ESTIMATES OF THE STOCKS OF OIL SARDINE AND MACKEREL IN THE PRESENT FISHING GROUNDS OFF THE WEST COAST OF INDIA

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ABSTRACT

The annual exploitation rate (U) in a fish population is given by the well-known expression $\frac{F}{F+M}(1-e^{-(F+M)})$ where M is the annual instantaneous natural mortality coefficient and F the annual instantaneous fishing mortality coefficient. An estimate of the annual total stock may be obtained by dividing the total catch (Y) by U, and the annual average standing stock by dividing the annual catch by F. In the oil sardine fishery of the west coast, M has been estimated as 1.12, F as 0.54 and U as 0.26. The annual average catch for 1960-71 was 210,000 tonnes. Then the annual total stock in the fishing grounds during this period may be estimated as 810,000 tonnes on the average, and the annual average standing stock as 390,000 tonnes. In the mackerel stock, M is estimated as 0.9 and F as 1.15. The annual average catch on the west coast for the period 1960-71 was 65,000 tonnes. The total annual stock in the fishing grounds may then be estimated as 130,000 tonnes on the average and the average standing stock as 57,000 tonnes. Stock estimates based on slightly different values of F and M are also given.

INTRODUCTION

During last decade the oil sardine fishery recorded remarkably high catches on the west coast. On the other hand, the mackerel fishery declined steeply in the nineteen-sixties, touching the lowest known levels, in contrast to most other fisheries of the west coast. The percentage of oil sardine in the all India marine fish landings was 32 in 1968, as against 16 in 1958, the corresponding values for mackerel being 2 and 16. This has focussed attention on the need for quick estimates of the magnitude of these populations. One approach for this would be to survey the areas occupied by these two species through acoustic and other means. Another approach would be to use the known population parameters and mathematical models to yield estimates of the populations. The latter method is adopted here.

METHODS

Beverton (1954) and Beverton and Holt (1957) have shown that if M is the annual instantaneous natural mortality coefficient, F the annual instantaneous fishing mortality coefficient, and N_o the initial population in numbers, the catch in numbers (Y_n) during the year would be

$$Y_n = \frac{F}{F+M}(1-e^{-(F+M)})N_o \quad \ldots\ldots\ldots\ldots(1)$$

$$= UN_o$$

Where, $U = \frac{F}{F+M}(1-e^{-(F+M)})$ = Exploitation rate (Ricker, 1958).

Multiplying both sides by $\bar{W}$, the average weight of the fish during the year, we get,

$$Y_n \bar{W} = UN_o \bar{W}$$

$$\therefore \frac{Y_n \bar{W}}{U} = N_o \bar{W} = \text{the weight of the population.}$$

It may be seen that $Y_n \bar{W}$ = the weight of the catch = Y

$$\therefore \frac{Y}{U} = N_o \bar{W} = \text{the weight of the population} \ldots\ldots\ldots(2)$$

$$\text{Again, } \frac{Y_n}{F} = \frac{N_o}{F+M}(1-e^{-(F+M)}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$= \bar{N} \text{ (Beverton, 1954)}$$

= Average number in the population during the year

$$\frac{Y_n \bar{W}}{F} = \bar{N}\bar{W} = \text{Average weight of the population during the year, (average standing crop)}$$

$$\frac{Y}{F} = \bar{N}\bar{W} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

The equations (2) and (4) are used here to estimate the population size of oil sardine and mackerel in the fishing grounds.

VALUES OF F AND M

Oil Sardine

The value of Z (= F + M) in oil sardine has already been estimated as 1.66 by Sekharan & Dhulkhed (1963), based on the data of the Mangalore area for the years 1957-63. The other estimates of Z are: 1.3 for the Mangalore area for the years 1963-68 by Prabhu and Dhulkhed (1970), 2.13-3.45 for the Karwar area by Annigeri (1971) and 1.42 for the entire west coast by Banerji (1973). Beverton (1963) gives Z T_{max} = 6 for *Sardinella* spp. If T_{max} is regarded as 4 years, Z becomes 1.5. In the present account Z is taken as 1.66. It is well known that the life span of tropical fishes is short. The value of T_{max} (the maximum life span) of oil sardine may be taken as 4 years (Nair and Chidambaram, 1950). Assuming that the mortality is at least 99% by the time this age is completed in the unexploited state, we get the value of M = 1.12; then F becomes 0.54. Based on the data from Karwar, Annigeri (1971) estimates M = 1.45 and F = 0.68-2.00. Banerji's (1973) estimate of M is 0.67 and F is 0.75.

Mackerel

Rao *et al.* (1962) calculated the monthly rate of decrease of mackerel in the Mangalore zone as 0.57 on the average (equal to instantaneous rate of 0.56), which found support in the account of Banerji (1963) on the mackerel fishery of Karwar. Since immigration into and emigration out of small zones during such short periods may not balance each other, it would obviously not be equal to total mortality. Later, Banerji and Krishnan (MS, quoted by Banerji, 1970) obtained the value of average annual Z as 2.05 (see also annual report of CMFRI for 1969), the range being 0.86-4.55. Banerji (1973) also estimated the value of M as 0.65, in which case F = 1.40. As in the case of the oil sardine, a rough estimate of M may be made based on the life span. Rao *et al.* (1962) showed that the effective life span of mackerel could be regarded as 5 years. Assuming that at least 99% of the population in the unexploited state die by this age, M can be estimated as 0.9; F then is 1.15.

RESULTS AND DISCUSSION

Oil Sardine

Taking M = 1.12 and F = 0.54, U is estimated as 0.26. The annual average catch of oil sardine on the west coast during 1960-1971 is 210,000 tonnes. Then the total annual stock in the fishing grounds during that period may be estimated as 810,000 tonnes. The average standing crop is 390,000 tonnes.

Accepting Banerji's estimate of M = 0.67, U becomes 0.48 (for Z = 1.66); the average annual stock in the fishing grounds would then be 440,000 tonnes,

and the average standing stock 210,000 tonnes. These as well as other estimates of the stock based on different values of M and F are given below:

Z	M	F	Y|U	Y|F
1.66	0.67	0.99	440,000	210,000
	0.90	0.76	570,000	280,000
	1.12	0.54	810,000	390,000
	1.30	0.36	1,200,000	580,000
1.42	0.67	0.75	530,000	280,000
	0.90	0.52	750,000	400,000
	1.12	0.30	1,300,000	700,000
	1.30	0.12	3,500,000	1,800,000

The value of Z used here appears to be quite satisfactory in view of the close agreement of the estimates arrived at by different workers, as mentioned above. The value of M = 0.67, estimated by Banerji (1973) appears to be too small. Even in the ninteen-thirties, when fishing effort was very much less than at present, the abundance of fish above 19 cm, which may roughly be regarded as the length at age of 4 years (Banerji, 1973), was very negligible (See Chidambaram, 1950). If M = 0.67, then in the virgin stock, the total life-span would become much more than 4 years, and in fact 7 years would be required to reduce a year-class to 1% of its original abundance.

On the other hand, a high value of M = 1.30 or above would indicate a mean life span of less than 0.8 year for the fish in the virgin stock, that is less than the age at first maturity (see Allen, 1971, for the relation between mortality and mean life span), and may therefore be rejected. A mean value of M around 1.00 seems more reasonable and therefore the estimate of 810,000 tonnes for the average annual weight of the stock in the grounds may be accepted as a first approximation.

Mackerel

Taking M = 0.9, and F = 1.15, U may be computed as 0.49. During the period 1960-71, the average annual mackerel catch on the west coast was 65,000 tonnes (See CMFRI annual reports). Dividing the average catch by U, the total annual stock of mackerel in the fishing grounds during this period may be computed as 130,000 tonnes on the average. The annual average standing crop then is 57,000 tonnes.

The stock estimates based on other different values of F and M are given below:

Z	M	F	Y|U	Y|F
2.05	0.65	1.40	110,000	46,000
	0.90	1.15	130,000	57,000
	1.00	1.05	140,000	62,000
	1.10	0.95	160,000	68,000
2.50	0.65	1.85	96,000	35,000
	0.90	1.60	110,000	41,000
	1.00	1.50	120,000	43,000
	1.10	1.40	160,000	46,000

The present value of M (0.9) is larger than that (0.65) given by Banerji (1973). If the latter value is accepted, then the life span in the unexploited state would have to be regarded as at least 7 years, a very high figure (that is, taking life span as equal tc the time required to reduce a year-class to 1% of the initial abundance in numbers). Rao *et al.* (1962) stated that the life span of the mackerel may be regarded as 5 years. However even if Banerji's (1973) estimates of F and M are accepted, U becomes 0.6, and the annual average stock 110,000 tonnes (as against the present estimate of 130,000 tonnes), and the average standing stock 46,000 tonnes (as against the present estimate of 57,000 tonnes). The estimates of the stock obtained by using other slightly different values of F and M also did not deviate very much from the present values.

At present, the total area of the commercial distribution of the oil sardine and the mackerel during the season is not known. The method adopted here pre-supposes that immigration into and emigration out of the present fishing grounds, are equal. If the density of the stocks in the grounds outside the present fishing range is known, it would be possible to compute the magnitude of the populations of both species.

A comparison of the values of F and M of oil sardine and mackerel would be interesting. The fishing grounds, as well as the season, of both are the same, and both are fished, to some extent, by the same type of gear. Nevertheless the fishing mortality of the mackerel is estimated as about twice that of the oil sardine both by Banerji (1973) and by the present author. This is to be expected, since at the height of the season the fishermen often restrict the oil sardine catch voluntarily, owing to the glut. Mackerel on the other hand is always eagerly sought and fetch much better price than oil sardine. Therefore no voluntary restraint is exercised in the fishery by the fishermen. The present study also shows that the average standing stock of mackerel is less than the annual catch, a situation contrary to what is seen in the oil sardine fishery.

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