SOME ASPECTS OF THE BIOLOGY OF BIGEYE TUNA (*THUNNUS OBESUS*, LOWE 1839) IN ANDAMAN AND NICOBAR WATERS

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Abstract

Among the three species of Oceanic tunas recorded in the Andaman and Nicobar waters *viz*. yellowfin tuna, bigeye tuna and skipjack tuna, the exploitation level of bigeye tuna is less in comparison to the other two species. Bigeye tunas are recorded mostly in the southern part of Andaman waters. This paper deals with some biological aspects of bigeye tuna landed by the survey vessel MFV Blue Marlin in A & N waters during 2003 - 2009. Morphometric characters, length frequency, length weight relationship, sex ratio, maturity and food and feeding habits of the species are presented in the paper. The males were in the FL range of 104-173 cm while the females were in the FL range of 122-172cm. The length weight relationship calculated are

Male: $W = 0.00001\ L^{3.25}$ ($r = 0.96$)
Female: $W = 0.00001\ L^{3.01}$ ($r = 0.98$)
Pooled: $W = 0.00001\ L^{3.09}$ ($r = 0.96$)

The male to female sex ratio was found to be 1:0.7. Maturity stages varied from immature to mature. The food and feeding studies indicated dominance of oceanic squids and teleosts in the diet.

(Key words: Bigeye tuna, Morphometry, Length-Weight relationship, Sex ratio, Gonadal Maturity, Food and Feeding)

INTRODUCTION

Andaman & Nicobar (A & N) group of islands are situated between latitude 6°45'N & 13°41'N; longitude 92°12'E & 93°57'E in the southeast of Bay of Bengal. Comprising more than 572 islands with a total area of 8249 sq. km, the islands are spread over a length of about 700 km and breadth of about 250 km. The coastline of A &N islands is about 1962 km with an EEZ of 0.6 million km^2 which is about 30% of the EEZ of India.

The mainstay of the tuna fishery of India continues to be the coastal tunas caught by the traditional sector. Very recently, the exploitation of the oceanic tuna and allied resources in the Indian EEZ has gained momentum due Government's policy to encourage oceanic fishery as an alternative to heavily exploited near shore resources. The oceanic tunas are widely distributed in the tropical and subtropical waters and constitute one of the economically important marine fishery resources of the EEZ of A & N Islands. Commercially important oceanic tunas recorded in A&N islands are Yellowfin tuna (*Thunnus albacares*), Bigeye tuna (*Thunnus obesus*) and Skipjack tuna (*Katsuwonus pelamis*).

The tuna longline surveys in the Indian EEZ and adjacent waters have indicated availability of bigeye tuna (*Thunnus obesus*) in the Southern Latitudes (0^o-10^o N). Annual

potential yield of oceanic resources in the Indian seas has been estimated as 246000 tonnes from sub surface and surface fishery (Sudarsan, *et al*., 1990). A lot of work has been done on yellowfin tuna of Indian waters (John *et al.*, 1989, 1993; John 1995; Pillai *et al.*, 1993, 2000; Sudarsan, 1978; Kumaran, 1973, Madanmohan *et al.*, 1985; Sudarsan *et al.*, 1990, 1993; Varghese *et al.*, 2002; Yohanan *et al.*, 1993; Somavanshi *et al.*, 2003; Pandian *et al*, 2007). However no such work on the biological aspects of BET has been attempted either from the A & N waters or from other parts of Indian EEZ. This paper is an attempt to study some of the biological observations of BET in the Andaman and Nicobar waters from the fishery survey vessel MFV Blue Marlin (OAL - 35.76 m) attached to Port Blair Base of FSI.

MATERIAL AND METHODS

The data of BET caught in the multifilament tuna longline surveys conducted by FSI in the EEZ of Andaman and Nicobar waters **(Fig.1)** by the survey vessel MFV Blue Marlin during the period 2003-2009 was analysed. The survey was carried out in the latitude 6°-14° and longitude 89°-95°E. The fishing gear operated for the study was the multifilament tuna long line gear with 5/7 hooks per basket. Everyday 625 hooks were operated and an average of 14 operations were made per voyage. Morphometric measurements were made onboard using measuring tape, body cavity is cut open to study the sex, maturity stage and gut contents.

For morphometric data analysis, the linear equation ($Y = a + b X$) was fitted for males and females separately among various parameters such as TL-FL, TL-HL, (S-1D) - (S-2D), (1D-A) - (2D-A), (1D-2D) - (1D-A) lengths,where TL is total length, FL is fork length, HL is head length, (S-1D) is snout to first dorsal length, (S-2D) is snout to second dorsal length, (1D-A) is 1^{st} dorsal to anal length, (2D-A) is 2^{nd} dorsal to anal length and (1D-2D) is 1^{st} dorsal to 2^{nd} dorsal length. The length-weight relationship $W= a L^b$ (Le Cren, 1951) was used, where 'W' is the weight in kilograms (kg) and 'L' is the fork length in centimeter (cm).

Gonads were examined for maturity stages are also assessed. The gonads observed were classified into four stages based on their size, colour and volume *viz*. immature, maturing (early developing and later developing), mature and spent according to Schaefer (1987).

RESULTS

A total of forty one speciemens of *T. obesus* were caught during the study period. The length frequency distribution of different size range of bigeye tuna recorded during the study period is given in **Fig 2.** It is observed that the male specimens of bigeye tuna in the population are in size range of 104-173 cm in fork length with the mean length at 136.4 cm. The males were dominant in all length classes except 121-140 cm. The females are in the size range of 102-172 cm fork length with the mean length at 136.3 cm. The dominant length class of bigeye tuna female was 121-140 cm . The mean weights of male and female bigeye tuna recorded was 41.5 and 47.9 kg respectively

Morphometric Relationship

The mimimum, maximum, mean and standard deviation of various morphometric parameters of samples collected are given in **table 1 , and 2**. The following are the linear relationship between various morphometric measurements**(table 3).**

Total length vs. fork length

Males , TL = 0.15 + 0.92 FL (r = 0.99)

Females, TL = 0.25+ 0.92FL (r = 0.99)

Total length vs. head length

Males, TL = 0.39+ 0.27 HL (r = 0.99)

Females, TL= -0.05 + 0.27 HL (r = 0.98)

Snout to 1st dorsal (S-1D) vs. Snout to 2nd dorsal (S-2D)

Males, S-1D = 0.13 +0.80 (S-2D) (r = 0.98)

Females, S-1D = 0.02+ 0.76(S-2D) (r = 0.99)

First dorsal fin to anal fin (1D-A) vs. second dorsal fin to anal fin(2D-A)

Males ,1D-A = 1.01+ 0.02 (2D-A) (r = 0.99)

Females, 1D-A= -0.79+ 0.72(2D-A) (r = 0.99)

Length – weight relationship

Male: $W = 0.00001\ L^{3.25}$, r = 0.96 (**Fig. 3**)

Female: $W = 0.00001\ L^{3.01}$, r = 0.98 (**Fig. 4**)

Pooled: $W = 0.00001\ L^{3.09}$, r = 0.96 **(Fig. 5)**

The b value for the male appears to be slightly on the higher side. Analysis of variance (ANOVA) was performed to test the significant difference in the length weight

relationship between the sexes. From the analysis of variance it could be seen that the male length weight relationship was found to be significant.

Sex and maturity

Of the forty one specimens of bigeye tuna studied, 24 were male and 17 were female. The details on the male and female bigeye tuna recorded at various size group and various months, their sex ratio and chi square test is given in **Table 4 & 5**. The study revealed that, during the month May to August not a single bigeye tuna was recorded except the month of December during other months the males were predominant. The overall sex ratio (M : F) of bigeye tuna obtained was 1 : 0.7. The sex ratio with respect to different size groups of bigeye tuna also revealed that males were dominant in almost all size ranges except 121-140 cm. Females were dominant in the size range 121-140 cm.

Maturity studies study indicated that 40% of the populations were immature, 35% maturing and 25% mature.

Food and feeding

The stomach analysis showed that, 54% of stomachs were empty. Among the remaining, 1/4th full, 1/2 full, 3/4th full and full stomachs formed 9%, 14%, 18% and 5% respectively**(fig.7).** The food constitutes mainly squids (36.4%), semi digested fish (22.7%), other teleost (18.2%) and deep sea shrimps (9.1%). Fully digested matter also comprised 13.6% of the food**(fig.8).** Among the teleosts Alepisaurids, Parallepidids, Clupeids, Mackerels were dominating, while Caridean shrimps were the major crustacean food item.

DISCUSSION

The work done on the biological parameters of bigeye tuna in the Indian EEZ is very scanty particularly in Andaman waters. In A&N waters targeted fishery for oceanic tuna has gained momentum very recently. Because of the similarity of bigeye tuna and YFT a separate fishery statistics is not available for bigeye tuna and it is landed with the yellowfin tuna. John and Somvanshi (2000) reported the availability of yellow fin tuna is more in Andaman waters where as the availability of bigeye tuna was relatively higher in Nicobar waters. The exploitation of bigeye tuna by the chartered vessel and leased vessel

during the period 1991-1997 showed it as 97.4 tonnes. Pillai *et al.* (2000) reported the length range of bigeye tuna caught from Indian EEZ as 60-180 cm. In French Polynesia, Bertrand *et al.* (2002) reported the average weight of bigeye tuna as 31.4 kg and the density indices (catch per unit effort over the habitat range) in three zones viz. (4°-9° S, 134°-145°W), (9°-14°S, 134°-146°W) and (14°-20°S, 138°-154°W) were 0.13, 0.13, and 0.05 respectively. Josse *et al.* (1998) reported the FL of bigeye tuna in between 35-100 cm in French Polynesia. In the present study, the male specimens were in the fork length range of 104-173 cm and female were 122-172cm and the average weight was 41.5 and 47.9 kg for male and female respectively. The present study agrees well with the earlier studies made by John *et al.* (2005). Kume and Shiohama (1964) reported the length weight relationship of bigeye tuna from the Pacific (128°-170° E, 28°-45°N) as Log W = -4.9340+ 3.1056 Log L. Iverson (1955) reported the length weight relationship as Log W = -7.1167+2.9304 Log L for the western Pacific bigeye. In the present study the relationship for the pooled data was Log W = -5+ 3.09 Log L. The above value agrees well with the value reported by Kume and Shiohama *et al*. (1964).The b value obtained in the length weight relationship of male (3.25) was slightly higher than that of female (3.011) which suggests that males are heavier than females of the same length. Mimura (1963) reported that in the Indian Ocean the sex ratio of bigeye tuna indicated that there were proportionally more males than female. Kataoka (1957) and Stequert and Marsac (1989) also found a higher proportion of males in their studies. Nootmorn (2004) reported the monthly sex ratio of bigeye tuna as 1: 1.8 in the Equatorial Indian Ocean. According to her, the small size of BET (85-115cm) comprise of more females than males, while large size of BET (125-155cm) have the proportion of more males than the females. Sakamoto (1969) reported the sex ratio of bigeye tuna in the pacific as 1.39. In the present study also dominance of males was observed. The male to female sex ratio was found to be 1:0.8 with dominance of male and female in the length range 131-140 cm followed by 121-130 cm respectively. This study agrees well with the study made by Sakamoto (1969). The maturity and spawning of bigeye tuna were investigated by Kikawa (1961,1962,1966); Kume and Joseph (1966); Kume (1969 a , 1969 b, 1979a); Sakamoto (1969); Shingu *et al.* (1974); Miyabe and Bayliff (1987); Nikaido *et al.* (1991); Mcpherson (1992 b) and Nakano and Bayliff (1992) and Nootmorn (2004) in the

pacific waters. Kume (1962) describes the stages of ovarian maturity of the bigeye tuna as immature, maturing, ripe and spent. Nootmorn (2004) reported 5 stages for both female and male in the Equatorial Indian ocean. The stages reported are Immature, early developing, later developing, mature and spawned. In the present study, a scale of four maturity stages were taken viz. Immature, Maturing, Mature and Spent. Three stages were mainly encountered viz. immature, maturing and mature. The spent stage was not encountered during the study period.

Investigators are in agreement on the general composition of the diet of the BET which they recognize as an opportunistic feeder. Areas with high prey abundance attracts BET but at a small scale if prey are patchy distributed tunas are more inclined to feed on them rather than on longline bait. Studies by Yabe *et al.* (1958) indicated that the bigeye preyed mainly on cuttle fish and the young of other fish, which were invariably found in the gut contents examined. De Jaeger (1963) who examined the gut contents of bigeye tuna from south African waters observed the composition to be 27% fish, 18% crustaceans and 55% cephalopods by number (26%, 18% and 56%) by volume. Talbot and Penrith (1963) concluded that bigeye fed exclusively on fish, squid and prawn (50.7, 38.8 and 10.1%) respectively by volume. Koga (1958) reports that the food in the stomachs of western Indian ocean bigeye included Alepisaurids, Sphyraenids, Sternoptychids and young skipjack (the main food type) as well as decapods. Watanabe(1960) reported that in the eastern waters around 10°S, the main food items were squids and fishes such as Alepisaurids, Sternoptychids, Paralepidids, Lepidotids and Chiasmodontids. Bertrand *et al.* (2002) in the French Polynesia reported the major food items of bigeye tuna as fish (75%), cephalopods (22%), crustaceans (1%) and gelatinous organisms. In the present study it could be seen that 55% of the stomach were empty. The major food components were squid (36.4%), semi digested fish (22.7%), other teleost fish (18.2%), deep sea shrimps (9.1%), while 13.6 % of the food were in fully digested form. The present study agrees with the studies made by previous workers.

Conclusion:

In view of the BET resource's potential in the EEZ of Andaman and Nicobar Islands and also non-availability of information on the biology of the BET this attempt has been made. As the present study provides only limited information on the biology of BET, for thorough understanding of the BET resources and its behavior further investigations are needed.

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Table 1. Morphometric measurements of *Thunnus obesus* (Male)

	MINIMUM	MAXIMUM	MEAN	SD
TOTAL LENGTH	112	185	141.4	21.8
HEAD LENGTH	27	51	37.1	7.4
S-1 D	30	51	38.1	6.6
1 D- 2D	24	41	30.9	5.6
S-2D	53	92	67.8	12.6
1 D-A	42	78	56.9	11.3
2 D-A	28	52	39.5	7.4
S-A	56	109	80.3	15.5
WEIGHT	16	100	41.5	23.2

Table 2. Morphometric measurements of *Thunnus obesus* (Female)

	MINIMUM	MAXIMUM	MEAN	SD
TOTAL LENGTH	134	186	148.4	19.0
HEAD LENGTH	37	50	40.4	4.6
S-1 D	30	53	40.0	6.8
1 D- 2D	20	40	30.0	6.1
S-2D	65	88	71.9	7.6
1 D-A	54	76	60.3	7.4
2 D-A	36	56	42.4	6.3
S-A	78	97	85.4	6.2
WEIGHT	30	90	47.9	19.8

Table 3. Value of a,b and regression coefficient r of *Thunnus obesus*(male and female)

	Male			Female		
	a	b	r	a	b	r
TL-FL	0.15	0.92	0.99	0.25	0.92	0.99
TL-HL	0.39	0.27	0.99	-0.05	0.27	0.98
(S-1D) – (S-2D)	0.13	0.80	0.98	0.02	0.76	0.99
(1D-A) – (2D-A)	1.01	0.02	0.99	-0.79	0.72	0.99

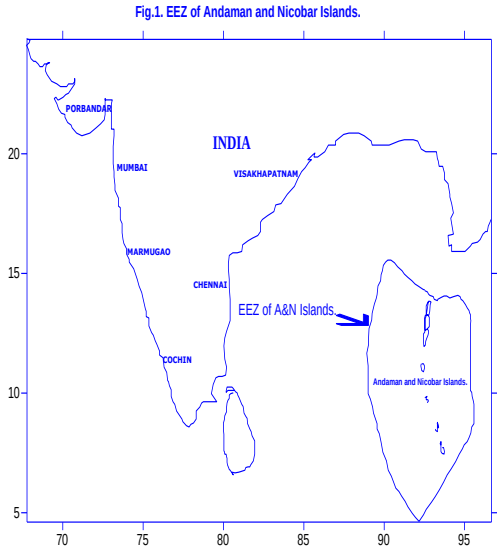
Table 4. Month wise sex ratio and Chi square value of *Thunnus obesus* in A& N waters

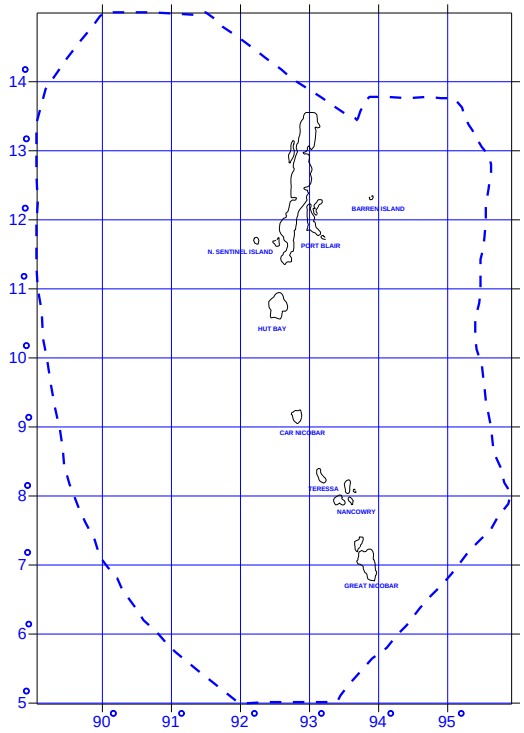
Months	Male	Female	Sex ratio (M:F)	Chi square
January	0	1	0	0.50
February	4	3	1:0.7	0.07
March	11	8	1:0.7	0.24
April	2	1	1:0.5	0.17
May	-	-	-	-
June	-	-	-	-
July	-	-	-	-
August	-	-	-	-
September	1	0	0	0.50
October	3	0	0	1.50
November	1	0	0	0.50
December	2	4	1:2	0.33
Total	**24**	**17**	**1:0.7**	**0.60**

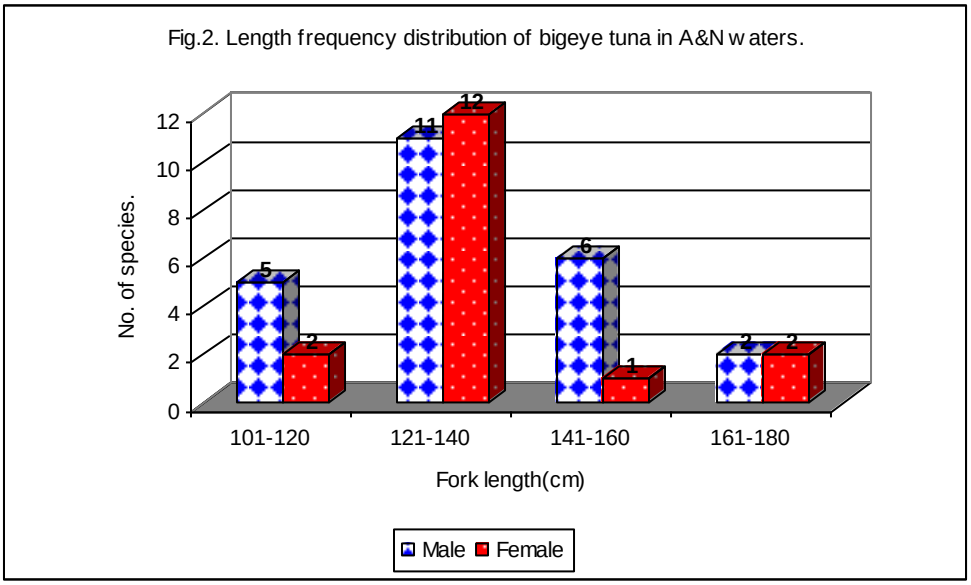
Table 5. Size wise sex ratio of *Thunnus obesus* in A&N waters

Length range (cm)	Male	Female	Sex ratio (M:F)	Chi square
101-120	5	2	1:0.4	0.64
121-140	11	12	1:1.1	0.02
141-160	6	1	1:0.2	1.79
161-180	2	2	1:1	0
Total	**24**	**17**	**1:0.7**	**0.60**

Fig. 1. EEZ of Andaman and Nicobar group of Islands.







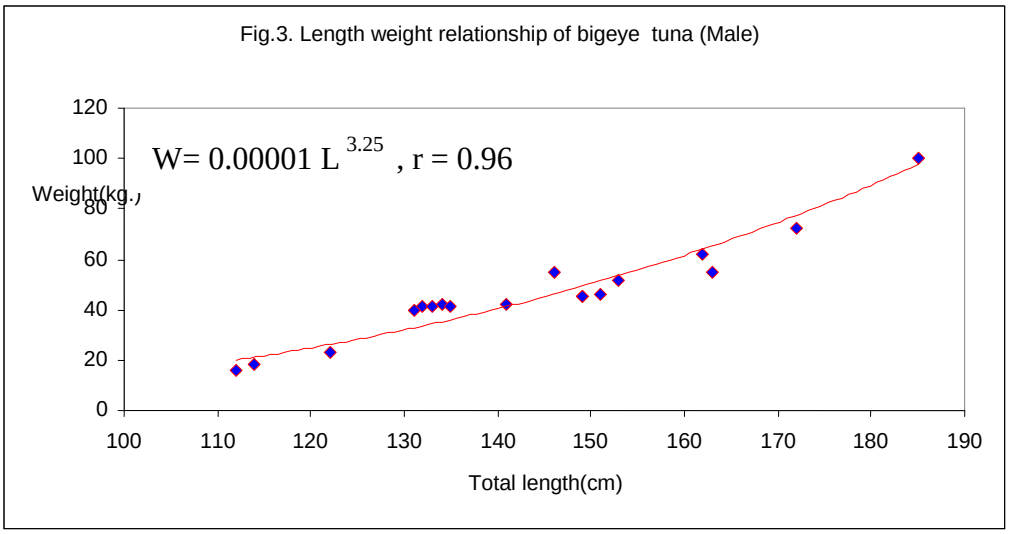


Fig.3. Length weight relationship of bigeye tuna (Male)
W= 0.00001 L 3.25 , r = 0.96
Weight(kg.)
Total length(cm)
0
20
40
60
80
100
120
100
110
120
130
140
150
160
170
180
190

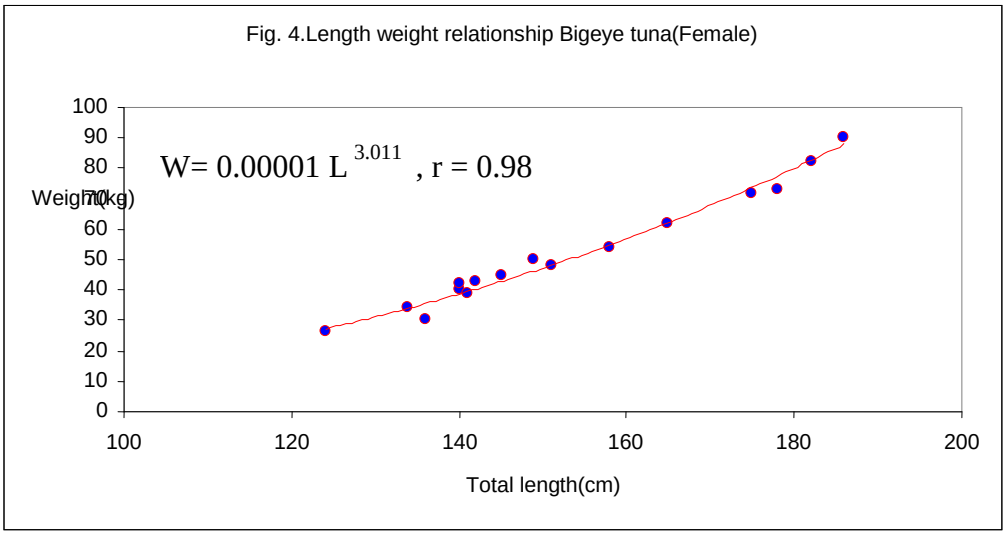


Fig. 4.Length weight relationship Bigeye tuna(Female)
W= 0.00001 L 3.011 , r = 0.98
Weight(kg)
Total length(cm)
0
10
20
30
40
50
60
70
80
90
100
100
120
140
160
180
200

Fig.5. Length weight relationship of bigeye tuna(Pooled)

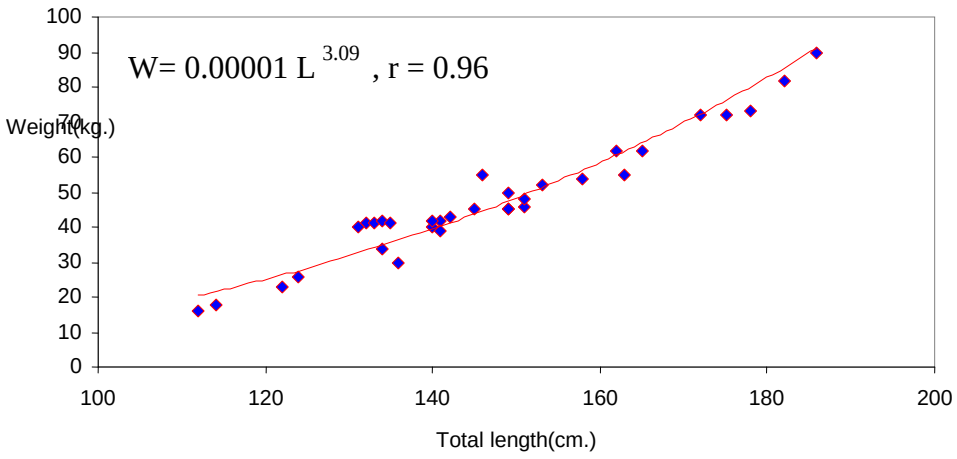


Fig.6. Gonad maturity stages of Bigeye tuna in A&N waters

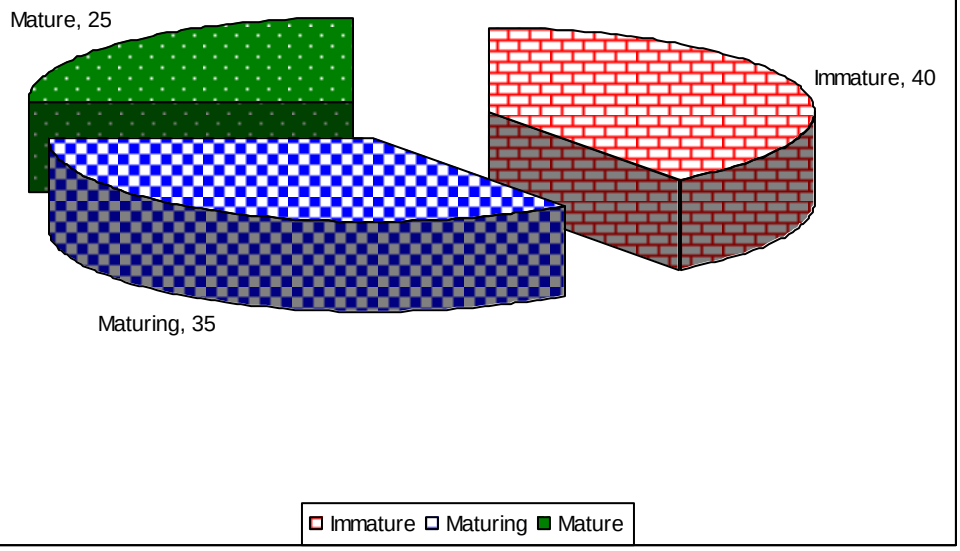


Fig.7. Feeding intensity of Bigeye tuna

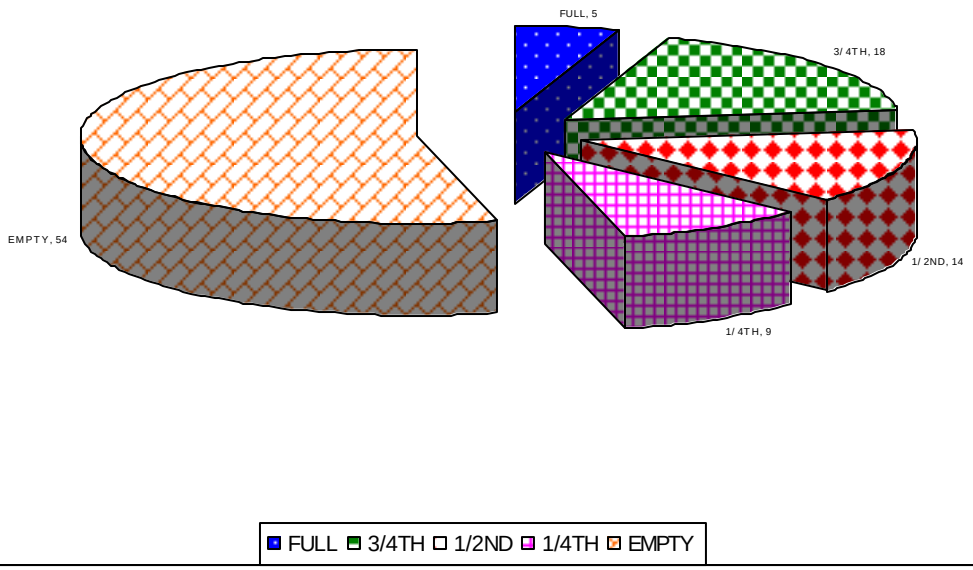


Fig.8

Food composition of Bigeye tuna in A&N waters