Egypt. J. Aquat. Biol. & Fish., Vol.5, No. 3 : 179 - 194 (2001) *ISSN 1110 – 6131*

DYNAMICS AND MANAGEMENT OF THE INDIAN MACKEREL *RASTRELLIGER KANAGURTA* (CUVIER, 1816) IN THE GULF OF SUEZ, EGYPT

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Key words: *Rastrelliger kanagurta*, Scombridae, Gulf of Suez, age and growth, mortality rates, yield per recruit

ABSTRACT

Based on the otolith's readings of 678 specimens collected during the fishing season 1998/1999, age, growth, mortality and yield per recruit of *Rastrelliger kanagurta* from the Gulf of Suez were studied. Age composition showed no variation between the two sexes. The oldest males and females were four years old. The values of the von Bertalanffy growth parameters were $K = 0.66$ year^{-1} and $L_\infty = 29.48$ cm for males and $K = 0.60$ year^{-1} and $L_\infty = 32.04$ cm for females. The mean total mortality coefficient "Z" was found to be 1.12 year^{-1} for males and 1.00 year^{-1} for females. The natural mortality coefficient "M" was 0.26 year^{-1} for males and 0.25 year^{-1} for females. The yield per recruit was estimated using the parameters obtained for the combined sexes. The results suggest that the present level of fishing mortality ($F = 0.82$) is much higher than that which gives the maximum yield per recruit.

INTRODUCTION

The Gulf of Suez is one of the most important fishing grounds in Egypt. It yields an average annual catch of 20,000 ton . The purse-seine is the common gear for pelagic fishery in the Gulf with an average annual total catch of 15,536 ton (during the period from the fishing season 1985/1986 to 1998/1999). The purse-seine catch composed of a mixture of fish species of which the indian mackerel, *Rastrelliger kanagurta* is among the most important species.

Despite the commercial importance of the indian mackerel in the Gulf of Suez, there are very few studies concerning its biology and dynamics. Rafail (1972) studied age, growth and mortality rates of *R. kanagurta* from Red Sea near Al-Ghardaqa. Sanders *et al.* (1984)

investigated age, growth and mortality rates of *R. kanagurta* from the Gulf of Suez.

On the other hand, many studies were carried out dealing with the biology and dynamics of *R. kanagurta* on other localities. Guanco (1991) investigated the growth and mortality of *R. kanagurta* in Philippines; Edwards and Shaher (1991) estimated the growth parameters of *R. kanagurta* from the Gulf of Aden; Torres (1991) estimated the growth parameters of *R. kanagurta* in Southern Africa.

For a judicious exploitation and management of this species, information on its biology and dynamics is essential. Thus, this study is undertaken to obtain the basic information required for the management of this valuable fish species in the Gulf of Suez.

MATERIAL AND METHODS

Monthly random samples of *R. kanagurta* were collected from the local market of Suez City during the period from September 1998 to April 1999. The total length to the nearest millimeter, total weight to the nearest 0.1 g and sex were recorded for each specimen.

Otoliths were used for age determination of R. kanagurta. Otoliths were taken out, cleaned carefully and washed in distilled water, then examined using optical system consisting of Nikon Zoom-Stereomicroscope focusing block, Heidenhain's electronic bidirectional read out system VR X 182, under transmitted light. The total radius of the otolith and the radius of each annulus were measured to the nearest 0.001mm. The body total length-otolith radius relationship was determined by using the least square method. The lengths at previous ages were back- calculated from otolith measurements using Lee's equation (1920).

The power equation ($W = aL^b$) was applied to describe the relationship between the total length (L) and the total weight (W).

The growth parameters of the von Bertalanffy growth model (K and L_∞) were estimated using the method of Ford (1933)-Walford (1946).

Total mortality coefficient "Z" is estimated using the methods of Ricker (1975) which is based on the analysis of catch curve using age composition data and Jones and Van Zalinge (1981) which is based on the analysis of catch curve used length frequency data.

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Natural mortality coefficient "M" was estimated using the formula suggested by Ursin (1967), while the fishing mortality coefficient "F" was computed as F = Z - M.

The yield per recruit of *R. kanagurta* was computed by applying the model of Beverton and Holt (1957).

RESULTS AND DISCUSSION

Age Composition

The age composition of *R. kanagurta* showed no variation between the two sexes (Table 1). The oldest males and females were four years old. The present data show that age group II is the dominant age group in the catch for both sexes and constituted 57.43% for males and 55.22% for females. This means that *R. kanagurta* in the Gulf of Suez becomes fully recruited to the purse-seine fishery at an age of two years.

Growth in Length

A- Body Length - Otolith Radius Relationship

Otolith's measurements of 343 males and 335 females were used for the estimation of the body length-otolith radius relationship of *R. kanagurta* collected from the Gulf of Suez. This relationship is linear and can be represented by the following equations:

For males $L = 3.45209 + 7.95719\ S$ $(r = 0.9986)$

For females $L = 4.00060 + 7.77050\ S$ $(r = 0.9895)$

where L = the total length in centimeter,
S = the otolith radius in millimeter
r = the correlation coefficient.

B- Back - Calculations

The back-calculated lengths at the end of different years of life of both sexes of R. *kanagurta* were computed according to Lee's equation as follows:

For males $L_n = (L - 3.45289)\ S_n / S + 3.45289$

For females $L_n = (L - 4.00060)\ S_n / S + 4.00060$

where L_n = the calculated length at the end of n^{th} year,
L = the total length at capture,
S_n = the otolith radius to n^{th} annulus
S = the total otolith radius in millimeter.

The back-calculated lengths are given in Tables 2 and 3. The results show that males reach 14.8, 21.9, 25.6 and 27.4 cm at the end of 1st, 2nd, 3rd and 4th year of life respectively while females attain 15.6, 22.9, 27.3 and 29.3 cm at the end of 1st, 2nd, 3rd and 4th year of life respectively. It is evident that both males and females attain their highest growth rate in length during the first year of life, after which, the annual increment in length decreases with further increase in age until it reaches its minimum value at the end of the 4th year of life. This result is in a good agreement with the finding of George and Banerji (1964) who reported that the young stages of *R. kanagurta* are characterized by a higher growth rate than the old ones. Seshappa (1969) found that the indian mackerel reaches a total length of 11 - 15 cm, 21 - 24 cm, 25 - 27 cm and 28 - 29 cm by the end of the 1st, 2nd, 3rd and 4th year of life, respectively. Rafail (1972) found that the *R. kanagurta* from Red Sea, Egypt attains lengths of 18.0, 24.0 and 28.5 cm by the end of the 1st, 2nd and 3rd year of life, respectively. Luther (1973) gave lengths of 14.8, 21.8, 26.5 and 30.2 cm for the 1st, 2nd, 3rd and 4th year of life, respectively for *R. kanagurta* from Andaman Islands, India.

Length - Weight Relationship

For the estimation of the length - weight relationship of *R. kanagurta* in the Gulf of Suez, the measurements of 343 males and 335 females were used. The lengths of males ranged between 14.3 and 27.7 cm and their weights varied from 25 and 226 g, while the lengths of females varied from 14.5 and 29.9 cm and their weights ranged between 26 and 282 g. The calculated length-weight equations were found to be:

For males $W = 0.00548\ L^{3.19871}$ $(r = 0.9968)$

For females $W = 0.00607\ L^{3.16818}$ $(r = 0.9984)$

The values of the power "b" obtained from the present study are more or less similar to those mentioned from the previous studies. Luther (1973) gave a "b" value of 3.2541 for males and 3.3149 for females of *R. kanagurta* from Andaman Islands. Sudjastani (1973)

gave a "b" value of 3.19 for *R. kanagurta* from Java Sea. Anon (1985) mentioned a value of "b" equal to 3.22 for *R. kanagurta* from west coast Malaysia and 3.09 from Malaysia.

Growth in Weight

Tables 4 and 5 show the calculated weights at the end of each year of life for males and females of *R. kanagurta*, respectively. The results indicated that for both males and females, the growth in weight is very slow during the first year of life and the annual increment in weight increases with further increase in age until it reaches its maximum value at age group II for males and III for females after which a decreasing in the annual increment was noticed.

Theoretical Growth

In the present study, the growth model of von Bertalanffy was applied. The growth parameters of the von Bertalanffy growth model were computed by applying the method of Ford (1933)-Walford (1946) as follows:

$$L_{t+1} = L_{\infty} (1 - e^{-K}) + e^{-K} L_t$$

where L_t and L_{t+1} are the length at age "t" and "t+1" respectively.

The growth parameters of *R. kanagurta* from the Gulf of Suez are shown in Table "6" along with those reported by other authors. The present study indicated that the asymptotic total length of the combined sexes of *R. kanagurta* from the Gulf of Suez was 32.15 cm while it was 42cm at Red Sea (Rafail, 1972) and 40cm at the Gulf of Suez (Sanders *et al*, 1984). On the other hand, the value of K in the present study was 0.57, while it was 0.29 (Rafail, 1972) and 0.23 (Sanders *et al*, 1984), indicating that the indian mackerel fish in the present study reach their asymptotic total length faster than those recorded in Rafail (1972) and Sanders *et al.* (1984) The present values of the growth parameters was found to be in the range of those recorded for the same species in other localities (Table 6).

Mortality

Total Mortality Coefficient " Z "

In the present study, two different methods were applied to estimate the total mortality coefficient "Z". The first is based on the analysis of age composition data (semilogarithmic regression method of Ricker, 1975) and the second is based on the analysis of length composition data (cumulated catch curve method of Jones and Van Zalinge, 1981).

The present results (Table 7 and Figs. 1&2) indicate that the estimated values of "Z" from the two different methods are very close to each other.

Natural Mortality Coefficient "M"

In the present study, the formula suggested by Ursin (1967) was applied to estimate the natural mortality coefficient "M". This formula can be expressed as $M = W^{-1/3}$. The values of "M" were 0.2611 for males and 0.2514 for females.

Fishing Mortality Coefficient "F"

Fishing mortality coefficient "F" was estimated as F = Z-M. It is found that F = 0.86 for males and 0.7536 for females.

Yield per Recruit "Y/R"

The model of Beverton and Holt (1957), which was based on the estimation of the yield per recruit under a particular set of fishing mortality coefficients, was applied. The input parameters used in Beverton and Holt model are the growth and mortality parameters of the combined sexes. These parameters are as follows:

$L_\infty = 32.15$ cm	$W_\infty = 362.41$ g	$K = 0.5734$ year^{-1}
$M = 0.2560$ year^{-1}	F = variable	$T_r = 0.8507$ year
T_c = variable	$t_o = -0.0529$ year	$Z = 1.0786$ year^{-1}

The estimated yield per recruit of *R. kanagurta* in the Gulf of Suez is represented graphically in Fig. 3. The results indicate that, the yield per recruit was zero when the fishing mortality was zero, then the yield per recruit increases rapidly as the fishing mortality increases and reaches its maximum value at fishing mortality coefficient of 0.4 after which the yield per recruit decreases with further increase of

fishing mortality (Fig. 3). The results indicate also that, at the present level of fishing mortality coefficient (F= 0.8226), age at first capture (T_c = 0.97 year) and natural mortality coefficient (M= 0.256), the yield per recruit was estimated to be 78.99 g. This means that, the present level of fishing mortality is higher than that which gives the maximum yield per recruit and to obtain the maximum yield per recruit (85.79 g), the fishing mortality coefficient must be reduced from 0.8226 to 0.4 (51.37 %).

To determine the most appropriate age at first capture "T_c" of *R. kanagurta* from the Gulf of Suez, which is related to the estimation of the optimum mesh size, the yield per recruit was estimated by applying different values of T_c (1.5 and 2 years with the present value 0.97 year). The results (Fig. 3) indicate that with the increasing of T_c a higher yield per recruit can be obtained. It is obvious also that if T_c is 1.5 instead of 0.97 year a maximum yield per recruit of 98.01g can be obtained at fishing mortality of 0.6 and if T_c is two years a maximum yield per recruit of 107.91 g can be obtained at fishing mortality of 0.9 which is very close to the present level (F = 0.8226). This means that, the present level of T_c is not the optimum T_c of this fish species in the Gulf of Suez and it must be in the range of two years.

The obtained results are in a good agreement with the finding of Sanders *et al.* (1984). They concluded that, the stocks exploited by purse-seiners in the Gulf of Suez are fully exploited. They also mentioned that, any additional effort to the purse-seine fishery in the Gulf of Suez will be associated with an annual decrease in the catch.

From the above mentioned results, it is clear that the *R. kanagurta* stock in the Gulf of Suez is in a situation of overexploitation and if the reduction of the fishing mortality coefficient is not possible, the age at first capture must be raised to two years.

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Table (1). Age composition of *Rastrelliger kanagurta* from the Gulf of Suez

Age (year)	Males		Females	
	Number	%	Number	%
I	19	5.54	16	4.78
II	197	57.43	185	55.22
III	106	30.90	110	32.84
IV	21	6.12	24	7.16
Total	343		335	

Table (2). Average back-calculated lengths (cm) of *Rastrelliger kanagurta* (males) from the Gulf of Suez.

Age group	No. of fish	Empirical length	Back-calculated lengths at the end of each year of life			
			1	2	3	4
I	19	15.50	**14.79**			
II	197	22.62	14.66	**21.88**		
III	106	26.15	14.58	21.79	**25.65**	
IV	21	27.61	14.55	21.68	25.57	**27.45**

Table (3). Average back-calculated lengths (cm) of *Rastrelliger kanagurta* (females) from the Gulf of Suez.

Age group	No. of fish	Empirical length	Back-calculated lengths at the end of each year of life			
			1	2	3	4
I	16	16.35	**15.59**			
II	185	23.63	15.48	**22.92**		
III	110	27.90	15.39	22.81	**27.26**	
IV	24	29.59	15.27	22.76	27.18	**29.27**

Table (4). Calculated weights (g) of *Rastrelliger kanagurta* (males) from the Gulf of Suez.

Age group	No. of fish	Calculated weights at the end of each year of life			
		1	2	3	4
I	19	**30.28**			
II	197	29.44	**105.97**		
III	106	28.93	104.59	**176.21**	
IV	21	28.74	102.91	174.46	**218.91**

Table (5). Calculated weights (g) of *Rastrelliger kanagurta* (females) from the Gulf of Suez.

Age group	No. of fish	Calculated weights at the end of each year of life			
		1	2	3	4
I	16	**36.50**			
II	185	35.69	**123.76**		
III	110	35.04	121.89	**214.38**	
IV	24	34.18	121.05	212.40	**268.58**

Table (6). Comparison of growth parameter estimates in *Rastrelliger kanagurta* (sexes combined).

Locality	L_∞ (TL)	K	t_o	Author
Egypt (Red Sea)	42.0	0.29	-0.95	Rafail, 1972
Egypt (Gulf of Suez)	40.0	0.23	---	Sanders *et al.*, 1984
India	31.6	0.60	---	Seshappa, 1958
India	31.3	0.64	---	Sekharan *et al.*, 1969
India	39.0	0.74	---	Luther, 1973
India	31.6	0.60	---	Banerji&Krishnan, 1973
India	31.3	0.64	0.06	Pauly, 1978
Seychelles	31.7	0.64	---	Lablache *et al.*, 1988
South Africa	30.3	0.72	-0.198	Torres, 1991
Philippines	38.0	0.80	---	Guanco, 1991
Yemen	32.3FL	0.67	0.69	Edward&Shaher, 1991
Egypt (Gulf of Suez)				The present study, 2001
Males	29.48	0.66	-0.055	
Females	32.04	0.60	-0.118	
Sexes combined	32.15	0.57	-0.053	

Table (7). Total mortality and survival rate estimates of *Rastrelliger kanagurta* from the Gulf of Suez.

Method	Males		Females	
	S	Z	S	Z
Ricker (1975)	0.3265	1.1193	0.3602	1.0211
Jones and Van Zalinge (1981)	0.3254	1.1228	0.3720	0.9889
Mean	0.3259	1.1211	0.3660	1.005

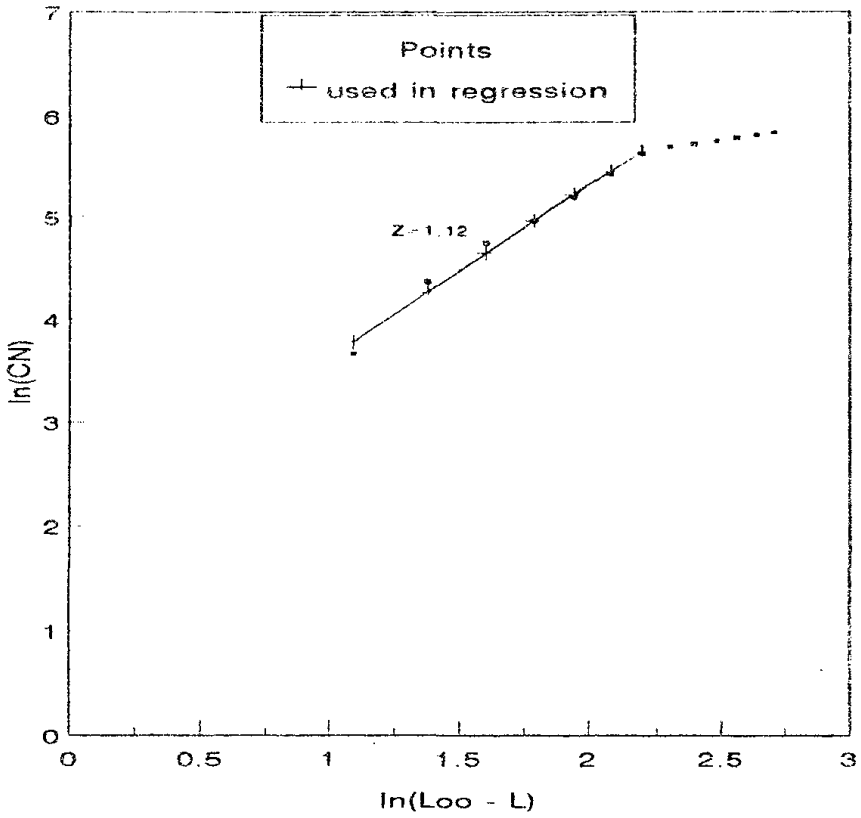

Fig.(1).Estimation of Z of *Rastrelliger kanagurta* (males)from the Gulf of Suez.

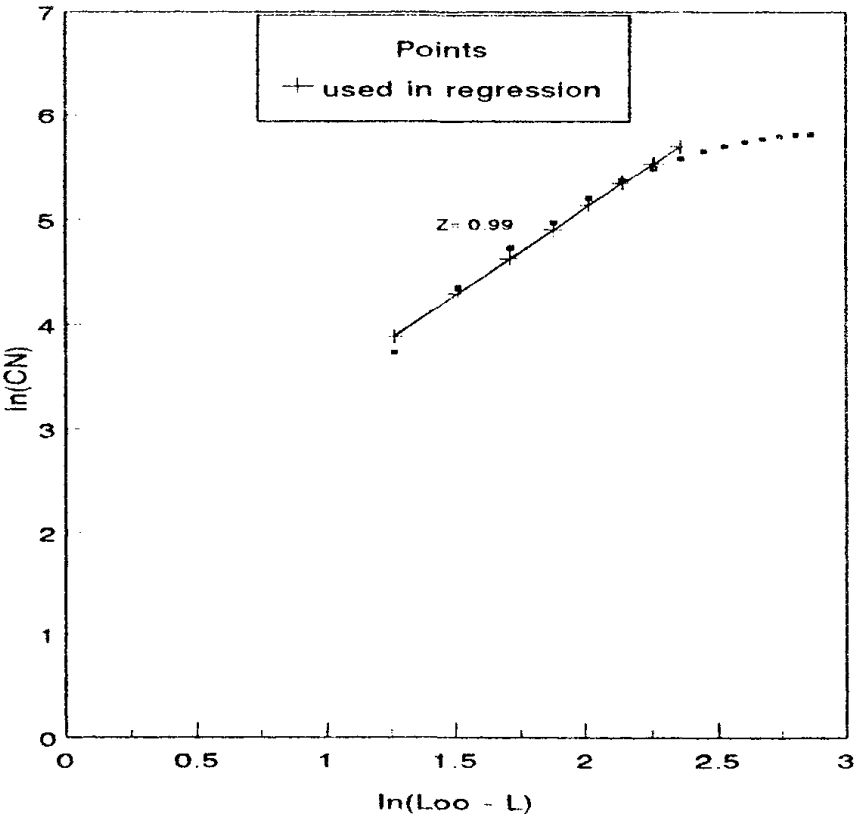

Fig.(2).Estimation of Z of *Rastrelliger kanagurta*(females)from the Gulf of Suez.

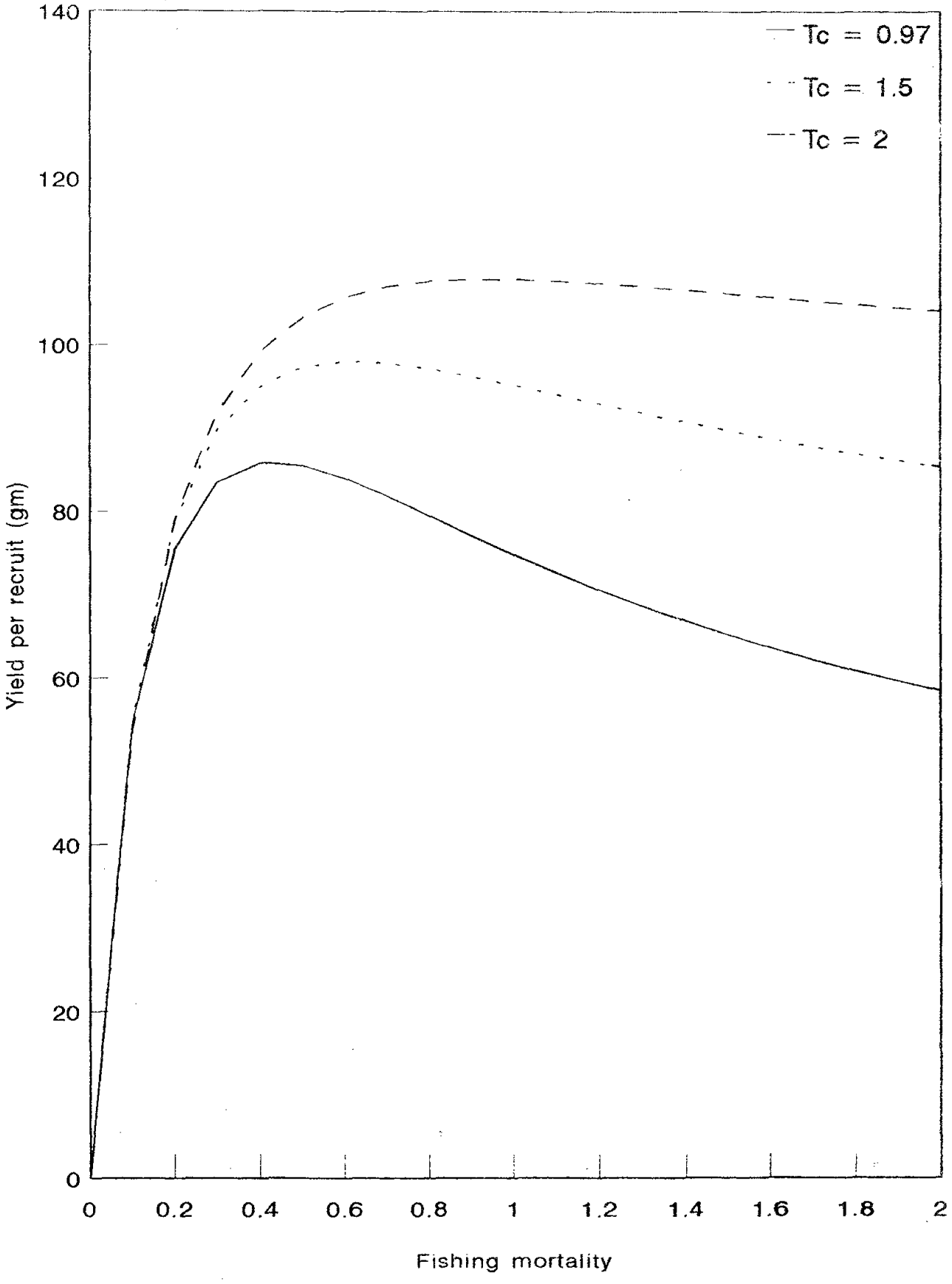

Fig.(3). Yield per recruit of *Rastrelliger kanagurta* as a function of fishing mortality and age at first capture at the Gulf of Suez.