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More on Estimating the Instantaneous Natural Mortality Rate for the Div. 4VWX Silver Hake

by

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ABSTRACT

New estimates of the instantaneous natural mortality rate for the Scotian silver hake were derived using different methods and new information that has been made available since 1977. The obtained results make it possible to estimate the current mean natural mortality rate at 0.50.

INTRODUCTION

Till now, the paper by Terré and Mari (1978) is the only document that gives the mathematical foundation of estimates of natural instantaneous mortality (M) for the silver hake stock on the Scotian Shelf. Since then, the mean estimate of M equal to 0.4 has been used for assessment of all silver hake stocks and TACs by the ICNAF STACRES in the past and by NAFO Scientific Council. The reliability of the coefficients of M, which change with age, has not been proved yet, though the attempts to use these for the 4VWX silver hake have been made since 1985 (Noskov, 1985).

Beginning in 1977, the conditions of the hake fishery markedly changed. Most probably the exploitation rate considerably reduced, and the stock size reached a rather high, if not the highest level in the recent years against the entire observation period. The age of complete recruitment to the fishery also increased. In this connection, it seems reasonable to make new attempts aimed at gaining information on natural mortality rate for the silver hake at present.

MATERIALS AND METHODS

For calculating the weighted Z (Rikhter, Peteropsh, 1986) the data on age composition of commercial catches per unit effort for the 1970 to 1985 period can be used (Waldron, Fanning, 1985, 1986). Before 1977 the calculations were made beginning from age 2, and since then from age 3. The parameters of the Bertalanfy growth equation were calculated by the Hohendorf's method (1966) based on the data on the fish length by age averaged for 1981-1986 (Atlant-NIRO data), and on the mean weight by age (Waldron, Fanning, 1986).

Mean lengths and weights by age used for calculating the parameters are given below:

Age	1	2	3	4	5	6	7	8	9
Length, cm	20.4	26.3	30.0	33.2	36.4	39.4	42.7	-	-
Weight, g	53	140	208	262	331	402	545	717	841

The per cent of mature specimens by age was determined from the data of biological analysis made in May-July 1986 by the USSR observers. The natural mortality rate was estimated by different *methods (Beverton and Holt, 1956; Silliman, 1943; Pauly, 1980;* Rikhter and Efanov, 1976).

RESULTS AND DISCUSSION

First we shall consider the results obtained by means of the methods based on dependence of the natural mortality rate on definite biological indices. The values of parameters of the Bertalanfy growth equation are *presented* in Table 1.

The mean ambient temperature in the silver hake habitat was taken to be 9°C. The results of calculations by the Pauly equation appeared to be 0.24 for the linear growth and 0.22 for the weight increase. Certainly these estimates of M for the silver hake are too low to be real. The reason may be an underestimation of the parameter K. The latter, however, is difficult to explain, as the initial data on the mean lengths and weights of the silver hake seem to be quite reliable.

For estimating the values of M by the equation of Rikhter and Efanov the data on the maturation rate by age are adequate. The pertinent data are given in Table 2.

As is evident from the data, the massive sexual maturation of the silver hake takes place at the age of 2-3 years and comes to an end by the age of 4. The values of M corresponding to the age of massive maturation at the age of 2 and 3 years are 0.77 and 0.53, respectively.

An attempt was made to estimate M using the method of Beverton and Holt based on the regression of total instantaneous mortality rates (Z) against the fishing effort (f). The data on the magnitude of the latter for the 1970 to 1985 period were adopted from the paper by Waldron and Fanning (1986) and expressed in standardized fishing hours for each year of the fishery. Below are given the weighted values of Z for the same period:

Years	1970	1971	1972	1973	1975	1977	1978	1979	1980	1984
$Z_{weigh.}$	1.38	1.35	1.81	1.66	1.18	0.98	0.44	1.37	0.63	0.83

The above-stated data show that the total mortality rate was considerably higher before 1977 compared with the subsequent period, which, certainly, can be attributed to a much higher intensity of fishing before the introduction of the 200-mile zone. The calculations were made only for those pairs of years, the information for which made it possible to obtain real estimates of Z. The parameters of the equation of regression were derived based on the weighted estimates of Z averaged by pairs of years (1970/1971, etc.) and on the fishing effort values combined by the same principle.

Periods	70/71	71/72	72/73	77/78	78/79	79/80
Z	1.36	1.58	1.74	1.71	0.90	1.0
f	147912	134664	181403	49336	59611	55946

The calculations revealed a strong correlation between Z and f ($P < 0.01$), and the intersection of regression line with

the y-axis produced the estimate M = 0.50 (fig. 1).

The Silliman's method can be only used if two fishery periods that satisfy certain conditions are available. In the given case the periods with the following characteristics were chosen:

A : 1971-1972	B : 1984-1985
Y_A = 134664	Y_B = 47742
Z_A = 1.35	Z_B = 0.83

where Y_A and Y_B are fishing efforts combined for two years and Z_A and Z_B are total mortality rates in 1971 and 1984.

The calculations resulted in the value of M = 0.54 close to that obtained by the same method of Terré and Mari (1978).

So a series of M values given below was compiled.

No.	Method	M
1.	Pauly's equation (1980):	
	a) for linear growth	0.24
	b) for weight increase	0.22
2.	Equation of Rikhter, Efanov (1978):	
	a) age at massive maturation 2 years	0.77
	b) - " - 3 years	0.53
3.	Weighted Z against fishing effort (method of Beverton and Holt, 1956)	0.50
4.	Silliman's method (1943)	0.54

The first two values can be omitted at once as absolutely unreal. The estimate of M = 0.77 stands by itself; it is not supported by the subsequent values and is probably overestimated. The latter three estimates are close and, evidently, are most reliable. Therefore the value of M = 0.50 can be recommended for practical use.

We believe that a certain increase of M compared with the estimate of 0.4 that has been used for a number of years is quite justified biologically under new fishing conditions. If before 1977 the mean natural mortality rate was determined for the age of 2 and older, subsequently it has been done beginning from the age of 3. Considering the fact that the natural mortality rate on the exploitable part of the stock has a tendency to increase

beginning from a definite age (for the silver hake it is evidently 3 years - the age of completed sexual maturation), the mean value of M should be somewhat higher now. A high abundance of the commercial stock and a low fishing intensity also promote the increase of the natural mortality rate.

REFERENCES

1. Beverton R.J.H. and S.J.Holt, 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. Cons. Int. Explor. Mer. Rapp. et Rroc. Verb., 140, Pt. 1, pp. 67-83.

2. Hohendorf K., 1966. Eine Diskussion der Bertalanfy Funktionen und ihre Anwendung zur Characterizierung des Wachstums von Fischen. Kieler Meeresforschungen, Heft 1: 1: 70-95.

3. Noskov A.S., 1985. Assessment of the Scotian silver hake (Merluccius bilinearis) stock and allowable catch in 1986. NAFO SCR Doc. 85/36, 13 p.

4. Pauly D., 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J.Cons. Int. Explor. Mer. 39(2): 175-182.

5. Rikhter V.A. and V.N.Efanov, 1976. On one of the approaches to estimation of natural mortality of fish populations. ICNAF Res. Doc. 76/8, 12 p.

6. Rikhter V.A. and V.V.Peteropsh, 1986. Estimating of total instaneous mortality rate for fishes using the weighting procedure by an example of division 4VWX silver hake. NAFO SCR Doc. 86/58,6 p.

7. Silliman R.P., 1943. Studies on the Pacific pilchard or sardine (Sardinops caerula), 5: A method of computing mortalities and replacement. Spec. Sci. Rep. U.S.: Fish. wildl. serv. - Fish., No. 24, 10 p.

8. Terré J.J. and Mari, 1978. Estimates of natural mortality for the silver hake stock on the Scotian Shelf. ICNAF Select. Pap., No. 3, pp. 29-31.

9. Waldron D.E. and L.P. Fanning, 1985. Status of the Scotian Shelf silver hake population in 1984. NAFO SCR Doc. 85/68, 28 p.

10. Waldron D.E. and L.P.Fanning, 1986. Assessment of the Scotian Shelf silver hake population in 1985. NAFO SCR Doc. 86/62, 27 p.

Table 1 Parameters of Bertalanfy growth equation for the 4 VWX silver hake

Parameters	Linear growth	Weight increase
K	0.134	0.124
L_∞	59.670	-
W_∞	-	1940.810
t_o	- 2.164	- 1,930

Table 2 Per cent of mature 4 VWX silver hake by age

Age	Per cent of mature silver hake			Observation nos.
	Males	Females	Total	
1	4.4	0.0	2.1	97
2	67.4	44.0	56.5	90
3	100.0	100.0	100.0	69

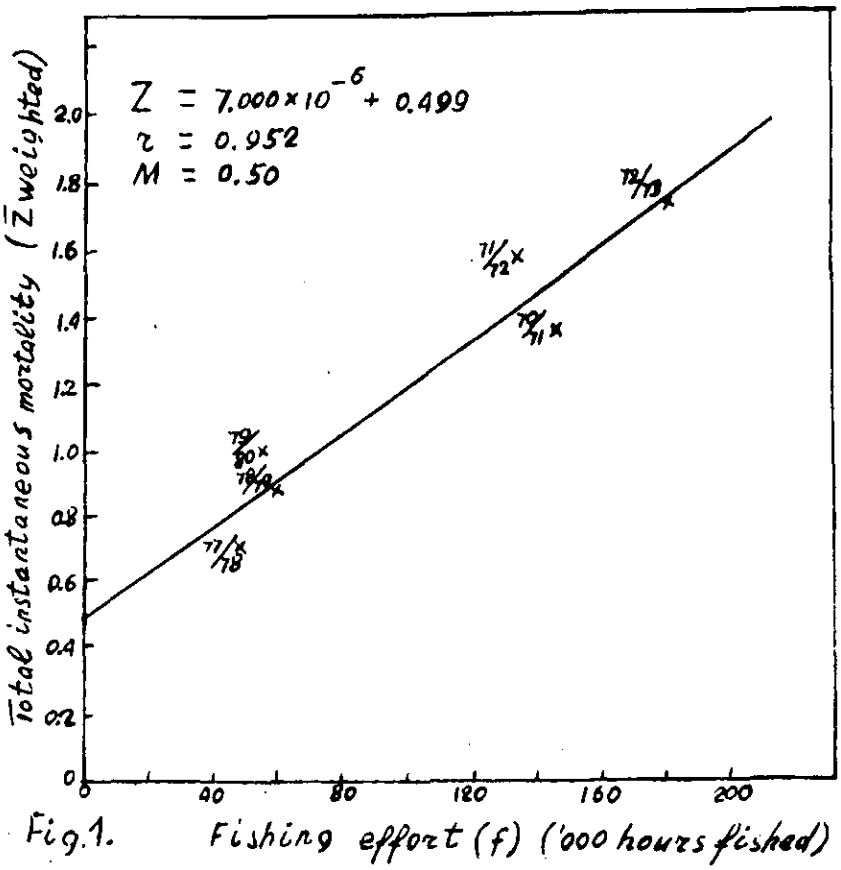

Fig. 1. Regression of total mortality (weighted Z) for completely recruited age groups per fishing effort for the Scotian silver hake.