

Age and growth of cobia, *Rachycentron canadum* (Linnaeus, 1766) occurring in North West coast of India

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An attempt is made to provide information on age and growth of cobia inhabiting in Indian waters. Growth parameters L_{∞} and K were estimated following five methods. Age at zero length (t_0) was estimated following von Bertalanffy plot. VBGF equation was fitted using various parameters and the equation thus arrived at was $L_t = 194.25 (1 - e^{-0.24(t-0.1567)})$. By fitting length at first maturity of cobia to the VBGF equation age at first maturity of male and female was estimated at 1.48 and 1.71 years respectively. Present study estimated L_{max} at 181 cm and life span of cobia was estimated at 12.48 years. Growth parameters estimated by the present study were compared with the available estimates round world and interferences were derived.

[**Keywords:** Stock assessment; Population dynamics; Cobia fishery, Cobia]

Introduction

Cobia, *Rachycentron canadum* (Linnaeus, 1766) is a coastal pelagic, fast growing fish and belongs to the monotypic family Rachycentridae. Cobia fishery exists in different parts of the world. High demand in market, significant qualities as a game fish and better culture prospective made it as an important resource in recreational and commercial fishery.

The knowledge of age and growth of a fish is an essential input for fishery management. Preliminary information on age and growth of cobia occurring in different parts of the world are available¹⁻⁸. But, except a preliminary investigation on cobia occurring along northwest coast of India⁹, information available on cobia occurring in Indian waters is meager. Hence, an attempt is made to provide information on age and growth of cobia inhabiting along the northwest coast of India.

Materials and Methods

1261 specimens of total length ranging from 22.6 cm to 181cm collected from the vessel *M.V. Matsya Nireekshani*, the survey vessel belonging to Mumbai base of Fishery Survey of India, Mumbai and from local landing centers at Mumbai were used for estimation of age and growth. All fishes collected during the period January 2008 to December 2009

were grouped in to length class of 10 cm interval. To ensure uniformity of length frequency, the entire data were pooled as one-year data and analysed using FAO-ICLARM Stock Assessment Tools (FiSAT)¹⁰.

The von Bertalanffy growth equation (VBGF)¹¹ was used to describe the growth. The simplest version of VBGF $L_t = L_{\infty} (1 - \text{EXP}(-K(t - t_0)))$ and $W_t = W_{\infty} (1 - \text{EXP}(-K(t - t_0)))$ were followed. Where, L_{∞} is asymptotic length, W_{∞} is asymptotic weight, K is growth coefficient, t_0 is the age of fish at length or weight zero if they grow as per equation, L_t is predicted length at age t and W_t is predicted weight at age t .

The analysis was carried out in the following stages:

1. Analysis of the data using Electronic Length Frequency Analysis (ELEFAN I) to estimate K value and L_{∞} ¹² and Shepherd's method¹³ to find out K value by fixing L_{∞}
2. Analysis of data using Powel-Wetherall plot^{14,15} to find out z/k value and L_{∞}
3. Model class progression analysis following integrated method¹⁶. The mean was estimated following Bhattacharya's method¹⁷
4. Estimation of K value and L_{∞} following Ford-Walford Plot^{18,19} and Gulland and Holt plot method²⁰

5. Estimation of t_0 following Beverton's method and von Bertalanffy plot using formula $t_0 = t_{(l)} + (1/k \ln (1 - Lt/ L_\infty))$. The parameters L_∞ and K used in the above formula were obtained from Ford-Walford plot.
6. The growth parameters thus arrived at was fitted in the VBGF to obtain growth model for the fish samples
7. By substituting the values of size at first maturity²¹ to von Bertalanffy growth equation age at first maturity of male and female was estimated
8. Sample weight of length group and mean weight of sample were estimated²² following Beyer (1987)
9. The growth performance index $\phi' = 2.3$ was estimated from asymptotic length from the formula: $\phi' = \log_{10}(K) + 2 \cdot \log_{10}(L_\infty)$
10. Life span was estimated from asymptotic length²⁴.

Results

Monthly length frequency distribution of cobia for the period from January 2008 to December is shown in the ELEFAN curve of cobia (Fig. 1). As showed in the Fig. 1, cobia reported throughout the period of study and stock was represented by different year classes.

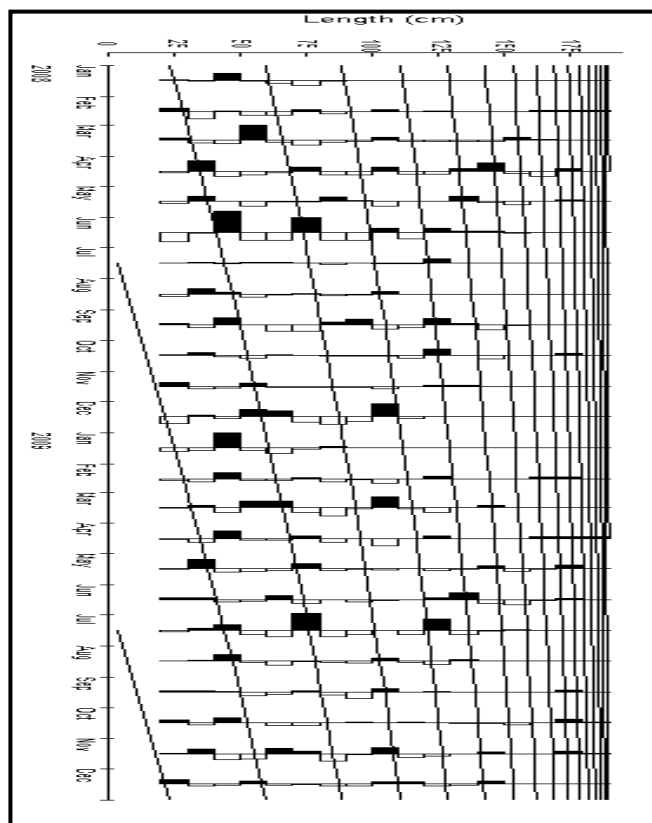


Fig.1-ELEFAN I curve of cobia *Rachycentron canadum*

K value and L_∞ estimated following three methods of direct fit of length frequency (ELEFAN, Shepherd's method and Powell and Wetherall method). Results obtained by all the three methods of direct fit of length frequency are furnished in Table 1. Parameters estimated by all the three methods were almost similar. However, L_∞ in cm and K value estimated by ELEFAN was used for further analysis as ELEFAN is considered as free from subjectivity.

Table 1-Growth parameter L_∞ and K of *Rachycentron canadum* obtained by direct fit of length frequencies

Methodology	L_∞ in cm	K value in K/yr
ELEFAN	194.25	0.24
Shepherd's method	194.25	0.25
Powell and Wetherall	199.85	0.23

Mean lengths of cohorts recorded in different months during the study obtained by Bhattacharya's method ranged between 34.58 cm and 174.73 cm. Sample represented specimens from all the size groups of 10 cm interval between 30 -180. Results of growth increment study are furnished as Table 2. As shown in Table 2, growth rate ranged from 1.25 cm per month to 7.5 cm per month. Faster growth rate in juveniles and seasonal difference in growth rate were observed.

Table 2- Growth increment data of *Rachycentron canadum* during the study following Bhattacharya's method.

Initial length in cm			Final length in cm			Growth rate per month in cm.
Month	Year	Length in cm.	Month	Year	Length in cm.	
Feb	2008	46.17	Mar	2008	51.63	5.46
Feb	2008	116.67	May	2008	130	4.44
Mar	2008	51.63	Aug	2008	70.07	3.69
Apr	2008	34	May	2008	37.3	3.30
Apr	2008	72.7	Sep	2008	91.74	3.81
Apr	2008	107.5	Aug	2008	115.05	1.89
May	2008	37.3	Jun	2008	41.25	3.95
May	2008	130	Oct	2009	163.33	6.67
Jun	2008	41.25	Sep	2008	45.69	1.48
Aug	2008	70.07	Jan	2009	80.93	2.17
Aug	2008	115.05	Jul	2009	143.09	2.55
Sep	2008	45.69	Mar	2009	56.11	2.08
Sep	2008	91.74	Mar	2009	103.75	2.00
Jan	2009	80.93	Oct	2009	94.61	1.52
Mar	2009	56.11	Nov	2009	69.06	1.62
Mar	2009	103.75	Oct	2009	125.21	3.07
Jun	2009	30	Aug	2009	45	7.50
Aug	2009	45	Dec	2009	50	1.25

Identification of cohort by linking of mean is furnished in Fig.2. Seven cohorts were visible in the figure and this indicated the occurrence of multi age stock of the species. By using the above length at age data and following Gulland and Holt plot method L_{∞} and K estimated were 194.20 cm and 0.299 respectively.

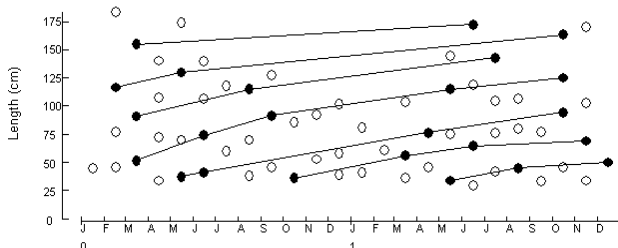


Fig.2- Linking of mean length of cobia *Rachycentron canadum* by Bhattacharyas method

Growth rate was plotted against mean length and percentage of deviation of growth during different season indicated that seasonal growth oscillation is significant. Lengths at age data derived by model progression analysis were further utilized for Ford Walford plot and estimated growth parameters as L_{∞} and K as 194.25 and 0.24.

Age of fish at length zero (t_0) was estimated following von Bertalanffy plot. Here L_{∞} and K estimated by Ford Walford plot were used as input parameter and substituted in to the equation by utilizing the length at age data derived by model progression analysis, t_0 thus obtained is -0.1567 .

Length at age derived by utilizing data based on linking of mean are depicted in Fig. 3. The VBGF equation was fitted using various parameters estimated following Ford Walford plot (L_{∞} and K) and von Bertalanffy plot (t_0). VBGF equation so arrived at is $L_t = L_{\infty} (1 - e^{-K(t-t_0)})$. It can be rewritten as $L_t = 194.25 (1 - e^{-0.24(t-0.1567)})$.

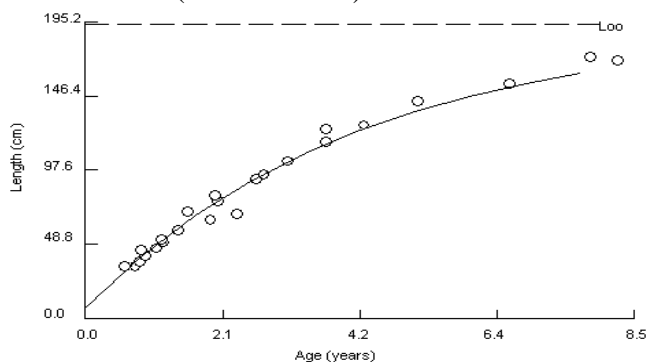


Fig.3-Analysis of length at age of *Rachycentron canadum*

Table 3-Age and length of *Rachycentron canadum* inhabiting along northwest coast of India

Age and length			
derived by linking of mean		Age and length by VBGF	
Age	Length in cm	Age	Length in cm
0.613	33.92	0.5	15.36
0.768	34.00	1	35.59
0.850	37.3	1.5	53.53
0.866	45.00	2.0	69.44
0.935	41.25	2.5	83.56
1.094	46.17	3.0	96.07
1.173	51.63	3.5	107.18
1.200	50.00	4.0	117.02
1.436	58.19	4.5	125.76
1.593	70.07	5.0	133.50
1.935	64.66	5.5	140.37
2.012	80.93	6.0	146.46
2.052	77.37	6.5	151.89
2.354	69.06	7.0	156.66
2.635	91.74	7.5	160.91
2.760	94.61	8.0	164.68
3.131	103.75	8.5	168.02
3.718	125.21	9.0	170.99
3.724	116.67	9.5	173.62
4.308	127.55	10.0	175.95
5.138	143.09	10.5	178.02
6.565	155	11.0	179.86
7.817	172.37	11.5	181.48
8.236	170.00	12.0	182.92

Length of fish derived by linking of mean and values obtained by fitting the VBGF equation is given in Table 3. Lengths at first maturity of cobia male and female are 63cm and 70cm respectively²¹. By Fitting these length to the VBGF equation age at first maturity of male and female was estimated as 1.48(rounded to 1.5) and 1.71(rounded to 1.75) years respectively.

Mean weight of cobia ranged between 91.21 gm to 42397.21gm and mean weight of the sample was more during April-July and November. Mean weight of each length class of fishes estimated is shown in Table 4. Growth rate was more during initial size groups, which was reduced when it grow. The growth performance index (ϕ') estimated was 3.957.

Life span of the species estimated based on asymptotic length and growth rate were 12.482 and 12.5 years respectively. Life span estimation based on growth rate will give only an approximate value²⁵; hence, value estimated based on asymptotic length is relatively more accurate and therefore longevity of cobia is considered as 12.48 years.

Table 4- Mean weight and growth rate of *Rachycentron canadum* inhabiting along North West coast of India on length group basis

Mid length of size class in cm.	Mean weight (in gm.)	Growth rate	Mid length of size class in cm.	Mean weight (in gm.)	Growth rate
25	91.21	-	115	9733.3	0.32
35	252.72	1.77	125	12640.7	0.30
45	544.61	1.15	135	16029.4	0.27
55	1007.91	0.85	145	19984.9	0.25
65	1684.44	0.67	155	24553.2	0.23
75	2616.74	0.55	165	26780.3	0.09
85	3847.90	0.47	175	35712.8	0.33
95	5421.57	0.41	185	42397.2	0.19
105	7381.85	0.36			

Discussion

Growth parameters L_{∞} and K were estimated following five methods. Parameters estimated are generally in agreement with other methods. Out of the five methods employed L_{∞} and K value estimated by ELEFAN method and Ford Walford plot were equal. Subjectivity is at minimum in the case of ELEFAN method; hence L_{∞} and K values estimated following ELEFAN method were used for further analysis. Age at zero length t_0 estimated following von Bertalanffy plot was -0.157. Negative t_0 value indicated the faster growth rate of fish in their juvenile stage^{18, 19}.

Growth parameters estimated by different authors from various localities are furnished in Table 5. As shown in the Table 5, except three studies^{7, 25-26}, L_{∞} estimated by the present study was on higher side when compared to other estimates.

K value estimates ranged between 0.09 to 0.63 and present estimate concur with the results of previous studies^{3, 27-28}. Similarly, t_0 value ranged between -3.6 to 0.67. Except three studies^{3, 27, 29}, invariably all previous workers reported negative t_0 value. This indicates the faster growth rate of cobia in their juvenile stage.

Model progression analysis, linking of mean of length class modes as a part of model progression analysis identified seven cohorts in the sample. This indicates the occurrence of multi- age groups in the cobia stock. Length of fish in different age groups estimated by model progression analysis and VBGF are of similar pattern. This shows the accuracy of the present estimates.

Age at maturity estimated for male and female cobia was 1.5 and 1.75 years respectively. Age at maturity of cobia inhabiting in Chesapeake Bay was estimated at 2 years and 3 years for male and female respectively^{3, 27}.

Table 5.- Growth parameters of *Rachycentron canadum* reported by various authors from different localities - Values (pooled) M/F

L_{∞} in cm.	K value in L/yr	t_0 in yr	ϕ'	Longevity in years	Location and Author/s
49/59	0.21/0.10	-0.67/0.80	3.6/3.7	(10)	Chesapeake Bay Richards (1967)
121/164	0.28/0.22	0.06/0.08	-	-	Chesapeake Bay Richards (1977)
(160)	(0.09)	(0.01)	-	-	Gulf of Aden Edwards <i>et al.</i> (1985)
(141)	(0.21)	-	(3.6)	-	South Africa Torres and Pauly (1991)
			3.8/3.9	(10)	Western Louisiana Thompson <i>et al.</i> (1991)
(184)	(0.13)	(-3.62)	-	-	North Carolina Smith (1995)
117/155	0.432/0.272	-1.15/-1.25	3.8/3.9	(11)	Texas Burns <i>et al.</i> (1998)
(135)	(0.17)	-	-	-	Northeastern Gulf of Mexico Franks <i>et al.</i> (1999)
115/185	0.38/0.125	-1.05/-3.07	-	(11)	North west Indian EEZ Somvanshi <i>et al.</i> (2000)
(169)	-	(-0.97)	-	-	Gulf of Mexico Williams (2001)
(116)	(0.63)	(-0.21)	-	(13)	Northeastern Persian Gulf Behnam <i>et al.</i> (2006)
(194)	(0.24)	(-0.15)	(3.9)	(12.5)	North and Eastern Australia Fry and Griffiths (2010)
					North west Indian EEZ Present study

Geographical difference of study area can be the attributed as an important factor for this variance.

Mean weight of the sample recorded during the study is 5637.75 gram. Month-wise analysis of mean of sample weight indicated that during April to July and September to November mean weight of sample were above the mean weight of the sample. This indicates that the increased spawning activity of cobia occurs during April to July and September to November²¹. In contrast to this number of juveniles were found dominant during January to March and August samples. This signifies that recruitment to the

fishery is mainly takes place during January to March and August.

As appears in Table 5, L_{\max} estimated by different authors ranged between 142 cm⁵ to 200 cm²⁸. Present study estimated L_{\max} and L_{∞} at 181 cm and 194.25 cm respectively. Landing records showed that cobia may reach up to 2 m^{1, 30}. Moreover, maximum size of the sample used was 185 cm. Hence it can be concluded that the estimates of the present study is rational.

Growth performance indices (ϕ') worked out by different authors from different geographical locations ranged from 3.6 –3.97. These values pertain to various habitats of cobia and therefore the values cannot be compared. However, ϕ' value (3.96) estimated by the present study is within the range of available estimates.

Life span of cobia in terms of years reported from different geographical areas varied from place to place. Longevity values ranged between 10 years and 14 years. Present study estimated the value as 12.48 years. From the high value of life span and low mortality rates²¹ it can be inferred that cobia stock in North West coast of India is in good condition.

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