ESTIMATES OF MORTALITY, POPULATION SIZE AND YIELD PER RECRUIT OF *NEMIPTERUS JAPONICUS* (BLOCH) IN THE TRAWLING GROUNDS OFF KAKINADA

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ABSTRACT

The mortality rates of *N. japonicus* are estimated from annual age composition of fish caught by trawlers. The estimated values are Z = 1.86, F = 0.72 and M = 1.14. The exploitation rate (U) is estimated at 0.33 and the total annual stock at 1181 tonnes. The yield curve shows that the fishing mortality can be increased from the present level of 0.72 to 1.75 to get increased yield.

INTRODUCTION

For rational management of fisheries resources a knowledge of various mortality rates (total, natural and fishing) of fish populations is necessary apart from the knowledge on various aspects of biology of the concerned species. In an earlier paper (Murty MS), the author presented the details of some aspects of biology of *N. japonicus* from Kakinada. The present paper deals with the mortality rates, population size and yield per recruit of this species in the trawling grounds off Kakinada.

The account is based on the data collected during 1976-79 from the trawlers operating off Kakinada. The methods of collecting data on catch and effort are given in the earlier paper (Murthy, MS). The length data collected on each observation day was raised to the day's catch and the monthly length composition of the catch was obtained by raising the pooled days' catch to the month's catch. The monthly data were pooled to get the annual length composition of the catch (i.e. the number of fish caught in each length group).

In the region off Kakinada (16° 35′-17° 25′ N Lat. and 82° 20′-82° 55′ E long.), *N. japonicus* is caught almost exclusively by trawlers, though it occurs in stray numbers in the catches of the indigenous gear operating in the same area. Hence, the fishing mortality can be taken as having been generated by trawlers only.

OBSERVATIONS AND RESULTS

Estimation of Mortality rates: Fishes of the length range 35-285 mm occur in the catches. A preliminary analysis of data on length composition of the catch indicated that fishes of the length range 35-75 mm are not fully recruited to the fishery. According to Ricker (1975), it is impossible to find out anything definite about the actual mortality rate of fishes which are not fully vulnerable to the gear, because representative samples of these lengths cannot be obtained. It is apparently for these reasons that Gulland (1977) states, "....that it is both simpler, and in many ways more realistic to omit fish below some chosen size (or age) from most of the analyses." (p. 77). In the present study, hence, only fishes of and above 85 mm are taken into account for estimating mortality rates.

Estimates of total Mortality are obtained by using the equation:

$$\log_e Nt = \log_e N_0 - Zt$$

Where Nt = number of fishes in differet age groups; t = age of fish, N_0 = number of fish when t = 0 and Z = total instantaneous mortality rate. Estimate of 'Z' are obtained separately (by the catch curve) for each year using the age groups represented in the catch of that year. For this purpose, the length composition of the catch is converted into age composition on the basis of age determined earlier (Murty MS), and the numbers of fish in each age group are scaled down to number of fish per 100 units of effort since the effort expended in different years was different.

The annual age composition of catch in different years is shown in Table 1 and the values of 'Z' for different years are shown in Table 2. It may be seen that the 'Z' values range from 1.58 to 2.03 in different years, with an average value of 1.86.

TABLE 1. *Number of fish in each age group (catch per* 100 *units effort) and their natural logarithms in* N. japonicus *during different years.*

Age	1976		1977		1978		1979	
groups	C/E	$\log_e$ C/E	C/E	$\log_e$ C/E	C/E	$\log_e$ C/E	C/E	$\log_e$ C/E
0	8515	9.0496	23056	10.0458	18203	9.8091	6784	8.8224
I	3410	8.1345	10005	9.2103	1338	7.1989	1627	7.3944
II	645	6.4693	1514	7.3225	312	5.7430	634	6.4521
III	77	4.3438	94	4.5433	—	—	12	2.4849

TABLE 2. *Estimated effort and 'Z' values during different years.*

Year	Effort (units)	'Z'
1976	33777	1.57826
1977	58450	1.83953
1978	53645	2.03305
1979	50125	1.99548
	Average	1.86158

Natural mortality rate (M) is estimated from the relation: Z = M + qf following Gulland (1969) and Ricker (1975), where, q = catchability co-efficient, and f = fishing effort. A plot of 'Z' against fishing effort is shown in figure 1. The estimated value of natural mortality is 1.14177 (value of Y-intercept in fig. 1). According to Gulland (1969), "A fish which approaches its ultimate length quickly — i.e., has a high value of K — is likely to have a high natural mortality, whereas a fish that grows slowly (a low K) is likely also to have a low M." (p. 70). The K value obtained for *N. japonicus* from Kakinada is 0.75142 (Murthy MS), and the high natural mortality rate obtained now (M = 1.14177) is in conformity with the theoretical concept outlined by Gulland (1969). In this connection it may be mentioned that, according to Krishnamoorthi (1978), the natural mortality rate of this species off Visakhapatnam is 0.5037, which is very low when compared to that from Kakinada. However, Krishnamoorthi (1978) did not take age composition of catch into account for estimating mortality rates. Fishing mortality rate (F) for the 1976-79 period is estimated as 0.71981.

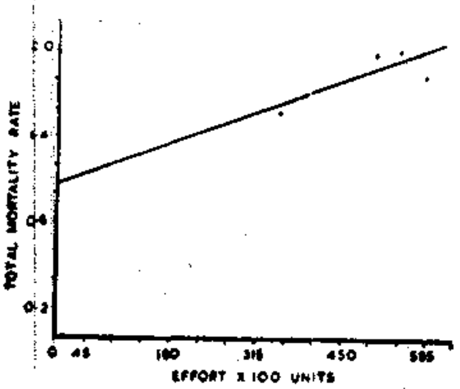

FIG. 1. Plot of instantaneous total mortality rate (Z) against fishing effort.

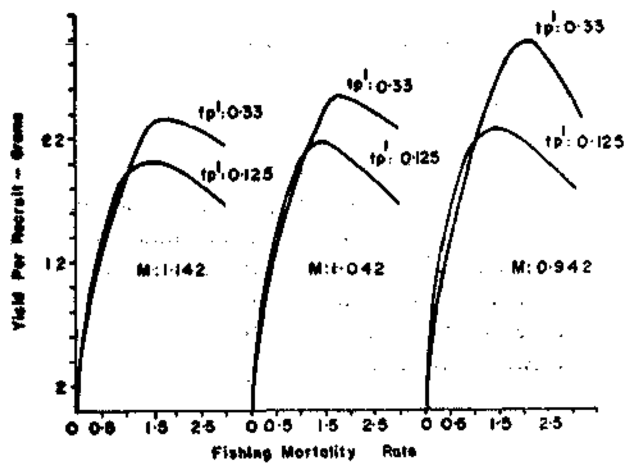

FIG. 2. Yield per recruit (YW/R) in relation to fishing mortality (F) at fixed ages of exploitation (Tp1) and natural mortalities (M).

Estimation of poulation size: The estimates of exploitation rate (U) are made using the equation:

$$U = \frac{F}{F + M} (1 - e^{-(F + M)})$$

(Beverton and Holt 1957; Ricker 1975), and, from this, the total annual stock (Y/U) and average standing stock (Y/F) are estimated (Y = annual estimated catch).

The exploitation rate (U) is calculated, keeping the value of Z constant, at 1.862 (The 1976-79 average value) and using different values of 'F'. The details are shown in table 3.

TABLE 3. *Stock estimates of* N. japonicus *based on different values of 'F'.*

Z	F	F|Z	U	*Y|U (kg)	*Y|F (kg)
1.862	0.42	0.2256	0.191	2022539	919774
	0.52	0.2793	0.236	1636885	742894
	0.62	0.3330	0.281	1374751	623073
	0.72	0.3867	0.327	1181361	536535
	0.82	0.4403	0.372	1038454	471104
	0.92	0.4941	0.417	926391	419897
	1.02	0.5478	0.463	834352	378730

* Y = The estimated annual average catch of *N. japonicus* for 1976-79 period is 386305 kg.

The estimated catches of *N. japonicus* at Kakinada range from 196 t, in 1979, to 862 t, in 1977, with an annual average of 386 t, for the four year period 1976-79. Since the maximum estimated landings of this species in any one year were at 862 t, the average annual stock should be above 900 t. This means that the value of F against Z = 1.862 can be at 0.92 (Table 3). It is observed that the present 'F' is at 0.72, and it may be concluded that the present trawling effort will not have any adverse affects on the stocks of *N. japonicus.*

Estimation of yield per recruit: The yield-in-weight per recruit (YW/R) was calculated from the equation of Beverton and Holt (Beverton 1953) as modified by Jones (1957), which states:

$$YW = \frac{F}{K} R' W\alpha\, e^{Z\,(t_{p1} - t_o)} \left\{ \beta\,(XPQ) - \beta\,(X_1PQ) \right\} \quad \ldots.(1)$$

Where K, t_o and $W\alpha$ are the parameters in Bertalanffy's growth equation, R' = number of recruits entering the fishery and t_{p1} = age at which fish become fully exploitable. The parameters for incomplete Beta function (Pearson 1948) are X, X_1, P and Q where $X = e^{-K(t_p 1 - t_o)}$, $X_1 = e^{-K(t\lambda - t_o)}$, $P = \frac{Z}{K}$ and, Q = one + exponent in the length weight relationship. In the above equation (1), R' = $Re^{-M(t_p 1 - t_p)}$ where R = number of fish first entering the fishing ground, The above yield equation can be rewritten as given below, after accounting for natural mortality during pre-exploited phase and by dividing both sides by R (Krishnan Kutty and Qasim 1967):

$$\frac{YW}{R} = \frac{F}{K} W_{\alpha} e^{Z(t_p l - t_o) - M(t_p l - t_p)} \left\{ \beta (XPQ) - \beta (X_1PQ) \right\} \quad \ldots\ldots(2)$$

The parameters of von Bertalanffy's growth equation for *N. japonicus* from Kakinada were estimated as K = 0.75, t_o = −0.17 and W = 320 g (Murty MS); it was shown that maximum age attained (t) in the population is 3 years.

The yield per recruit at natural mortalities (M) 1.142, 1.042 and 0.942 and at two different ages of exploitation (t_p l), against fishing mortality rate (F), are shown in figure 2. Since in the present work M is estimated as 1.142, it was felt reasonable to consider lower values of M as given above for calculation of yield per recruit, because the life span of the fish being 3 years a value higher than 1.142 for M is not expected: the value of M estimated on the basis of life span is at 1.0 (assuming that about 95% of the fish would die before they attain 3 years of age if they are not subjected to exploitation).

In the present work, the age of exploitation of the population (t_p l) is estimated at 0.33 year, according to the growth rate and age determined earlier (Murty MS). Since the commercial trawlers are engaged in fishing almost exclusively for prawns (Silas et al 1976), and since there is reduction in the cod-end mesh size of trawl nets at Kakinada (Rao et al 1980), to facilitate catching even smaller prawns which have a lucrative market, it is felt that the industry will not increase the cod-end mesh size in the coming few years. Hence, there is no possibility of getting an increased age of exploitation for *N. japonicus* from the present 0.33 year. Keeping this point in mind, the yield per recruit is calculated taking the present age of entry (t_p) of *N. japonicus* into the fishing ground as the age at recruitment to the fishery (i.e., t_p l = t_p) and also taking the present age at recruitment. (fig. 2).

It is observed (fig. 2) that, at t_p l = 0.125 and at different M values, maximum YW/R is reached at F = 1.50 and decreased thereafter with further increase in F. When t_p l = 0.33 and at different values of M, maximum yield is obtained at F = 1.75 (fig. 2). It is also observed that, with decreasing M, the yield per recruit is increasing.

Since the value of M obtained for the period of investigation is at 1.142, and the present F is estimated at 0.72, there is scope for increasing the yield of *N. japonicus* from the present fishing ground by increasing the fishing effort and without changing the cod-end mesh size. As stated above, even if there will be change in the mesh size, it will only be towards decreasing it, and even then the yield can be increased by increasing the effort (i.e., at t_p l = 0.125, vide fig. 2).

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