Estimation of Age, Growth Parameters and Mortality Indices in *Lutjanus fulviflamma* (Forsskal 1775) (Pisces: Lutjanidae) from Kenyan Inshore Marine Waters

B. Kaunda-Arara[1] and M.J.Ntiba[2]

[1]Moi University, Department of Fisheries, P.O. Box 1125, Eldoret, Kenya; [2]University of Nairobi, Department of Zoology, P.O. Box 30197, Nairobi, Kenya.

ABSTRACT

Age and growth parameters of the reef fish *Lutjanus fulviflamma* have been estimated from tri-monthly plots of length frequency data and a knowledge of the spawning time of the fish. The growth parameters, $L\infty$, K and t_o were derived from the progression of modal lengths as; 35.0 cm (total length), 0.59 and -0.55 years, respectively. These parameters were used to fit a von Bertalanffy growth equation for the species as: $L_t = 35.0\ [1 - \exp(1 - (0.59\ (t + 0.55))]$.

The total mortality (Z), fishing (F) and natural (N) mortality coefficients were derived for the species from length converted catch-curve and Pauly's empirical formula as, 1.97, 0.27 and 1.70/year, respectively. The low fishing mortality (on a 0-1 scale), together with low exploitation rate(E_{opt}) of 0.137, derived for the stock of *L. fulviflamma* in Kenya's nearshore fishery suggests that the stocks are under exploited. The possible reasons for this under-exploitation are discussed. It is recommended that the growth parameters derived in this study be validated further in order to allow the application of this rapid age assessment method for other species in the Western Indian Ocean, given the difficulties of aging tropical fishes.

KEY WORDS
Age, Growth Parameters, Mortality, *Lutjanus fulviflamma*

1.0 INTRODUCTION

Lutjanids, commonly referred to as snappers form a substantial proportion of the demersal fish catches off the Kenya coast. They constitute the third most abundant group of fish in the annual landings after the Lethrinids and Siganids (Kenya Fisheries Dept,. unpublished data). While four species of snappers including *Lutjanus sanguineus*, *L. gibbus* (red snappers), *L. kasmira* (blue stripped snapper) and *L. fulviflamma* (dory snapper) are landed from Kenyan waters, the dory snapper is the mos abundant and has the highest market value (Kenya Fisheries Department, 1989/90 Stat. Bull.). In spite of their importance, very little work has been done on the Lutjanidae from East Africa. Studies on marine fishes in Kenya have focused mostly on the reproductive and feeding ecology (Reay and Rashid, 1985; Nzioka,1981; Ntiba and Jaccarini, 1992; Kaunda-Arara and Ntiba, 1997a,b) and on the community ecology of reef fishes (Ntiba *et al.*, 1993; McClanahan, 1994; McClanahan and Kaunda-

Arara, 1996). There is only scanty literature on age and growth of the reef fishes in Kenya. This scarcity is mostly due to the difficulty of aging tropical fishes (Panella, 1971; Bagenal and Tesc, 1980; Brothers, 1980; Morales and Ralston, 1990). This paper presents information on age and growth parameters of *L. fulviflamma* useful in studying population dynamics and production of this important reef fish.

2.0 MATERIALS AND METHODS

Fish were caught using baited traditional dema traps. The traps which are fabricated from reeds, range in size from about 91 cm in height, with a mesh size of 3.6 cm^2, to about 2 m, with a mesh size of 20.5 cm^2. Three traps were set at a depth of 8-14 m during day-time low tide at the mouth of the creeks surrounding Mombasa Island, Kenya. The location and characteristics of these creeks have been described in details (McClanahan and Obura, 1995). Each trap was visited after 24 h (next low tide) and the catch inspected. Sampling was done twice-monthly from October 1991 to September 1992. The total length (TL) of each fish caught was measured to the nearest millimeter and total wet body weight recorded to the nearest 0.1 g on a top-loading balance.

Length frequency histograms on a tri-monthly basis were constructed for 891 fish caught during the study period. The histograms were analyzed following the paper and pencil modal progression analysis method (Pauly, 1982). The modal length observed in these histograms were followed and converted to age groups based on knowledge of the spawning season of the species (Kaunda-Arara and Ntiba, 1997a). The derived mean lengths at age for *L. fulviflamma*, were used to fit a von Bertalanffy growth curve (VBGF) for this species based on the following equation:

$$L_t = L\infty [1 - \exp(-K(t - t_o))]$$

Where: L_t is length at age t; $L\infty$ is asymptotic length; K is the constant with which the asymptotic length is approached; and t_o is the hypothetical age the fish would have been zero length had they grown in the manner described by the equation and t is age of the fish.

The total mortality coefficient (Z) of *L. fulviflamma* stock in the coastal waters on an annual cycle, was estimated from the gradient of the descending arm of the constructed length converted catch-curve (Pauly, 1982). Natural mortality (M) was determined from an empirical relationship linking M with environmental temperature (T) as described by Pauly (1980). This relationship is described as:

$$\text{Log}_{10} M = 0.0066 - 0.279 \text{Log}_{10} L\infty + 0.6543 \text{Log}_{10} K + 0.4634 \text{Log}_{10} T$$

Where: M is the exponential rate of natural mortality on a yearly basis; and T is the mean environmental temperature for stock.

3.0 Results

The tri-monthly plots of the length frequency distribution for *L. fulviflamma* are shown in Fig.1.

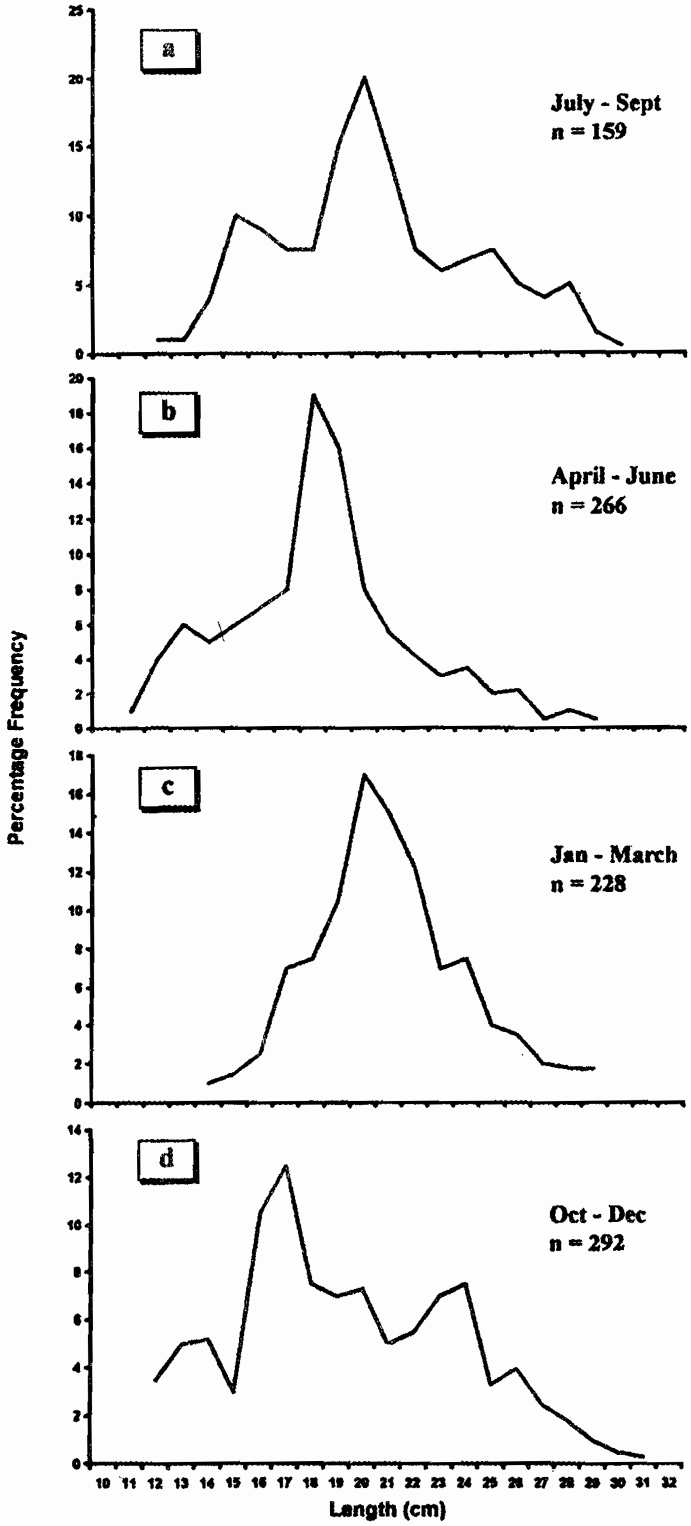

Figure 1: Tri-monthly length frequency distribution in *L. fulviflamma* in Kenyan Coastal Marine waters

The spawning season for the fish, which runs from October to March (< biblio >), has (for the convenience of aging the modal peaks) been divided into two quarters; October-December and January-March. It is seen during the October-December quarter (Fig.1d) that, 5 size groups are traceable, viz, A, B, C, D, and E, with modes 14.0 cm, 17.5 cm, 20.5 cm, 24.5 cm and 26.5 cm, respectively. Mode A is considered to have been spawned in the January-March quarter of the previous year and thus at the end of one year, it reached a modal size of 17.5 cm represented by mode A_1 (Fig. 1c) in January-March quarter. The second mode B, in October-December quarter at 17.5 cm was represented by 15 months old fish, having been spawned in the October-December quarter of the year preceding mode A fish. In the April-June quarter (Fig. 1b) the new position of A is at A_2 and mode B at 24.5 cm. In addition mode F at 13.5 cm (Fig. 1b) might be due to recruitment as a result of spawning in January-March period of the previous year and can be traced as mode F_1 at 15.5 cm in July-September period. The probable ages of the modes in the length frequency polygons are presented in Table 1.

Table 1. The probable ages of the modes in length frequency polygons of *L. fulviflamma* in Kenyan inshore marine

	Age of modes in years											
Mode	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
A	-	-	13.5	-	-	-	-	-	-	-	-	-
B	-	-	-	-	17.5	-	-	-	-	-	-	-
C	-	-	-	-	-	-	-	20.5	-	-	-	-
D	-	-	-	-	-	-	-	-	24	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	26.5
A1	-	-	-	17.5	-	-	-	-	-		-	-
A2	-	-	-	-	18.0	-	-	-	-	-	-	-
A3	-	-	-	-	-	20.0	-	-	-	-	-	-
B1	-	-	-	-	-	20.5	-	-	-	-	-	-
B2	-	-	-	-	-	-	24.5	-	-	-	-	-
B3	-	-	-	-	-	-	-	26.5	-	-	-	-
C1	-	-	-	-	-	-	-	-	24.5	-	-	-
C2	-	-	-	-	-	-	-	-	-	26.5	-	-
C3	-	-	-	-	-	-	-	-	-	-	28.5	-
D1	-	-	-	-	-	-	-	-	-	26.5	-	-
D2	-	-	-	-	-	-	-	-	-	-	28.0	-
F	-	13.5	-	-	13.5	-	-	-	-	-	-	-
F1	-	-	15.5	-	-	15.5	-	-	-	-	-	-
Mean Size (cm)	-	13.5	14.5	17.5	17.75	18.7	24.5	23.2	24.3	26.5	28.3	26.5

The three parameters of the von Bertalanffy growth curve, L∞, K and t_0 are estimated using a Ford-Walford plot (Ford, 1933; Walford, 1946) where the values of L_t are plotted against the values of L_{t+1}

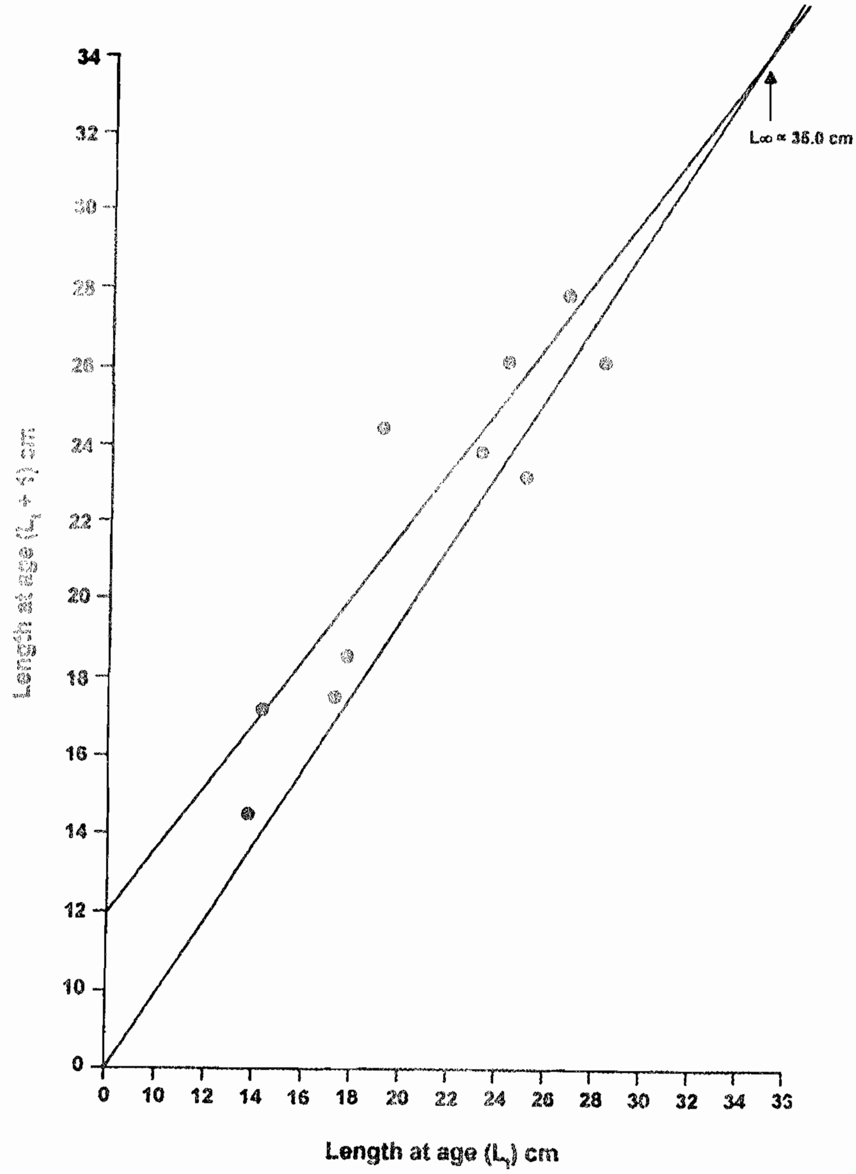

Figure 2. Ford-Walford plot of the growth of *L. fulviflamma* in Kenyan Coastal marine waters

By fitting a least squares line to this data, L∞ is taken as the point of intersection of the line with the bisector drawn through the origin. This was estimated to be 35.0 cm total length. The slope of this line is equal to exp (-K) of the VBGF and was found to be 0.828, and since, K = - In (b), K for *L. fulviflamma* with the present data was estimated to be 0.195, based on a 3 months basis, the value of K was then multiplied by 4 in order to have the von Bertalanffy growth equation for the fish based on an annual cycle (Pauly, pers comm), this gives the value of K as 0.59.

To estimate the last parameter, t_o, for VBGF, the age of the fish was plotted against. In $(L\infty-L_t/L\infty)$, t_o, was taken as the point of intersection of the least squares regression line with the Y-axis (Fig. 3).

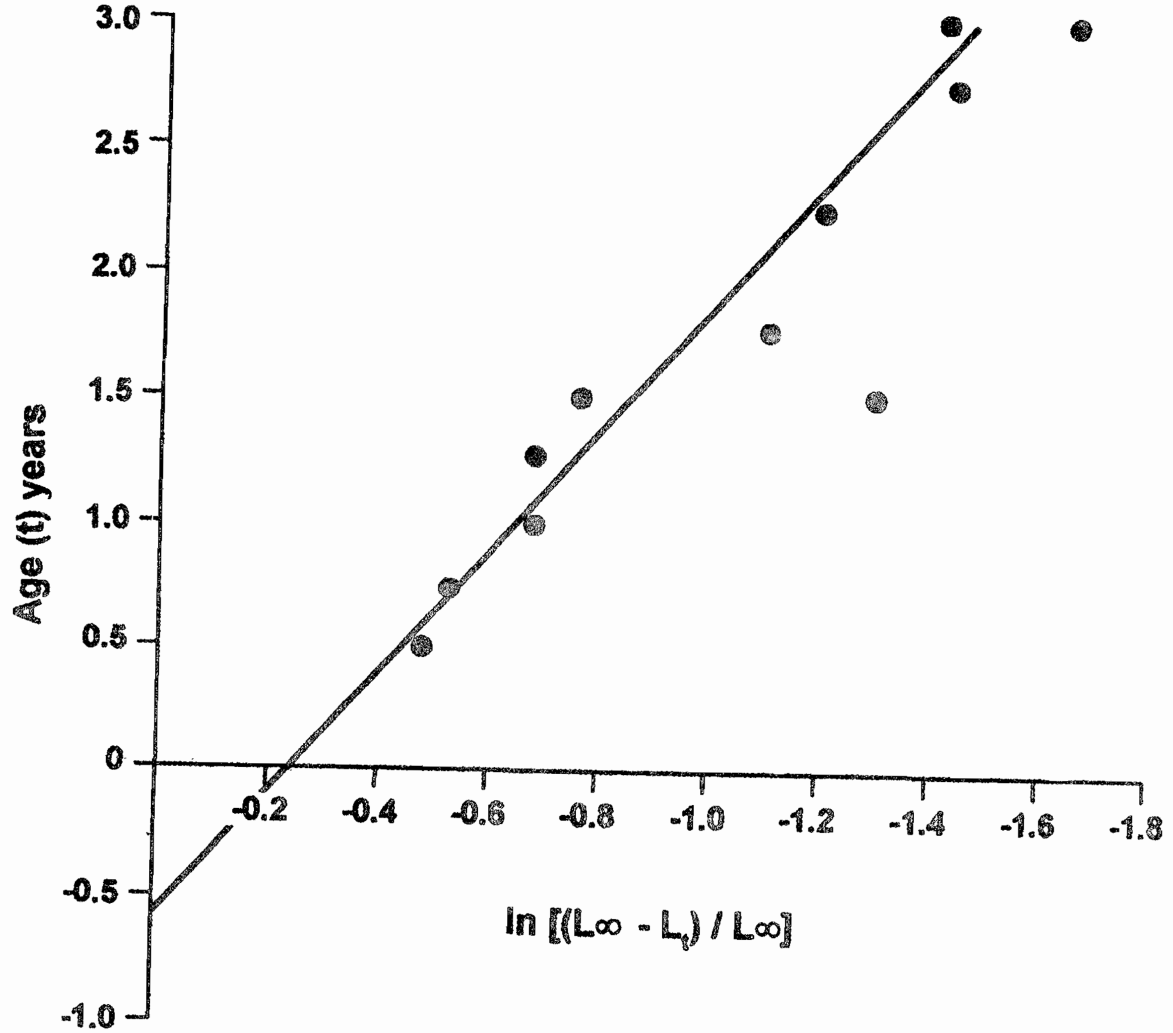

Figure 3. Graphical estimation of t_o of *L. fulviflamma* in Kenyan coastal marine waters

From this Figure, t_o = - 0.55. Having computed the growth parameters, the growth equation for *L. fulviflamma* in the Kenyan nearshore marine waters is therefore expressed as: $L_t = 35.0\,[1 - \exp(1 - (0.59\,(t + 0.55))]$. The growth curve for this species as predicted by this model is fitted through the observed mean length at age and shown in Fig. 4.

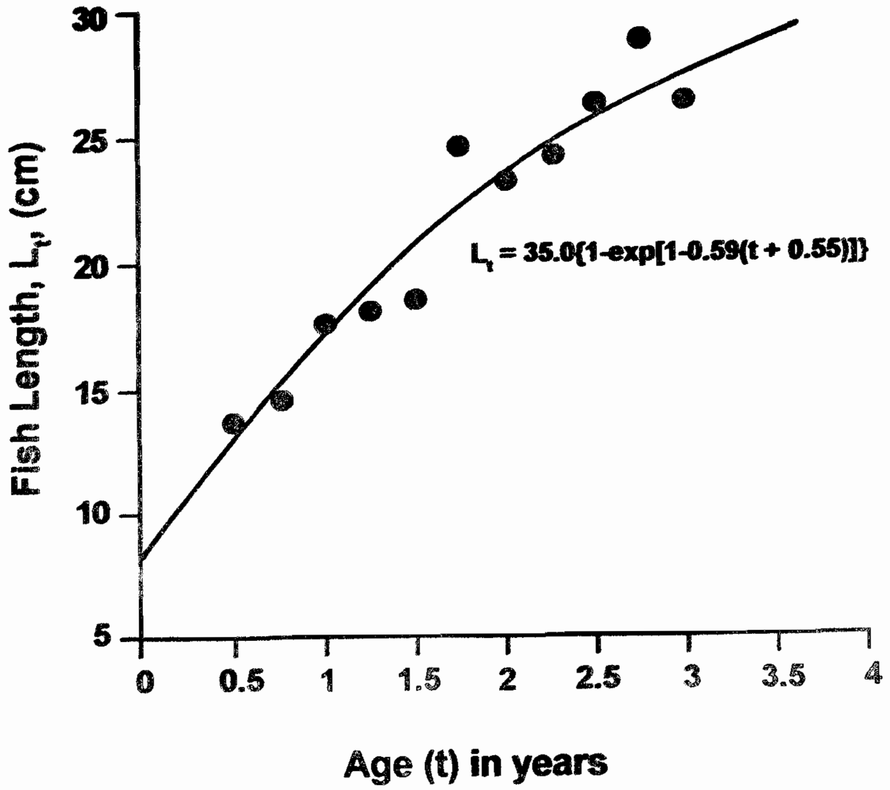

Figure 4. Growth of curve of *L. fulviflamma*, in Kenyan coastal marine waters drawn through the observed mean length at age

For the growth of fish through a size group dt, the catch curve equation as suggested by Pauly (1982) was followed thus: $Log_e (N / dt) = a + bt$);

Where; t is the age corresponding to the mid-length of each length class; b = -Z, N is the number of fish in each length class; and 'a' is a constant. The length converted catch-curve for *L. fulviflamma* constructed using this equation is shown in Fig. 5.

The total mortality coefficient (Z) is calculated as, 1.97, from the slope of the catch-curve (Fig. 5), and following Pauly's empirical formulae (described above), M, the natural mortality coefficient is estimated as 1.7/year at a mean environmental temperature of 28°C for the Kenyan coastal waters (Meteorological Dept,. unpublished data). Since, Z = M + F; the fishing mortality (F) is derived as 0.2698/year. With the derived mortality coefficients, a quick assessment of whether the stock of *L. fulviflamma* is over-fished or not is possible, based on the assumption that the value of F which optimizes yield should be similar to M, or; $E_{opt} \approx F / F+M \approx 0.5$ where E_{opt} is the exploitation rate which optimizes the yield from a given stock (Gulland, 1969).

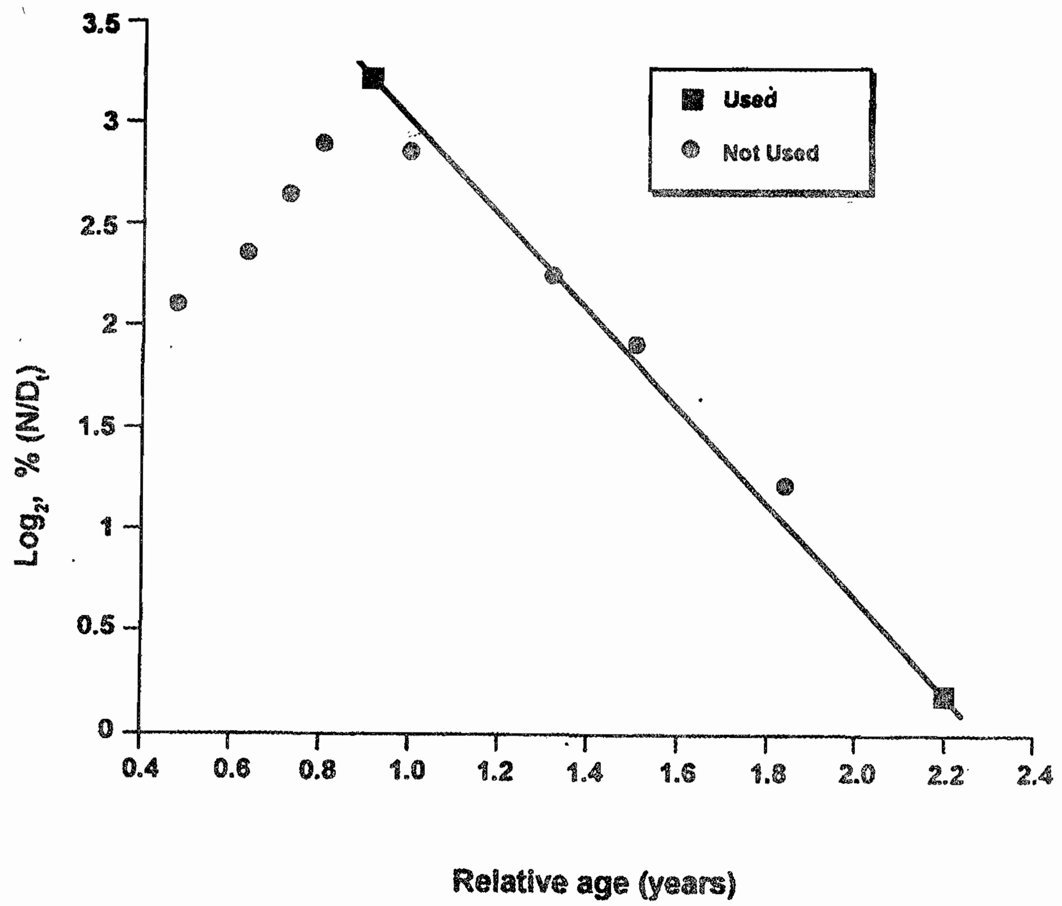

Figure 5. Length converted catch-curve of *L. fulviflamma*, used to derive Z from the descending arm

From this relationship, E_{opt} for *L. fulviflamma* in the Kenyan inshore waters is derived as 0.137, on a 0-1 scale of optimal harvest.

4.0 DISCUSSION

The apparent fit of von Bertalanffy's growth equation or the Ford-Walford plot line graph data in some cases is found to vary with the method of sampling or combining data (Parker and Larkin, 1959). Therefore, the closeness of t_o to zero for the dory snapper (t_o = -0.55) would probably justify the use of von Bertalanffy growth model to describe it's growth pattern. The maximum length that this species can theoretically reach (L∞) was found to be 35.0 cm, total length. The closeness of L∞ to the largest fish sampled (31.0 cm, total length) together with the low E_{opt} (0.137) suggest that *L. fulviflamma* population in the Kenyan inshore waters is probably not heavily fished. Thomson and Munro (1983), working on the Lutjanidae in the Caribbean, have found a large difference between the theoretical L∞ and the maximum size of fish caught in heavily exploited stocks.

Data on stock assessment of marine fishes in Kenya is lacking, except for the monoclebream, *Scolopsis bimaculatus* (Nzioka, 1981). The mortality indices and E_{opt} values derived in this study, will further support the conclusion that the stocks of *L. fulviflamma* in Kenyan inshore waters is not over-fished. Pauly (1980) suggests a multiplication of M by a factor of 0.8 for schooling tropical species like the Lutjanidae. Such an adjustment gives, F, M and E_{opt} values of 0.61, 1.36 and 0.309, respectively. Despite the adjustments, the *L. fulviflamma* stock can still be said to be under exploited given the low E_{opt} value and a modest fishing mortality coefficient. This observation contradicts recent studies which show an over-exploitation of Kenya's nearshore fisheries (McClanahan and Kaunda-Arara, 1997; Kaunda-Arara, 1998). The Lutjanidae show a large concentration of schools on the deeper outer reef (Thomson and Munro, 1983) which leads to their under representation in the nearshore fisheries exploited by artisanal fishers in Kenyan reef lagoons. They migrate to the nearshore waters to feed in less compact schools than that in the outer reef, these factors may contribute to their under-exploitation in the Kenyan nearshore fishery. Therefore fishing in the deeper waters than is currently practiced by the artisanal fishers will ensure greater exploitation of *L. fulviflamma* stocks in Kenyan marine waters.

It is felt by many workers that the current known methods for aging fish can only be reasonably used to age temperate zone fish (Bagenal and Tesc, 1978; Brothers 1980; Morales and Ralston; 1990). The non-annual nature of the pattern of marks on skeletal parts of most tropical fish (Morales and Ralston, 1990) makes their use in aging tropical fish less valuable. The additional requirement of validating these structures further complicates their application. Because of these difficulties workers have mostly used length frequency analysis to age tropical fish with various degrees of success. Although this paper presents a simple way of aging a tropical species given it's spawning time, it will be important to validate the age and growth parameters obtained for *Lutjanus fulviflamma* in this study in future studies using other methods such as the examination of skeletal parts and length based computer packages such as ELFA.

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