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Estimating of Total Instantaneous Mortality Rate for Fishes Using the Weighting Procedure by an Example of Division 4VWX Silver Hake

by

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Abstract

A detailed description of the procedure of calculation of arithmetical weighted means of total mortality rates is given. A corresponding formula is presented. Based on comparative analysis of arithmetical means and weighted estimates of total mortality rate preference should be given to the latter.

Introduction

During a meeting of Standing Committee on Fishery Science (STACFIS) in June 1985, among the other matters a possible application of the estimation method for arithmetical mean weighted values ($Z_{weighted}$) of total instantaneous mortality rate (Z_{ti}) of the fish represented by age groups (i=1, 2 ... N) was considered. After discussion it was recognized necessary to provide a more detailed description of suggested method in order to evaluate the feasibility of its utilization in the future. The present paper is a response to the above-mentioned opinion of STACFIS.

Materials and Methods

The data used for calculations were adopted from the papers by Waldron and Harris (1984) and Waldron and Fanning (1985) as these contained the most complete information on commercial and research (trawl surveys) silver hake catches for a rather great series of years. It is noteworthy that before introduction of the 200-mile zone in 1977 the data on catches at age given in the above-mentioned documents usually differed from similar data of the Soviet scientists (Noskov, 1976, 1985). According to the latter 3 year-olds but not 2 year-olds as in Canadian scientists were mostly predominant in the catches. Probably, the reason of disagreement was different interpretation of annual rings by the USSR and Canada experts.

The results of estimation of arithmetical unweighted ($Z_{unweighted}$) means of Z_{ti} and $Z_{weighted}$ presented previously (Rikhter, 1985) were reconsidered. In addition, "fishing" $Z_{unweighted}$ and $Z_{weighted}$ were estimated for 1983. As usual, the values of Z_{ti} by age were derived using Paloheimo's method (1958). The weighting procedure is shown below. The data on catch per unit effort (CPUE) by age for 1983 and 1984 were used.

Results and Discussion

The calculations of $Z_{weighted}$ are shown in table 1. The value of $Z_{unweighted}$ calculated for the same age groups was estimated at 1.4156. A procedure of calculations given in the table can be presented as:

$$Z_{unweighted} = \frac{\sum_{i=1}^{N} Z_{ti}}{} = \frac{\sum_{i=1}^{N} (l_n n'_{ti} - l_n n''_{ti+1})}{N}$$

$$Z_{weighted} = \frac{\sum_{i=1}^{N} Z_{ti} n'_{ti}}{\sum_{i=1}^{N} n'_{ti}} = \frac{\sum_{i=1}^{N} (l_n n'_{ti} - l_n n''_{ti+1})}{\sum_{i=1}^{N} n'_{ti}}$$

where N is number of age groups

i is 1,2...N

n'_{ti} is abundance of year-class at age ti in the first year

n''_{ti+1} is abundance of year-class at age ti+1 in the second year.

Now, the values of $Z_{weighted}$ estimated previously (Rikhter, 1985) should be reconsidered with the 1983 data added (table 2).

The given data permit to reveal some peculiarities which have not been considered in the previous paper. "Fishing" $Z_{weighted}$ is to be mentioned in the first instance. It is not difficult to note that prior to 1977 these values usually appeared to be higher than the corresponding values of $Z_{unweighted}$. Means of the above values from 1970 to 1976 inclusive were 1.58 and 1.44 respectively. During the following period (1977-1983) an opposite picture with one exception was observed. The values of $Z_{weighted}$ and $Z_{unweighted}$ over 1977-1983 were 0.68 and 0.98, respectively. The differences between two fishing periods are so distinct that these can hardly be explained by an accidental nature. Probably, a solution should be looked for in the different age composition of commercial catches in the given periods (Waldron, 1984). The table 13 data in the mentioned paper indicated that before introduction of 200-mile zone two year-olds predominated in the catches in terms of abundance. In addition, as is evident from table 12 in the same paper, total mortality rate for this age group was very high. Due to observed peculiarities, in most cases the values of $Z_{weighted}$ appeared to be higher than those of $Z_{unweighted}$. During the following period fishing conditions sharply changed which accordingly resulted in the change in age composition of the catches. A marked decrease in number of two year-olds in the catches was observed. Total mortality rate for the given age group decreased (table 1 in Res. Doc. 85/35 and table 12 in Res. Doc. 84/VI/85). Under these conditions, the values of $Z_{unweighted}$ began to prevail over those of $Z_{weighted}$ which is attributed to an increase in Z_{ti} with age at low abundance of older age groups. The above statement permits to suppose that on the whole arithmetical mean weighted values of Z_t more really show the real total mortality rate compared to unweighted values. Probably, the latter appeared to be somewhat underestimating in the first period of fishing and overestimating in the second period. As regards the values of "research" $Z_{unweighted}$ and $Z_{weighted}$, a discrimination between above-mentioned periods can hardly be made there. However, the higher values of $Z_{weighted}$ are noticeable on the whole which may also be explained by an influence of high abundance of younger age groups (first of all, of two year-olds). In comparing the data of tables 13 (Res. Doc. 84/VI/85) and 9 (Res. Doc. 85/68), it is not difficult to note that at least prior to introduction of 200-mile zone research indices of abundance, taking into account a succession in change in abundance of adjacent age groups, had no evident preferences compared to fishing indices. Since introduction of 200-mile zone the data on commercial catches per unit effort should probably be taken into account only if there is a confidence that conditions of silver hake habitat (and accordingly its behaviour and distribution) were approximately similar in the reference years.

Certainly, the weighting procedure may be applied to the fish species with long life cycle. An increase in natural and accordingly, total mortality rates of older age groups with their abundance being low will result in that in most cases in these fish species the values of $Z_{unweighted}$ will appear to be higher than those of $Z_{weighted}$.

Conclusions

In our opinion, the results of studies permit in some cases to give preference to the weighted estimates of total mortality rate as they more really show the actual loss rate of the exploitable part of the stock.

References

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5. Waldron D.E. and C.Harris, 1984. Assessment of the Scotian shelf silver hake population size in 1983. NAFO SCR Doc. 84/VI/85, Serial No. N875, 35 p.

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Table 1 Arithmetical weighted means from the silver hake fishery data for 1983 and 1984 (CPUE by age)

Age ti	1983 $l_n n'_{ti}$	1984 $l_n n''_{ti+1}$	$Z_{ti} = l_n n'_{ti} - l_n n''_{ti+1}$	CPUE for 1983 (no. per hauling hour	$Z_{ti} \cdot n'_t$
3	1.0571	-	0.1489	2.878	0.4285
4	0.458	0.9082	0.8675	1.581	1.3715
5	-0.3188	-0.4095	1.3632	0.727	0.9910
6	-1.3984	-1.6820	1.9258	0.247	0.4757
7	-2.7489	-3.3242	2.7726	0.064	0.1774
8	-	-5.5215	-	-	-
				5.497	3.4441

Hence $Z_{weighted} = \frac{3.4441}{5.497} = 0.6265$

Table 2 Arithmetical mean unweighted and weighted values of Z_{ti} by year

Year	Survey data		Fishery data	
	Unweighted Z	Weighted Z	Unweighted Z	Weighted Z
1970	-	-	1.28	1.38
1971	-	-	1.19	1.35
1972	-0.27	1.19	0.40	1.82
1973	1.73	2.11	2.81	1.70
1974	1.53	2.22	0.75	1.91
1975	0.61	0.61	1.26	1.18
1976	0.36	1.24	0.16	0.53
1977	0.18	0.56	0.18	0.65
1978	-	-	0.36	0.35
1979	1.53	1.74	1.54	1.03
1980	-	-	0.89	0.19
1981	1.42	1.86	-	-
1982	1.02	0.87	1.52	1.24
1983	-	-	1.42	0.63