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The estimation of natural mortality and optimum fishing intensity of mackerel from the New England area

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ABSTRACT

In this report the natural mortality of mackerel is estimated. The age at optimum exploitation and the optimum fishing intensity is determined.

INTRODUCTION

The efficient fishery of mackerel in the West Atlantic requires specific proposals on the abundance regulation. For solution of certain problems of the efficient fishery we have made some attempts in estimating the natural mortality and optimum intensity in mackerel fishery.

MATERIAL AND METHODS

The growth equation of von Bertalanffy is known to be a component of a productivity model suggested by Beverton and Holt (1957). The parameters of von Bertalanffy growth equation accepted by Working Group on mackerel (Redbook P.I., 1973) are in close agreement with our data (Isakov 1973). Therefore, in further calculations we used the estimates accepted by the Working Group. The natural mortality rate was estimated by means of integral method

(Beverton and Holt, 1958). The calculations were based on the data on mackerel size composition for 1926-1935 from New England area which represent at present the only possibility to estimate the value sought for, since other data (age composition, yield per unit effort statistics) are not reliable or available. It should be noted that the natural mortality rate of New England mackerel was never estimated before. The estimate of optimum fishing intensity was obtained from the tables of Beverton and Holt (1966).

The symbols for parameters occurring in text are as follows:

Y/R - yield per recruitment;
Z - total mortality rate;
F - fishing moratality rate;
M - natural mortality rate;
L_{∞} - theoretically possible maximum fish length, cm;
K - factor of growth rate deceleration;
t_o - theoretical age at which the fish length is zero;
l' - the least fish length fully represented in catches, cm;
$\bar{l}$ - mean length calculated for sizes from l' and over, cm;
l_c - mean fish length at entering the exploitational phaze;
C - l_c/l_{∞}
E - exploitational rate determined from the F/F+M ratio;
MR - mortality rate, %.

ESTIMATION OF NATURAL MORTALITY RATE

Among the major parameters of any population are the values of natural and fishing mortalities. The separation of these two values is considered to be the most difficult task. The methods available need as a rule a series of

representative data on dynamics of fishing effort and catches for a number of year-classes for a certain period of time. Many scientists (Beverton and Holt 1958, Baranov 1961, Boiko 1964) used to take the total instantaneous mortality during the first year of exploitation, or in the period when the population virtually was not fished for the natural mortality rate, supposing that in this period the age-length composition characterizes the virgin state of the exploited population. Basing on the above-said we used a popular formula suggested by Beverton and Holt (1958) for estimation of the natural mortality:

$$Z = \frac{K(l_\infty - \bar{l})}{\bar{l} - l'} = \frac{0.25\ (45.0 - 36.5)}{36.5 - 30.0} = 0.33$$

where K and l_∞ are the known parameters of von Bertalanffy equation, while for calculation of the values $\bar{l}$ and l' we used the massive measurements of mackerel from the New England area for 1926-1935 (table 1). These measurements are represented by an American scientist O.Sette (1950). Since at present mackerel is measured from the tip of the snout to the end of the middle caudal finrays (according to Smith), while in 1926-1935 it was measured to the end of the caudal fin (absolute length), we applied the conversion factor (0.916) calculated by Mackay (1967), to convert the lengths. In 1926-1935 a total of 65 593 specimens of mackerel was measured. The sampling was made in June-July from purse-seine catches. The fishing for mackerel in 1926-1935 was insignificant, the catches fluctuating from 20 to 30 thous. tons a year, so the mackerel stock was supposed to be virgin in that period. Relatively large mean length of fish constituting during the above period 35.6 cm (31.9 cm in 1972) confirms the supposition.

CALCULATION OF THE OPTIMUM FISHING INTENSITY

Two points are obligatory in fishery regulation, namely, the choice of fishing intensity (F) and minimum size (or age) of exploitation.

The catch model by Beverton and Holt allows to reveal optimum fishing conditions at constant values of growth equation parameters by Bertalanffy (K, L_{∞}, t_o) and constant natural mortality rate. The fluctuations in population abundance determined by recruitment level are of no importance in estimating the parameters of optimum fishing, since all the calculations are made relative to conventional value of yield to recruitment (Y/R) ratio.

The age of optimum exploitation is determined by modified formula (Katty and Qasim 1968):

$$t' = \frac{\ln(3K+M)-\ln M}{K} + t_o = 2.68 \text{ years}$$

The length found according to von Bertalanffy growth rate corresponds to the age calculated above:

$$l_c = l_{\infty} \; /1 - e^{-k}(t' - t_o)/ = 30.06 \text{ cm}$$

and the C value constituts $c = \frac{l_c}{l_{\infty}} = 0.66$

At a given value of C the ratio of yield to recruitment (Y/R) increase practically infinitely, with an increase in fishing intensity (F) reaching maximum at E= 1 (Beverton and Holt, 1966). The trend of the catch curve presented in Fig.1, shows that the original increase of F from zero to 0.3-0.4 is accompanied by a sharp increase in catch size, while further on the curve is characterized by a marked decrease in catch growth rate.

The analyses of the curve trend according to the method suggested by Rikhter (1970) is presented below; the increase in Y/R and F is given in per cent (Table 2).

Within the range of increase from 0.2 to 0.4 (18-33%) a difference between the increase in catch size and fishing intensity is relatively insignificant, however, the further increase in F gives rise to considerable discrepancy, as a result of a sharp decrease in catch size.

It can be suggested that the optimum exploitational level for mackerel stock is reached at F=0.4 (33%).

SUMMARY

A preliminary value of natural mortality for mackerel from the New England area is 0.33. Despite of preliminary character of the results, the value of M most probably lies within the range of 0.3-0.4. According to our data the optimum fishing intensity for mackerel from the West Atlantic is reached at F=0.4 (33%).

REFERENCES

1. Baranov, F.I. "On biological aspects of fisheries" The papers on biological aspects of fisheries. USSR Ac. of Sc. Publ. 1961.

2. Boiko, E.G. "On estimation of natural mortality rate for the Azov pike perch". Trudy VNIRO, v.50, 1964.

3. Beverton, R.I. and Holt, S.D., 1958. The review of methods for determination of mortality of exploited fish populations. Izd. VNIRO (translated from English).

4. Rikhter, V.A. Optimum intensity of red hake, Urophycis chuss (Walbaum), from the Western Atlantic Ocean. "Voprosy ikhtiologii", vol.10., iss 6, (65), 1970.

5. Beverton R.I., Holt S.I., 1957. On the dynamics of exploited fish populations. Fish. invest. Ser. v. 19.-1966. Manual of methods for fish stock assessment. Part II - Tables of yield Functions, FAO.

6. Isakov V.I. Growth and total mortality of mackerel from the New England area. ICNAF Res. Doc.73/23. Annual meeting. June. Canada.

7. Kutty M.K., Qasim S.Z. 1968. The estimation of optimum age of exploitation and potential yield in fish populations. J. du Cons., v.32. No.2.

8. Mackay K.T. Ecological study of mackerel, Scomber scombrus, in the coastal waters of Canada. Fisheries Research Board of Canada Technical Report No. 31. 1967.

9. Report of ad hoc mackerel working group. 1973. ICNAF Redbook p.1. Annual Meeting. - June. Canada.

10. Seete O.E. Biological of the Atlantic mackerel (Scomber scombrus) of North America, Fishery Bulletin 49. Vol. 51, 1950.

Table 1

SIZE COMPOSITION OF MACKEREL CATCHES FROM THE NEW ENGLAND AREA FOR 1926-1935

Size frequency, cm	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	30** 33*	34	35	36	37	38	39
%	+	+	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.5	0.8	1.1	1.3	1.5	2.4	2.8	3.6	4.6	4.5	6.1	9.7	10.8

40	41	42	43	44	45	46	47	48	49	50	51	52	53	Mean size	Mean size from 30 and over
9.0	8.2	9.5	9.8	6.8	3.4	1.2	0.6	0.3	0.1	0.1	+	+	+	100% 38.9*(35.6)**	39.8* (36.5)**

* mean size (total length)

** mean size (length according to Smith)

Table 2

THE INCREASE IN CATCH SIZE AND FISHING INTENSITY, %

Indices	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
K fishing mort.	9.5	18.1	25.9	33.0	39.4	45.1	50.3	55.1	59.3	63.2
Increase in K fishing mort.	-	47.5	30.0	21.0	16.0	12.4	10.3	8.6	7.0	6.2
Increse in Y/R	-	35.4	18.0	10.0	7.2	4.1	3.6	2.5	1.4	1.4

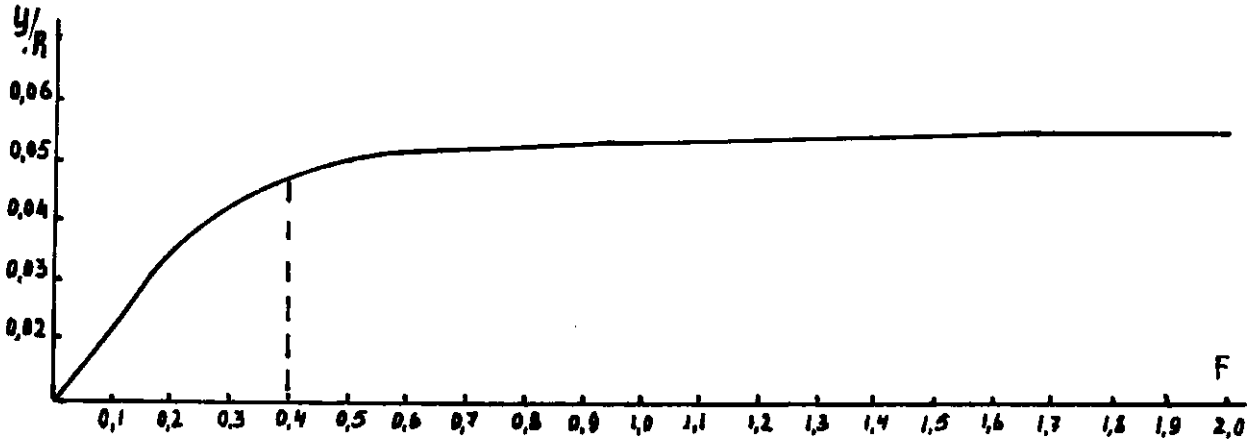

Fig. The ratio of yield to recruitment (Y/R) and the fishing mortality rate (F).