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CHARACTERISTICS OF THE EXPLOITED STOCK OF *NIBEA MACULATA* (SCHNEIDER) (SCIAENIDAE) AS REVEALED BY TRAWL LANDINGS AT KAKINADA

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ABSTRACT

Nibea maculata forms about 7% of total sciaenids landed by trawlers at Kakinada. June, September and January are the periods of abundance of this species in the trawling grounds. The length at first maturity is estimated as 180 mm and the spawning period as April-November. The length-weight relationship is calculated as log W= — 4.82369+2.98333 log L. The von Bertalanffy growth parameters are estimated as L_∞ = 315 mm, K = 0.61 per year and t_o = — 0.07 year. The total mortality rate is estimated as 2.93. The yield per recruit as a function F and t_c is estimated.

INTRODUCTION

THE FISHES of the family Sciaenidae, popularly called as croakers or jewfish, constitute an important component in the marine fish landings of India: during 1989 and 1990, an estimated 101154 t and 119224 t respectively of croackers are landed (Anon 1991) with an annual average of 110189 t forming 5% of total marine fish landings and 12% of total demersal fish landings. In the trawl catch at Kakinada, these fishes occupy an important position in regard to their abundance; an estimated annual average of 1144 t are landed during 1987-91 forming about 8.5% of total trawl catch. Sciaenids constitute a multispecies fishery with over 30 species known from India; at Kakinada about 20 species contribute to the fishery in varying quantities and aspects of biology have been studied in *Johnius carutta, J. dussumieri, Atrobucca nibe, Pennahia macrophthalmus* and *J. vogleri* (Murty 1980, 1984, 1986a and Murty and Ramalingam, 1988). To enable the assessment of multispecies stocks, it is essential to have estimates of vital statistics of all the constituent species in the multispecies group. The present study on *Nibea muculata,* is an attempt in this direction. Except the work of Jayasankar (1989) from the Mandapam region, there is no report on the biology of this species from India.

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MATERIAL AND METHODS

The study is based on material collected from the trawlers at Kakinada. For the study of various aspects of biology, data collected during April 1990-October 1992 have been used and the catch data of the species of the years 1977-91, for the study of the fishery.

Effort and catch statistics of sciaenids collected for about 18 days every month are used for making monthly estimates. Data on species composition and length composition are collected in the landing place at weekly intervals; these data are weighted to the day's catch and estimates of all the days' catch in a month are pooled and then weighted to get the monthly estimates of species composition and length composition of catch. For detailed biological studies, samples brought to the laboratory have been examined. Stages of maturation are fixed following those fixed for *A. nibe* from Kakinada (Murty, 1980). Length at first maturity has been estimated for females only considering fishes of and above stage III of maturation as mature. For determining the spawning period, the data of corresponding months have been pooled and the fishes of and above length at first maturity only have been considered. Length-weight relationship has been calculated with the help of the formula: log W=log a + b log L (Le Cren, 1951) where W=weight of fish in grams, L=total length in mm, a=elevation and b=regression coeficient. Weight of fish is taken to an accuracy of 0.5g and total length to 1 mm. The length data are grouped into 10 mm class intervals and the mid points in these groups are considered for studying growth. The von Bertalanffy parameters of growth in length are estimated using the data on monthly length frequency distribution of catch during the period April 1990-October 1992 and following the integrated method of Pauly (1980a). Estimates of L_∞ and K are obtained by the Ford-Walford plot (Ford 1933, Walford 1946) as adapted by Manzer and Taylor (1947).

The instantaneous rate of total mortality (Z) has been estimated using the pooled length frequency data of the period April 1990-March 1992 and following the length-converted catch curve method of Pauly (1982). The natural mortality rate (M) has been estimated using the empirical formula of Pauly (1980b) by taking the value of T as 27.2°C; it has also been estimated by assuming that 99% of the fish by numbers would die (in the absence of fishing) by the time they attain t_{max} ($Z=M=L_n 100 \div t_{max}$). For this purpose, the age of the largest fish in the catch is taken to represent t_{max}. The length corresponding to the first point in the descending limb of length-converted catch curve has been taken as L_c and the length of smallest fish in the catch as L_r. The yield in weight per recruit has been calculated using the equation of Beverton and Holt (1957).

FISHERY OF *Nibea maculata*

Trawling, which is mainly aimed at catching prawns, is carried out by shrimp trawls with the cod end mesh size ranging from 10 to 26 mm with a mean value of 18.5 mm. Fishing is carried out in the depth range of 5-50 m during greater part of the year and upto 80 m during December-March.

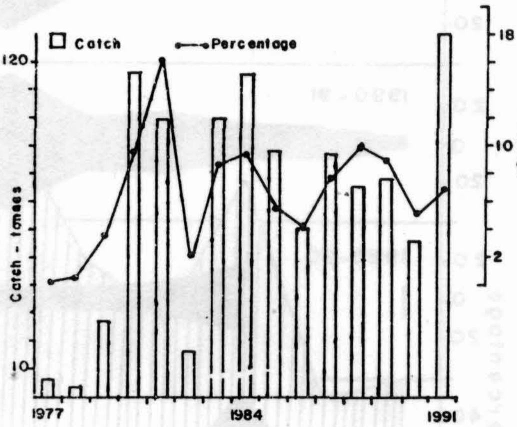

FIG. 1. Estimated catches of *N.maculata* and its percentage composition in the Sciaenids landed by trawlers at Kakinada during 1977-1991.

The annual estimated catch of *N.maculata* during 1977-1991 (Fig. 1) has ranged from a minimum of 3 tonnes in 1978 to a maximum of 130 tonnes in 1991 and its percentage in the sciaenid catch from 0.7 to 16.1 (Fig. 1). Wide fluctuations in the landings have been noticed. During the fifteen year period, *N.maculata* has formed 7% of average annual sciaenid catch.

The data on monthly variation in catch during six years from April 1986 to March 1992 (Fig. 2) show that periods of peak catches are different in different years and that this species is not found in the catches in one or two months every year, these months also varying between years. It is also clear that the bulk of the year's catch is obtained during the peak periods only. Though there are differences between years, the monthly variation in catches in different years indicates that June, December-February are the peak periods of abundance of *N.maculata* in the fishing grounds. The pooled data of all these years show that June, September and January are the months of peak abundance of this species (Fig. 2).

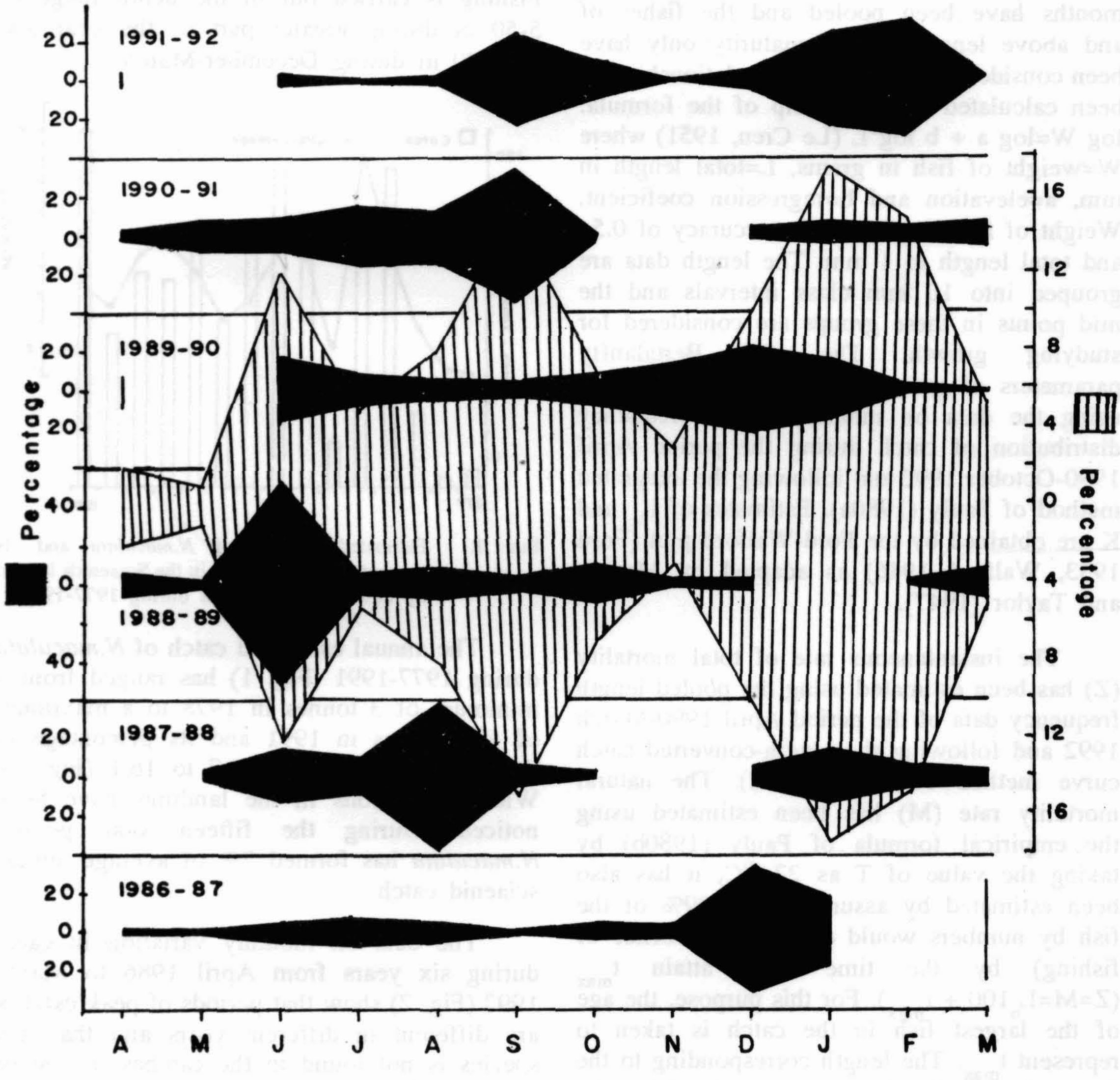

FIG. 2. Monthly catch of N.maculata expressed as percentage of annual catch of the species during different years (The figure depicting the data pooled for all six years is shown superimposed).

Maturation and Spawning

A total of 398 females of the length range 90-245 mm have been examined for this study.

i. *Length at first maturity:* Females larger than 160 mm only have shown mature ovaries. The percentage of mature fish is minimum in 165 mm group (Fig. 3) and this has increased slowly to 80% in 185 mm group. Though the percentage of mature fish has fallen to 55-74 in 195-215 mm groups, all the fishes are mature from and above 225 mm group. The graph (Fig. 3) shows that 50% of the fish at 180 mm are mature and therefore this length is taken as length at first maturity. As there is

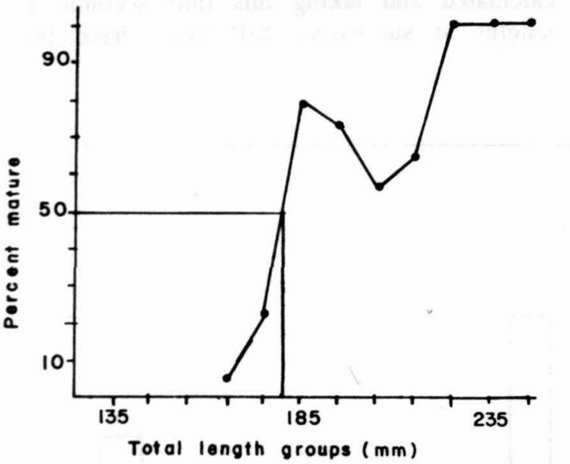

FIG. 3. Percentage of mature females in each length group and determination of length at 50% maturity.

no difference between the largest lengths of sexes, the estimate of length at first maturity of females can be considered as pertaining to both the sexes.

ii. *Spawning:* The distribution and abundance of adults in different stages of maturation during different months (Fig. 4) show that mature adults occur during February, April-July and December. Since these fishes are already mature, it may not take more than two months for them to reach ripe stage and release the eggs. The situation, then indicates that these fishes are likely to spawn from April to September and February. The occurrence of resting adults in February, May to October and December is indicative of spawning in January, April to September and November. Though there are no data for the months of January, March and November and adults in ripe condition are rarely found in the catches, the distribution and abundance of mature and resting adults (Fig. 4) indicate that *N.maculata* has a protracted spawning period extending from April to November.

Growth

i. *Length-weight relationship:* A total of 279 specimens (139 males ranging from 110 to 233 mm total length and from 20 to 176 g weight and 140 females ranging from 114 to 233 mm total length and from 24 to 202 g weight) have been examined for this purpose. The relationship has been calculated separately for the sexes and the equations are:

Males: log W = — 4.96006+3.04524 log L; R^2 = 0.98

Females: log W = — 4.73076+2.94093 log L; R^2 = 0.95.

The significance of difference between regression coefficients of the sexes has been tested by Analysis of Covariance following Snedecor and Cochran (1967); the difference is not significant at 5% level. The data of sexes, therefore, have been pooled and the relationship for the species has been calculated as:

log W = — 4.82369+2.98333 log L; R^2 = 0.96.

The significance of difference between the estimated value of b (2.98333) and the theoretical value (of 3 respresenting isometric growth) has been tested by the t-test (Pauly 1984). It is observed that the estimated value of 'b' is not significantly different from 3 (t=0.4646; df:277).

ii. *Estimation of growth parameters:* The length measurements of a total of 4965 specimens of the length range 50-289 mm have been used. The modal lengths in different months from April 1990 to October 1992 and the growth traced are shown in Figure 5. For drawing the growth curves, the points that are likely to fall in a curve are connected first and then the curve is extended both upward and downward. Several curves are drawn passing through different modes and the lengths attained at six-monthly intervals are read from each curve starting from the smallest modal length and ending at the largest modal length in the curve (sometimes beyond the largest modal length for 1-3 months to get the growth for constant half yearly intervals). Using these lengths, the values of Lα and K are estimated. This has been repeated several times until reasonably satisfactory values of parameters are obtained. Finally a total of five growth curves (A—E. in Fig. 5) have been considered as representing the actual growth and the lengths at half yearly intervals taken from these curves for estimating Lα and K using Ford-Walford plot (Fig. 6). The curves C and E pass through smaller modal lengths of 75 mm and 95 mm; from the origins of these curves, the ages of these smaller modal lengths have been read from the graph. From these two values the average length at six months age has been calculated and taking this into account, the lengths at successive half years have been estimated using the values of slope and elevation in the Ford-Walford plot (Fig. 6) for the purpose of estimating the value of t_0. The von Bertalanfy parameters of growth in length, thus obtained are : Lα= 315 mm, K = 0.61 per year and t_0 = — 0.07 year. The maximum recorded length in the catch is 289 mm which is only slightly smaller than the Lα value estimated. The life-span in the fishery is calculated as 4.02 years.

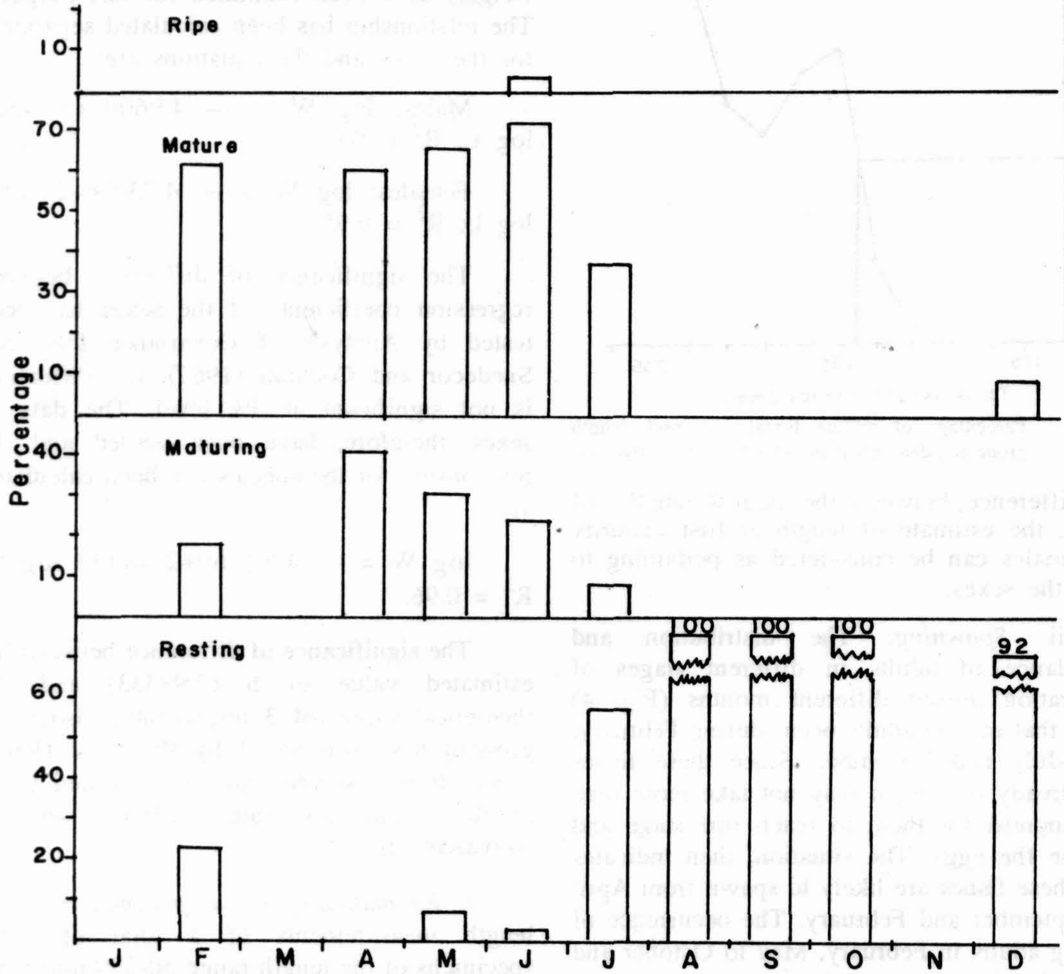

FIG. 4. Percentage distribution of adult females of *N. maculata* in different stages of maturation in different months.

Mortality Rates

From the points that represent the straight descending limb of the length-converted catch curve (Fig. 7), the value of total mortality rate (Z) has been estimated as 2.93. Value of natural mortality rate (M) has been calculated as 1.26 using the equation of Pauly and as 1.15 using the life-span. The fishing mortality rate (F), hence, is 1.67 or 1.78.

YIELD PER RECRUIT

The value of W_∞ corresponding to L_∞ is calculated as 426.2 g. The smallest length (Lr) in the catch is 50 mm and its age (t_r) is calculated as 0.3. From the first point in the descending limb of length-converted catch curve, the value of t_c is taken as 1.0; the value of L_c is 140 mm. Taking these values and the value of K at 0.61, t_o at — 0.07 and two values of M at 1.26 and 1.15, the yield per recruit at different values of F has been calculated (Fig. 8). When M = 1.26, the yield curve shows Y_{max} corresponding to F=4.2, when M=1.15, the Y_{max} corresponds to F=3.2. In these two cases the present F is 1.67 or 1.78. Though there is scope for increasing production by increasing the effort by 80%—150%, the increase in yield at this effort level will only be 3%—7% (Fig. 9). The increase in effort, therefore, will result in drastic reduction in CPUE; this is also clear from the poor biomass per recruit values (Fig. 8) at higher F.

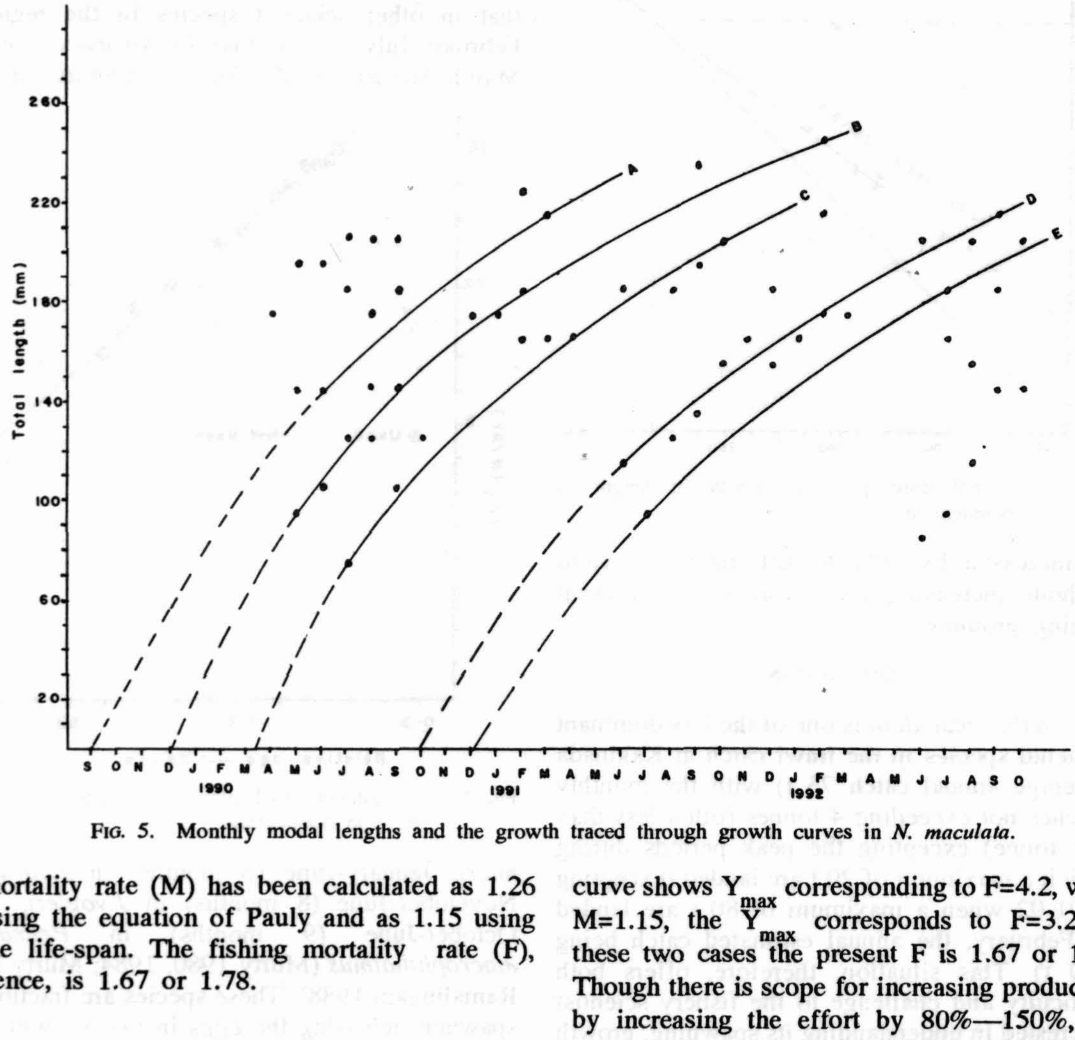

FIG. 5. Monthly modal lengths and the growth traced through growth curves in *N. maculata*.

The yield per recruit as a function of age at first capture (t_c) (Fig. 10) under the two values of M and the present F, shows that Y_{max} corresponds to the present t_c or to the t_c 10% greater than the present. Thus it appears the present cod end mesh size can be retained or increased by 10% to get maximum yield without increasing the effort in the present fishing grounds.

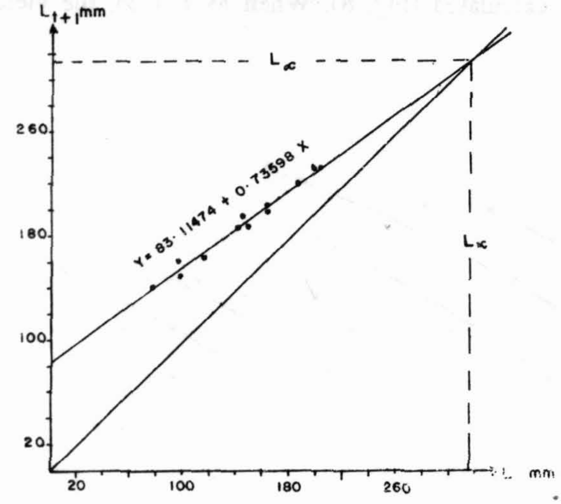

FIG. 6. Ford-Walford plot of growth in length in *N.maculata*.

DISCUSSION

Nibea maculata is one of the less dominant sciaenid species in the trawl catch at Kakinada (average annual catch 75 t) with the monthly catches not exceeding 4 tonnes (often less than one tonne) excepting the peak periods during which a maximum of 20 t are landed (excepting 1991-92 when a maximum of 80 t are landed in February, the annual estimated catch being 270 t). This situation, therefore, offers both difficulty and challenge to the fishery scientist interested in understanding its spawning, growth etc. The present study is attempted, inspite of this, because in multispecies fisheries such as those of Sciaenidae, knowledge on the spawning, growth, mortality rates etc. of all constituent species is necessary for a proper understanding of the dynamics of exploited stocks of such multispecies groups. The poor abundance and absence in some months, of this species in the landings, has resulted in limited and smaller samples for biological study rendering it difficult to understand the spawning season precisely. The interpretation of protracted spawning period (8 months) as April-November, however, is more or less in confirmity with that in other sciaenid species in the region: February-July (6 months) in *Atrobucca nibe*, March-August (6 Months) in *Johnius dussumieri*, January-June (6 months) in *J.carutta*, November-June (8 months) in *J.vogleri*, and October-June (9 months) in *Pennahia macrophthalmus* (Murty 1980, 1984; Murty and Ramalingam 1988). These species are fractional spawners releasing the eggs in two spawnings. *N.maculata* is also a fractional spawner with the spawning period extending from April to August in the Mandapam region (Jayasankar 1989) whereas the same extends from April to November off Kakinada. The growth traced through growth curves (Fig. 5) suggests spawning to take place during April and September to December. Though it has not

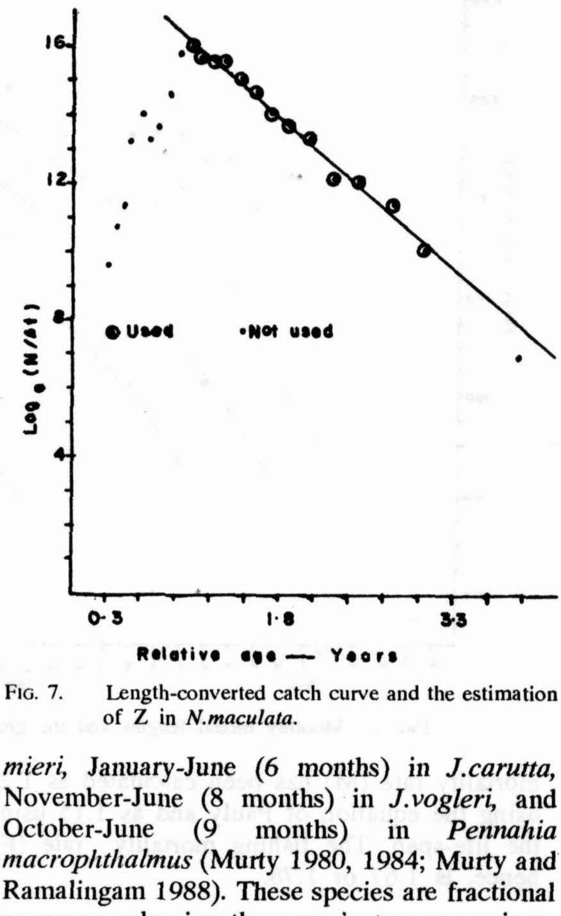

FIG. 7. Length-converted catch curve and the estimation of Z in *N.maculata*.

been possible to trace the growth and origin of all the modes in the monthly length frequency distribution to enable an understanding of the spawning period indirectly, it appears reasonable

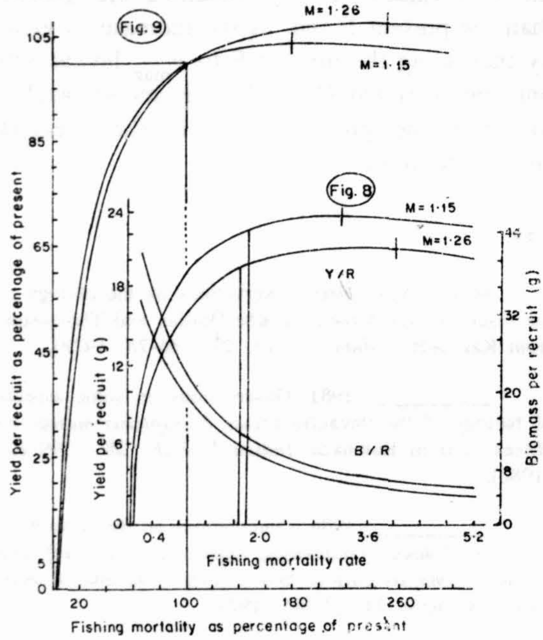

FIG. 8. **Yield and biomass per recruit as a function of fishing mortality in *N.maculata* under two values of M. (The small vertical lines on the curves show Y_{max} and the long vertical lines the current F corresponding to each M value considered).**

FIG. 9. **Yield per recruit of *N.maculata* expressed as percentage of present value as a function of fishing mortality rate also expressed as percentage of present value.**

to believe that spawning extends from April to December which is almost the same as April-November determined by gonadal study. The growth curves (Fig. 5) also show that recruitment to the exploited phase takes place at modal lengths ranging from 75 to 115 mm during May-July probably the result of spawning in April and September-December. Thus the spawning during May-August does not appear to result in the recruitment. Only further studies based on larger samples round the year can help a better understanding of spawning and recruitment.

According to Fischer and Whitehead (1974) and Mohan (1984), *N.maculata* attains maximum lengths of 280 mm and 300 mm, respcetively. In the present study, the largest specimen measures 289 mm. The estimated

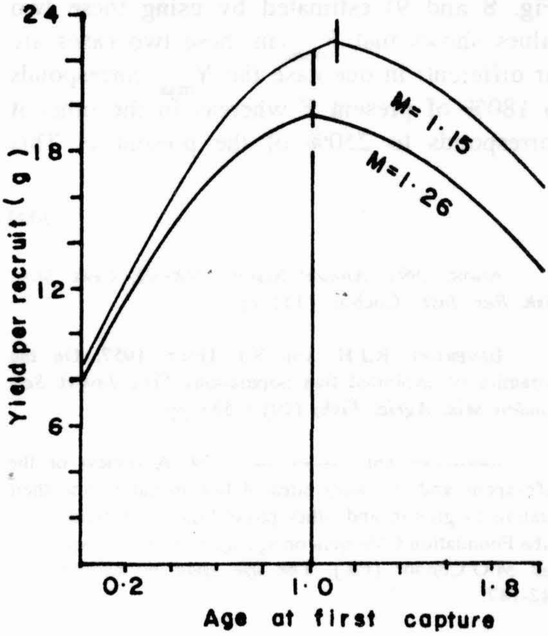

FIG. 10. Yield per recruit of *N.maculata* as a function of age at first capture under two values of M and current F.

value of Lα at 315 mm therefore appears to be a reasonable one. In earlier studies on growth of some demersal fishes, the life-spans are shown as 2.5-2.9 years in silverbellies, 3.3 years in one sciaenid and 4.3-4.8 years in threadfin breams (Murty 1981, 1986a, 1986b, 1987, 1991); the life-span of *N.maculata* as estimated in the prersent study at 4.02 is well within the above range. Further, the M/K values (for both the values of M considered at 1.26 and 1.15) are 2.1 and 1.9 which are also well within the range known in fishes (Beverton and Holt 1959).

The estimation of natural mortality (M) still remains to be a problem and so far there is no way of making an objective estimate of this parameter. Moreover, a slight variation in this parameter can result in a large difference in the estimated value of Fmax.In the present study, though the difference between the two M values considered is very small, the yield per recruit as a function of fishing mortality (Fig. 8 and 9) estimated by using these two values shows that F_{max} in these two cases are far different: in one case the Y_{max} corresponds to 180% of present F whereas in the other it corresponds to 250% of the present F. This situation therefore suggests the need to use more than one estimate of M, in yield studies to enable giving a reliable value, depending on the situation. In the present case, the two values of F_{max} obtained are greater than the present F and, as the increase in yield by increasing the present F to F_{max} levels will only be marginal (Fig. 9), it is recommended to retain the present effort in the prersent fishing grounds.

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