FURTHER STUDIES ON THE GROWTH AND YIELD PER RECRUIT OF *NEMIPTERUS JAPONICUS* (BLOCH) FROM THE TRAWLING GROUNDS OFF KAKINADA

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ABSTRACT

On the basis of data on *N. japonicus* from trawl landings at Kakinada, the von Bertalanffy parameters of growth in length are estimated as L_∞ = 339 mm, K = 0.52 per year and t_0 = —0.16 year. The mortality rates are estimated as Z = 2.64, M = 1.11 and F = 1.53. The length at first capture is estimated as 120 mm. The yield per recruit analysis shows that increase in effort from the present level results in reduced yield from the present fishing ground if the cod end mesh size is not increased.

INTRODUCTION

Nemipterus japonicus (Bloch) is the most dominant species in the nemipterid landings along both coasts of India and some information is available on various aspects of biology and population dynamics of this species from Visakhapatnam (Krishnamoorthi 1973, 1976, 1978; Dan 1980) and on biology and fishery from Cochin (Vinci and Nair 1975; Vinci 1983). On the basis of data collected during 1976-79 from the landings of small commercial trawlers at Kakinada, the author (Murty 1983, 1984) reported on various aspects of biology and yield per recruit of this species. The results of the study using the data collected during 1980-83 on the growth and population dynamics of *N. japonicus* in the trawling grounds off Kakinada are presented in this paper.

MATERIAL AND METHODS

Data on effort and catch were collected from the trawlers for 18-20 days in each month; these data were weighted to get monthly estimates of effort, catch and species composition. Boats of three different sizes are engaged in trawling in this region (see CMFRI, 1981, for details) and the effort (no. of units as well as trawling hours) was standardised taking *Pomfret* as the standard effort and all demersal groups together were considered as one species for this purpose. The length data of *N. japonicus* collected on each observation day (at weekly intervals) were weighted to get the day's and then the month's length composition of estimated catch. The length data were grouped into 10 mm-class intervals and the mid points in these groups were considered to study the growth. Parameters of growth in length were estimated following the 'integrated method' of Pauly (1980) and using the well-known von Bertalanffy growth equation:

$$L_t = L_\infty \left(1 - e^{-K(t - t_0)} \right)$$

Eestimates of L_∞ and K were obtained using Ford-Walford plot (Ford 1933, Walford 1946) as adapted by Manzer and Taylor (1947); the growth data of *N. iaponicus* of different lengths at intervals of six months were used for the purpose.

Instantaneous rate of total mortality (Z) was estimated using the data of annual length-frequency distribution of catch and following:

1. the length-converted catch curve method of Pauly (1982),
2. Cumulative catch curve method of Jones and van Zalinge (1981) and
3. Beverton and Holt (1956) method.

The coefficient of natural mortality (M) was estimated using the relation $Z = M + qf$ where q is the catchability coefficient and f the fishing effort. It was also estimated using the equation of Pauly (1980):

$$\log M = -0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T$$

where L_∞ is in cm, K per year and T in °C. For the purpose of this equation the value of T was taken as 27.2°C from Ganapati and Murty (1954) and La Fond (1958).

Length at first capture (L_c) was estimated following the method given by Pauly (1984).

The yield in weight per recruit was estimated from the equation of Beverton and Holt (1957).

Estimation of Growth Parameters

The monthly modal lengths of *N. japonicus* during January 1980-December 1983 and the growth traced through them are shown in figure 1. While drawing the growth curves, the points that are likely to fall in a curve were joined first and then the curve was extended further both upwards and downwards. A total of nine curves, each of them passing through several modal points, were thus drawn (Fig. 1). The lengths attained at intervals of six months, starting from the smallest modal length in each curve, were read from these growth curves for estimating L_∞ and K using 'Manzer-Taylor plot'. (Fig. 2). From the origins of

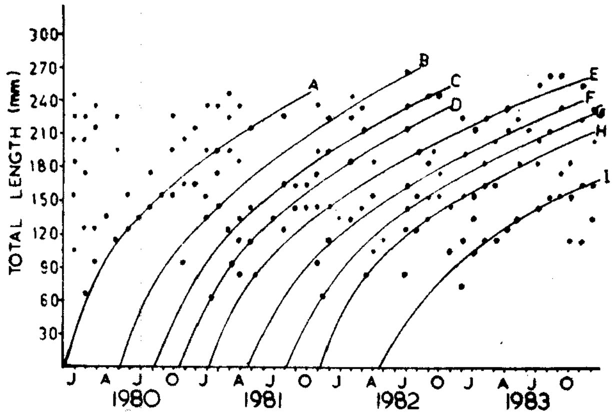

FIG. 1. Estimation of growth in length through growth curves in *N. japonicus*.

the curves D and G (Fig. 1), the age of smallest modal length at 65 mm was read as three months and, taking this into account, the lengths at successive half years were estimated using values of slope and elevation of Manzer-Taylor plot, for purpose of estimating t_0 (Fig. 3). The von Bertalanffy parameters of growth in length were, thus, estimated as L_∞ = 339 mm, K = 0.52 per year and t_0 = —0.16 year. Since the maximum length observed in the catches is 305 mm, the life-span of *N. japonicus* in the trawling grounds is 4.26 years.

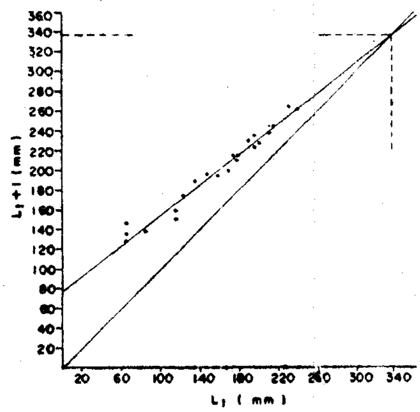

FIG. 2. Manzer and Taylor plot in *N. japonicus*.

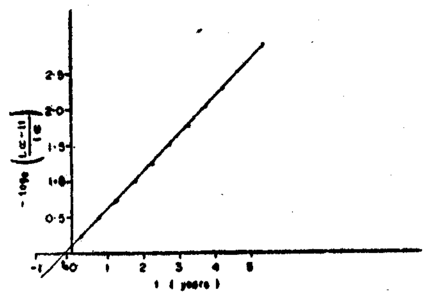

FIG. 3. Estimation of t_0 in *N. japonicus*.

ESTIMATION OF MORTALITY RATES

Total mortality rate (Z): The points that represent the straight descending part of the length-converted catch curve (Fig. 4) and the points that fall in a straight line of cumulative catch curve (Fig. 5) were taken into account to estimate the total mortality rate. For Beverton-Holt method, the mean length was calculated taking fish of and above length at first capture.

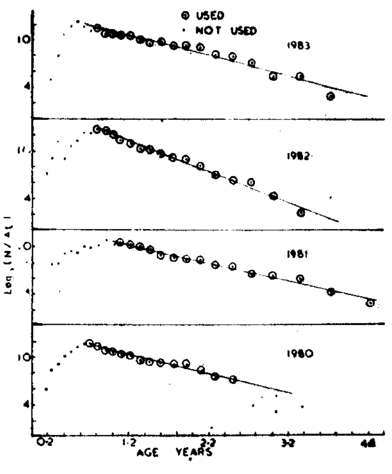

FIG. 4. Estimation of Z of *N. japonicus* by length-converted catch curve.

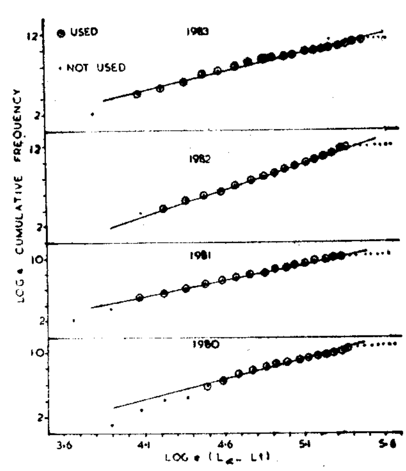

FIG. 5. Estimation of Z of *N. japonicus by* cummulative catch curve.

The estimated values of Z by different methods during different years (Table 1) show that, in any one year, the values obtained by different methods are in close agreement; the average of the values obtained by different methods during different years at 2.64 was taken as Z during the four-year period.

TABLE 1. N. japonicus: *Estimated values of Z by different methods in different years. (The estimated catches of this species during different years are also shown)*

Methods of	1980	1981	1982	1983	Average
Pauly	2.2964	2.2571	3.8364	2.5427	2.7332
Jones and van Zalinge	2.5606	2.0901	3.4288	2.4281	2.6269
Beverton and Holt	2.2027	2.1450	3.6742	2.2402	2.5655
Average	2.3532	2.1641	3.6465	2.4037	2.6419
Estimated catches of *N. japonicus*	261	201	632	365	364.8

Natural mortality rate (M): An attempt was made to estimate the value of M with the help of regression of Z against effort. For this purpose, the values of Z obtained by different methods were used separately and the effort was taken as number of units as well as trawling hours. The estimated values of M are negative in all cases indicating that they are unrealistic.

Using the formula of Pauly (1980), the M value was calculated as 1.11. Assuming the value of t_{max} in the population to be the one in the unexpoited phase and also assuming that 99% of the fish by numbers would die by the time they reach this age in an unexploited phase (Sekharan 1975), the M value can be estimated as 1.08 which is almost the same as that obtained by Pauly's formula. For the present study this value was taken as 1.11.

The various mortality rates in *N. japonicus* during the period of study, thus, are:

$Z = 2.64$, $M = 1.11$, $F = 1.53$

ESTIMATION OF LENGTH AT FIRST CAPTURE

The data on length composition of catch of the four years were pooled (because the mesh size of the gear was the same during different years) and a length-converted catch curve was obtained to estimate Z value for this purpose and also to obtain an estimate of the number of fish in the first length class that is fully selected — i.e. the estimated number of fish corresponding to the first point in the straight descending portion of the length-converted catch curve (number of fish against the 135 mm group in table 2). Using these two values and also the value of M obtained above, the length at first capture was estimated as 120 mm (Table 2 and Fig. 6).

Using the data in table 2 and varying the values of M, several values of L_c were obtained to see whether they would be different. For different values of M ranging from 0.1103 to 5.0 and 25.0, the estimated values of L_c are not quite different (Fig. 7).

ESTIMATION OF YIELD PER RECRUIT

The value of W_∞ corresponding to L_∞ was calculated as 389.7 g. The smallest length in the catch at 50 mm was taken as the length at recruitment whose age (t_r) is 0.15 year. The age at first capture (t_c) is 0.68 year on the basis of the estimated value of length at first capture.

The yield in weight per recruit (YW|R) with the value of M at 1.11 and with five values of t_c ranging from 0.43 to 0.77 (corresponding to L_c ranging from 90 to 130 mm) against F (Fig. 8A) shows that for higher values of t_c, maximum YW|R is obtainedat greater values of F, and that the YW|R is greater

TABLE 2. *Derivation of selection curve of* N. japonicus *caught by trawlers at Kakinada (Data of* 1980-83 *pooled).*

Mid points of 10 mm length classes	Numbers caught (Ni)	mid point to mid point	Mortality I (M Z)	Mortality II (means)	Numbers available (Ni|Pi)	P Ni——— (Ni|Pi)	Cumulative P
45	(0)		M=1.1103		—	(0)	(0)
		—		—			
55	101		1.2978		179564	0.00056	0.00056
		0.069		1.3916			
65	1027		1.4853		163124	0.00629	0.00685
		0.0715		1.5791			
75	5348		1.6728		145708	0.03670	0.04355
		0.0742		1.7666			
85	6139		1.8603		127807	0.04803	0.09158
		0.0773		1.9541			
95	15711		2.0478		109889	0.14297	0.23455
		0.0804		2.1416			
105	27968		2.2353		92507	0.30233	0.53688
		0.0840		2.3291			
115	38884		2.4228		76069	0.51117	1.04805
		0.0879		2.5166			
125	36620		2.6103		60973	0.60059	1.64864
		0.0920		2.7041			
135	*(47544)		(2.7978)		*(47544)	(1.00000)	2.64864

* Camputed from the equation of the length-converted catch curve.

when tc is higher. Under the current value of tc (0.68), the yield per recruit attains its maximum when F is 1.6 and declines slowly thereafter with further in crease in F. It may be noted that the present F is 1.53.

The yield per recruit as a function of tc under the present rate of fishing mortality (Fig. 8B) shows that maximum YW|R is attained when tc is 1.1 and with increase in tc thereafter the yield per recruit declines.

DISCUSSION

The models dealing with fish stock assessment assume the growth pattern, natural mortality and recruitment in a species to be constant. However, according to Gulland (1923, p. 165), "This is obviously not true; in a year of good food supply, growth is likely to be unusually good, while in unfavourable years

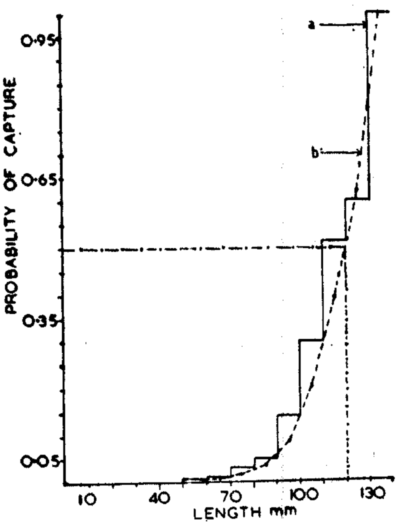

FIG. 6. a. Results of division of numbers caught by numbers available, representing selection pattern and b. cumulative curve to estimate the length at first capture, in *N. japonicus.*

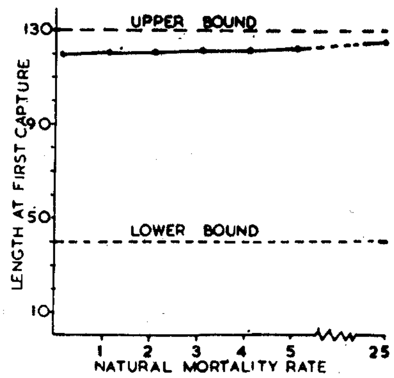

FIG. 7. Results of analysis of sensitivity of Lc estimates to changes in natural mortality input in *N. japonicus.*

natural mortality may be high". On the basis of the data obtained during 1976-79 at Kakinada, the parameters of von Bertalanffy growth equation were estimated as: L_∞ 314 mm, K = 0.75 per year and t_0 = — 0.17 year (Murty 1984) whereas in the present study from the same area, these parameters were estimated as 339 mm, 0.52 per year and —0.16 year respectively. In the earlier study, growth was estimated by following (for shorter intervals) the modes in the monthly length frequency distribution in the succeeding months whereas in the present study, the integrated methods of Pauly (1980) was followed. While the observed differences (though not very great) in the methods used, it is also possible that the growth rate has really changed, whatever may be the reasons for the differences in the estimated values of parameters, the fact that there are differences between them (assuming of course, that the methods used give reliable results) indicates the need for updating the parameter estimates, whenever attempts at stock assessment are made.

The values of total mortality coefficient (Z) obtained by different methods (Table 1) in any one year are close to each other. The choice of taking the average (at 2.64) of the values obtained by all methods of all four years to represent the Z during the four-year period can therefore the taken as reasonable. The estimated values of Z (Table 1) during 1982 are much greater than those

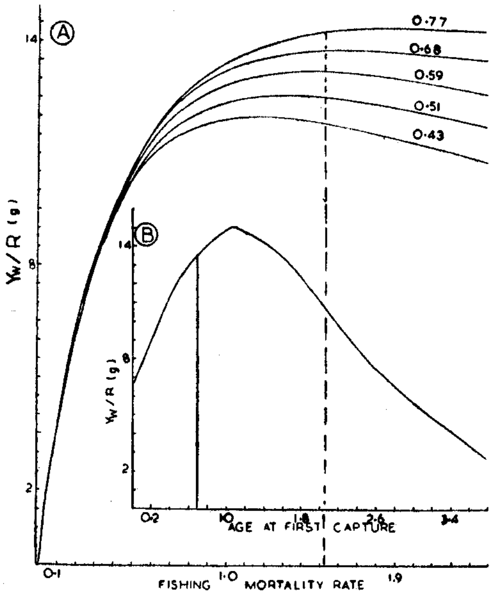

FIG. 8. Yield per recruit of *N. japonicus*: A. as a function of fishing mortality rate (numerals indicate the age at first capture and the broken vertical line the present fishing mortality rate). B. as a function of age at first capture (vertical line indicates the present age at first capture).

of the other three years: the average during this year is 3.65 whereas during the other three years the averages range from 2.16 to 2.40. The estimated catches of *N. japonicus* during 1982 were 632 tonnes — the highest during the four-year period — whereas the same during the other three ranged from 201 to 365 tonnes (Table 1).

It is known that the estimation of coefficient of natural mortality in exploited populations is difficult (Cushing 1981). It is particularly difficult in the case of tropical demersal fisheries which exploit a large number of species simultaneously, with the result, information on effective effort with reference to a particular species cannot be obtained. Hence the regression of Z (of a particular species) against multispecies effort is likely to result in unrealistic values of M including negative ones (Ricker 1975, Pauly 1982). Obviously because of this reason, the values of M obtained by regression in the present study are negative and naturally the M|K value is less than unity, whereas this ratio in fishes is known to range from 1 to 2.5. (Beverton and Holt 1959). The value (1.11) obtained by using the formula of Pauly gives an M|K value which is within the above range; for this reason and for reasons mentioned above, this value was taken as M in the population of *N. japonicus* at Kakinada. In the earlier work, however, the author (Murty 1983) obtained an M value of 1.14 on the basis of regression of Z on multispecies effort which is almost the same (obviously accidentally) as that obtained by using the Pauly's formula in the present work. With the parameters of growth estimated earlier (Murty 1984, *vide supra*) and with the Pauly's formula, the M value can be calculated as 1.44 which is slightly more than the one obtained in the present study. It may be mentioned in this connection that the author has also studied (Murty 1986a, b) the growth and mortalities of sciaenid and silverbelly species from Kakinada and realiable estimates of M could not be obtained by the regression of Z on effort.

Length at first capture (L_c) is an important parameter in yield equation and has to be estimated through selection experiments, for each type of gear separately. In the absence of such a study, some authors have resorted to selecting a value arbitrarily (Krishnamoorthi 1978) or to considering the smallest modal length (Banerji and George 1967; Murty 1983) in the monthly samples as the L_c. If the value of L_c (and hence t_c) is taken like this for computing yield, the yield curve cannot be taken as representing a true situation because, even when the same values of M and F are used, the values of yield per recruit will be different when t_c is different; further, the value of F against which Y_{max} is attained can also be different when different values of tc are considered. This is evident from the present study also (Fig 8.A). Thus any arbitrariness in considering the L_c values is likely to result in incorrect advice for the management of a resource. Pauly (1984) developed a method with the help of which "the selection curve of the gear can be inferred from the shape of the ascending arm of a length-converted catch curve and the growth parameters" (p. 17), if the natural mortality rate is known. Further according to him (p. 19), "the values of L_c obtained through this method are indeed close to those obtained from selection experiments" in Mediterranean hakes and sardines. However, three assumptons have to be fulfilled for the estimate by this method to be accurate (Pauly 1984). One of them is that the gear in question is a trawl or a gear where it is only the smaller fish that are selected against. Obviously, this assumption is fulfilled in the present work. In *N. japonicus,* the fact that gravid and ripe fish occur in the trawling ground in considerable numbers during the spawning period August-April and that smaller fish of the length range 35-85 mm also occur in the fishing ground (Murty 1984) suggest that spawning takes place in the usual fishing ground and this ground itself serves as nursery area also. Hence, there is no question of smaller fish reaching the fishing ground from a separate nursery ground (recruitment) in this species, as opposed to penaeid prawns or some temperate fish species. Hence the smallest fish caught can be safely taken as fully recruited, thus fulfilling the second assumption also. The third assumption is that the M value used for fish below the smallest recruited length and the mortalities generated by interpolation between M and the Z value of the fully selected fish are accurate. This assumption was verified using sensitivity analysis and it was observed (Fig. 7) that the L_c is not very sensitive to changes in the input value of M.

The yield per recruit analysis shows that any increase in effort (F) in the present fishing ground will result in reduced yield, if the present cod end mesh size is retained (Fig. 8A); if the cod end mesh size is increased, effort can also be increased to get increased yield (Fig. 8A) or even if the effort is not increased, increasd yield can still be obtained by increasing the cod end mesh size (Fig. 8B). The length at first maturity in this species is 120 mm (Murty 1984). Since the length at first capture is also 120 mm, increasing the cod end mesh size will be beneficial in the sense that there will not be any problem of recruitment overfishing brought about by continuous removal of prospective spawners.

The private trawlers at Kakinada fish in depths up to 50 m most of the time and go up to 80 m depth only during certain months of the year (November-February). During these latter months the catches are generally good (Murty 1984). Further, it is known (Silas 1969; Zupanovic and Mohiuddin 1975) that *N. japonicus* is abundant in 75-125 m depth zone. Hence there is need to fish in such depths at Kakinada to get higher yield of this species.

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References

Beverton, R. J. H. and S. J. Holt. 1957. On the dynamics of exploited fish populations *Fish. Invest. Ser. London., Min. Agric. Fish.*, (19): 533 pp.

Beverton, R. J. H. and S. J. Holt. 1959. A review of Life spans and mortality rates of fish in nature and their relation to growth and other physiological characteristics. Ciba Foundation Colloquia on ageing. G. E. W. Wolsenholny and M.O.'. Connor. (Ed.) *The life span of animals*, 5: 142-147.

CMFRI. 1981. Commercial trawl fisheries off Kakinada during 1969-1978. *Mar. Fish. Infor. Serv. T & E Ser.*, (31): 1-6. (Central Marine Fisheries Research Institute, Cochin).

Cushing, D. H. 1981. *Fisheries Biology: A study in population dynamics*. Second edition. The university of Wisconsin press, 295 pp.

Dan, S. S. 1980. Intra ovarian studies and fecundity in *Nemipterus japonicus* (Bloch). *Indian J. Fish.*, 24: 48-55 (1977).

Ford, E. 1933. An account of the herring investigations conducted at plymouth during the years 1924-1933. *J. mar. biol. Ass. U.K.*, 19: 305-384.

GANAPATI, P. N. AND V. S. R. MURTHY. 1954. Salinity and temperature variations of the surface waters off Visakhapatnam Coast. *Andhra Univ. Mem. Oceanogr.* I: 125-142.

GULLAND, J. A. 1983. *Fish stock Assessment: A Manual of Basic Methods*, John Wiley and Sons, 223 pp.

JONES, R. AND P. N. VAN ZALINGE. 1981. Estimation of mortality rate and population size of shrimps in Kuwait Waters. *Kuwait Bull. Mar. Sci.*, 2: 273-288.

KRISHNAMOORTHI, B. 1973. Biology of the threadfinbream, *Nemipterus japonicus* (Bloch). *Indian J. Fish.*, 18: 1-21 (1971).

KRISHNAMOORTHI, B. 1976. A note on the size differences between males and females of *Nemipterus japonicus* (Bloch). *Indian J. Fish.*, 21: 608-609 (1974).

KRISHNAMOORTHI, B. 1978. A note on the mortality rates and yield per recruit in *Nemipterus japonicus* (Bloch). *Indian J. Fish.*, 23: 252-256 (1976).

LA FOND, E. C. 1958. Seasonal cycle of sea surface temperature and salinity along the east coast of India. *Andhra Univ. Mem. Oceanogr.* II: 12-21.

MANZER, J. I. AND F. H. C. TAYLOR. 1947. The rate of growth in lemon sole in the straight of Georgia. *Prog Rep. Fish. Res. Board Pacific Coast Stn.*, (72): 24-27.

MURTY, V. SRIRAMACHANDRA. 1983. Estimates of mortality, population size and yield per recruit of *Nemipterus japonicus* (Bloch) in the trawling grounds off Kakinada. *Indian J. Fish.*, 30: 255-260.

MURTY, V. SRIRAMACHANDRA. 1984. Observatiions on the fisheries of threadfin breams (Nemipteridae) and on the biology of *Nemipterus japonicus* (Bloch) from Kakinada. *Indian J. Fish.*, 31: 1-18.

MURTY, V. SRIRAMACHANDRA. 1986a. Growth and yield per recruit of *Johnius (Johnius) carutta* Bloch in the trawling grounds off Kakinada. *Indian J. Fish.*, 33: 163-170.

MURTY, V. SRIRAMACHANDRA. 1986b. Studies on growth and population dynamics of the silverbelly *Leiognathus bindus* (Valenciennes) in the trawling grounds off Kakinada. *Indian J. Fish.*, 33: 277-284.

PAULY, D. 1980. A selection of simple methods of for assessment of tropical fish stocks. *FAO. Fish. Circ.* (729): 54 pp.

PAULY, D. 1982. Studying single-species context. pp 33-70; *In*: Pauly, D. and G. I. Murphy (eds.) *Theory and management of tropical fisheries.* ICLARM Conference Proc. 9, 360 pp. ICLARM, Philippines and CSIRO Australia.

PAULY, D. 1984. Length-converted catch curves: A powerful tool for Fisheries Research in the tropics. Part II. *Fishbyte*, 2(1): 17-19.

RICKER, W. E. 1975. Computation and Interpretation of Biological statistics of Fish populations. *Bull. Fish. Res. Board. Can.* 191: 382 pp.

SILAS, E. G. 1969. Exploratory Fishing by R. V. Varuna. *Bull. Cent. mar. Fish. Res. Inst.*, 12:1-86.

VINCI, G K. 1983. Threadfinbream (*Nemipterus*) resources along the Kerala coast with notes on biology of *Nemipterus japonicus*. *Indian J. Fish.*, 29: 37-49 (1982).

VINCI, G. K. AND A. K. K. NAIR. 1975. Length-weight relationship in the threadfin bream, *Nemipterus japonicus,* along the Kerala coast, *Indian J. Fish.,* 21: 299-302 (1974).

WALFORD, L. A. 1946. A new graphic method of describing the growth of animals. *Biol. Bull. Woods Hole,* 90: 141-147.

ZUPANOVIC, S. AND S. K. MOHIUDDIN. 1976. A survey of the fishery resources in the north eastern part of the Arabian sea. *J. mar. biol. Ass. India.* 15: 469-537.