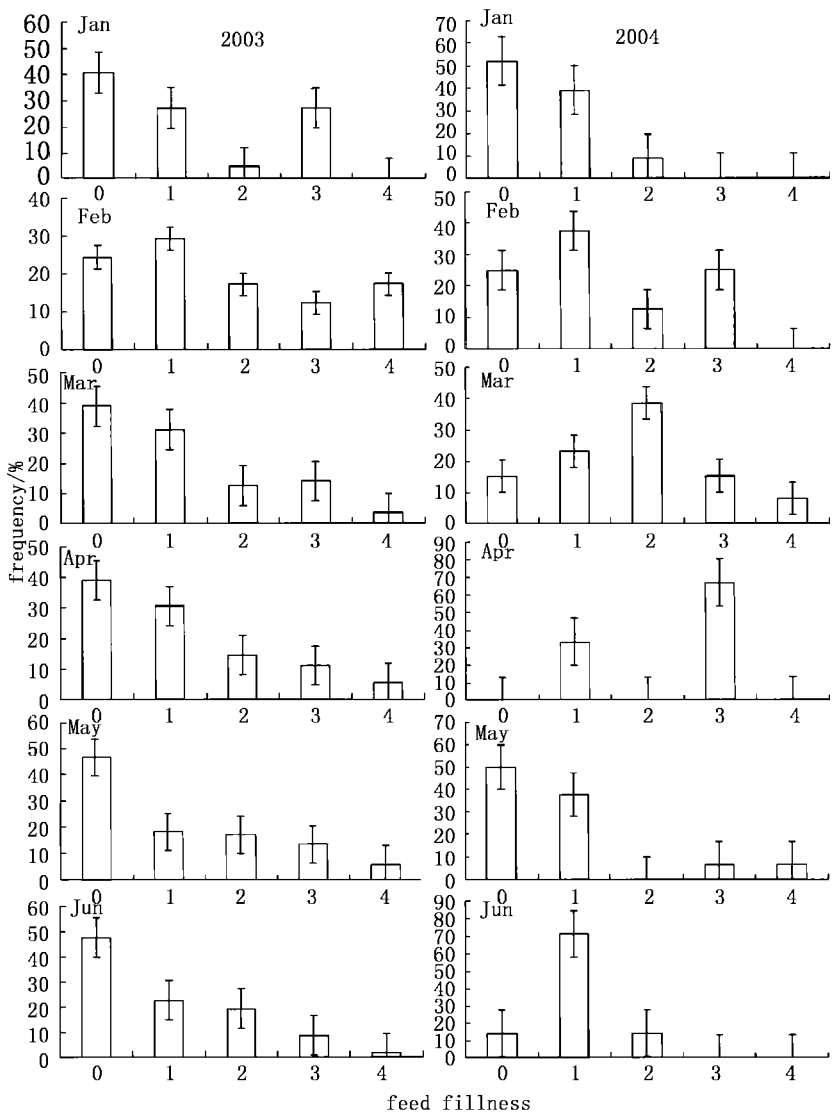

Fig. 5 Monthly frequency distribution of feed fillness in yellowfin tuna sampled from the catch of Chinese tuna longliners in the Indian Ocean (January to June in 2003 and 2004) (Vertical bars indicate positive S. E.)

3.6 Length-Weight relationship

Fig. 7 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:

$$W = 2.189 \times 10^{-5} L^{2.9269}$$

Where, W is the processed weight (kg); L is the fork length (cm).

3.7 Gonad maturity rate

Gonad maturity rate of the yellowfin tuna sampled in 2003 is indicated as in Tab. 1. It showed that most of the yellowfin tuna reached stages 2 and 3 in the gonad maturity in January. Between February 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.

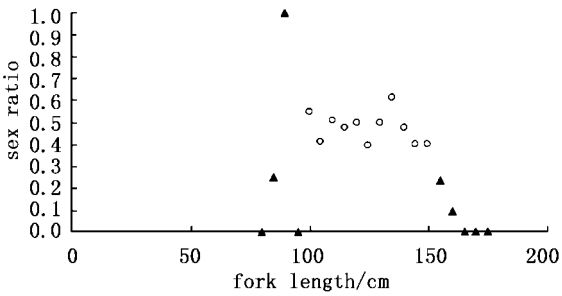

Fig. 6 Relationship between fork length and sex ratio of yellowfin tuna captured by tuna longline fishery in the Indian Ocean (January to June in 2003, 2004)

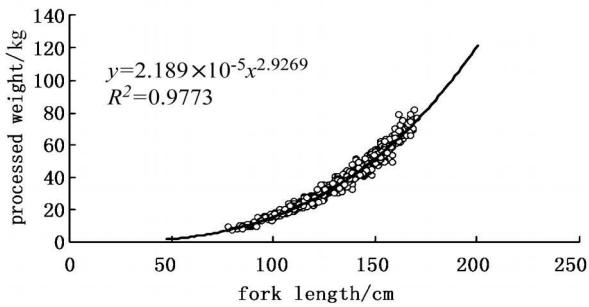

Fig. 7 Relationship between processed weight and fork length of yellowfin tuna based on the samplings from Chinese tuna longliners in the Indian Ocean (January to June in 2003, 2004)

Tab. 1 Gonad maturity rate of yellowfin tuna %

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

The Von Bertanlanffy growth equation of the yellowfin tuna in the western Indian Ocean was calculated according to the results of Stequert, *et al.*[5], the data were collected by Chinese tuna longline fishing fleet from January to June in 2003 and 2004. The growth equation expresses below:

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

Age composition is domainant in age 2 - 5 in 2003, and age 3 - 5. Fig. 8 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.

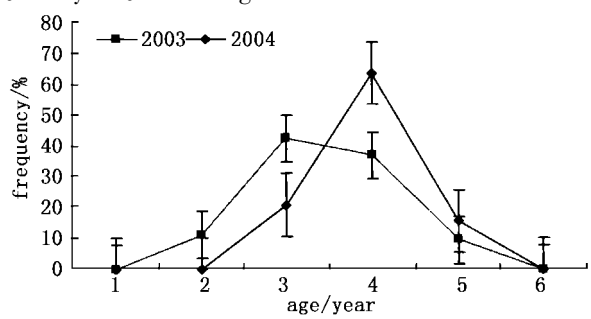

Fig. 8 Age frequency distribution of yellowfin tuna captured by Chinese tuna longline fishery in the Indian Ocean from January to June in 2003 and 2004 (Vertical bars indicate S.E.)

4.2 Size composition

Fork length Fork length in 2003's and 2004's survey covers 70– 180 cm and 110– 170 cm 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– 164 cm, 58 – 181 cm, and 48 – 168 cm 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– 181 cm and 50– 165 cm[7, 9].

Obviously, some differences exist in those results, the main reason, maybe, is the quantity of data, particularly in 2004's survey. However, some reasons, such as data sources, fishing methods, fishing periods, and marine environment in the fishing ground, also resulted in the differences.

Length-weight relationship Our sampling showed a bigger yellowfin tuna with 180 cm fork length compared with other reports as indicated in Tab. 2. Tab. 2 also shows that length range varies with the time and areas sampled. Compared with 2003's survey, quantity of data in 2004 is less; 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.

Tab. 2 A comparison of the length-weight relationship observed in different studies

region	gear	sex	sample size	size range(cm)	length-weight relationship	source
western and Central Indian Ocean	LL	M+F	668	70– 180	$W= 0.0002\ L^{2.936}$	This study, 2003
Maldives' EEZ	LL	M+F	78	110– 170	$W= 0.0006\ L^{3.1708}$	This study, 2004
Arabian Sea	LL	M+F	210	50– 170	$W= 0.0001036\ L^{2.66410834}$	Silas, *et al*., 1985
Arabian Sea	LL	M+F	98	92– 153	$W= 0.00049557L^{2.8055}$	John & Reddy, 1989
Arabian Sea	LL	M+F	133	–	$W= 0.00040697L^{2.8496}$	Sudarsan, *et al*., 1991
Indian EEZ	LL	M+F	243	59– 155	$W= 0.00039528L^{2.8318}$	John & Sudarsan, 1993
Andaman Sea	LL	M+F	351	100– 150	$W= 0.00038812L^{2.8507}$	Sudarsan & John, 1993
Andaman Sea	LL	M	304	58– 163	$W= 0.00034569L^{2.8653}$	John, 1995
		F	118	59– 147	$W= 0.0005518 47L^{2.7565}$	
		M+F	422	58– 163	$W= 0.00038062L^{2.8423}$	
Northern Arabian Sea	LL	M+F	850	50– 165	$W= 0.00004626L^{2.8012}$	Govindraj, *et al*., 2000
Western Indian Ocean	PS	M+F		> 64	$W= 0.00005313L^{2.7536}$	Stequert, *et al*., 1996
Western Indian Ocean	PS	M+F		= > 64	$W= 0.00001585L^{3.0449}$	Stequert, *et al*., 1996
Eastern Ocean Indian	LL	M+F	1398	84– 174	$Wx= 0.000018L^{2.9841}$ $Wy = 0.000691L^{2.7396}$	Morita, 1973
Indian Coastal	PS, GILL	M+F	628	32– 118	$W= 0.00003852L^{2.7443}$	Pilllai, *et al*., 1993

LL: longline; PS: purse seine; GILL: gill net; Source: V. S. Somvanshi, 2002

4.3 Relationship between 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. Fig. 9 indicates that the relationship between 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].

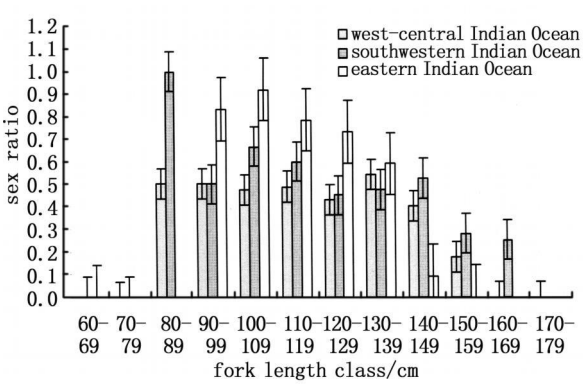

Fig. 9 Relationship between fork length and sex ratio of yellowfin tuna in the Indian Ocean

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印度洋黄鳍金枪鱼生物学特性的初步研究

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摘要: 根据2003- 2004年1- 6月印度洋中西部海域金枪鱼延绳钓所捕获的黄鳍金枪鱼数据, 对其基本的生物学特征进行了研究。结果表明, 2003年和2004年渔获物中黄鳍金枪鱼加工后体重分别为7~ 81 kg和20~ 78 kg, 优势组分别为20~ 50 kg和30~ 60 kg。叉长范围分别为70~ 180 cm和110~ 170 cm。2003年渔获物雌雄性比的平均值为0.71, 月间性比组成差异较小; 2004年渔获雌雄性比的平均值为1.00, 月间性比组成差异较大。2003年各月的摄食等级以1- 2级为主, 月间差异较小; 2004年摄食等级以一级为主, 并且月间各等级组成差异大。当渔获个体的叉长小于100 cm时, 其性比组成波动较大; 当渔获个体的叉长范围在100~ 150 cm之间时, 性比组成的变化相对较小, 基本上维持在0.5左右, 也就是说雌雄个体数量大体保持平衡; 当渔获个体的叉长大于160 cm时, 所有样本个体均为雄性。体长与体重关系为 $W = 2\times 10^{-5}L^{2.926}$。

关键词: 黄鳍金枪鱼; 生物学特性; 印度洋中西部
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