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Comparative Estimating of Total Instantaneous Mortality Rate for the Scotian Shelf Silver Hake (Divisions 4VWX) from the Data of Canadian Groundfish Surveys and Commercial Catches Per Unit Effort

by

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Abstract

Total instantaneous mortality (Z) rate for silver hake derived from the research and commercial abundance indices by age group is analysed. A procedure of weighting of Z values for each observation year and year class is suggested. It has been noted that after introduction of the 200-mile zone commercial catches per unit efffort (CPUE) lacked reliability as abundance indices, and, therefore, their utilization.in assessment of total and fishing mortality (F) rates may lead to dramatic errors. In such a situation preference should be given to the data from the Canadian groundfish surveys which are being conducted annually in July. It is also recommended to resort to a weighting procedure for assessment of Z which will help to obtain more reliable results provided that the ratios of abundance indices for adjacent age groups are relatively real.

Introduction

Validation of a terminal F for the last year of fishery still offers considerable difficulties. Relative to silver hake from Divisions 4VWX, these difficulties are aggravated by the fact that the catch data which are used to determine a terminal F have, evidently, lost their significance after introduction of 200-mile zone in 1977 due to possible considerable fluctuations in CPUE not correlated with the stock size. Consequently, the role of inventory surveys as an instrument allowing to obtain independent and real abundance estimates has increased.

A comparative analysis of the total instantaneous mortality rate (Z) derived from the research indices of silver hake abundance and from the data on commercial CPUE is made in this paper in an attempt to discriminate between actual merits of both values with a view to prospects of their utilization in the future.

Materials and methods

The calculations were based on the data on abundance of silver hake age groups from Divisions 4VWX obtained during annual July groundfish surveys which have been conducted since 1972, standardized CPUE value and fishing effort over the period 1970 to 1983 inclusive (Waldron, Harris, 1984). The values of Z have been determined both for the exploitable part of the stock (annual observations) and separate year classes. Indices of population size for the fish at the age of 2 to 8 were used. The values of Z were derived using Paloheimo's method (1958). To give more precise values of Z a weighting procedure was used with the difference of natural logarithms multiplied by abundance indices for corresponding age groups. Both values were then compared. Rates of correlation with the fishing effort by year were found.

Results

Table 1 presents the values of Z derived from the June survey data (Waldron, Harris, 1984).

A similar table containing the values determined from commercial data is not given here, for it was adopted from NAFO SCR Doc. 84/VI/85 in a slightly contracted form.

Results of calculation of arithmetical means and weighted values of Z from the survey and commercial data as compared with the fishing effort amount are presented in table 2 (Table 4 NAFO SCR Doc. 84/VI/85).

The origin of gaps in some columns can be attributed to an obvious discrepancy of abundance indices of adjacent age groups, which has resulted in negative arithmetical means and weighted Z values. These data were not used in the analysis. The discrepancy of fishery data can be related to anomalous conditions of fishing for silver hake in 1982, but the reasons of discrepancy of survey indices can be only guessed.

As is evident from comparing arithmetical means and weighted values of the "research" Z's, the preference should be given to the latter. Unlike weighted values, arithmetical means for 1972, 1976 and 1977 cannot be regarded as real ones, if the minimum instantaneous natural mortality rate (M) for silver hake is estimated at 0.4 (Terré, Mari, 1978).

Arithmetical means of "fishing" Z's are unreal in four cases (1972, 1976, 1977, and 1978), while unreal weighted means were derived only in two cases (1978 and 1980). It should be remembered that the fishery data which had been used prior to 1977 and following that year are not equivalent. Introduction of the 200-mile zone has entailed a sharp restriction of fishing grounds and seasons in silver hake fishery, and the CPUE fluctuations by year could no more surve as indices of population size changes. In the present situation it is reasonable to confine to comparison only for the period preceding 1977. Over this period (1970-1976), unreal weighted values of Z were not available, and only two unreal arithmetical means were found in 1972 and 1976.

Calculated correlation factors and their errors are presented in table 3.

The data indicate a bad correlation of the "research" Z's and fishing effort. Nevertheless, a certain advantage of weighted values is evident. Judging from correlation of the "fishing" Z and fishing effort, preference should be given to arithmetical means, as they are more consistent in showing changed mortality rates by year, although the above unreal values hinder subsequent calculations. In particular, they prevent from estimating M using the regression of Z on fishing effort (Beverton, Holt, 1956). A bad correlation of the "fishing" Z and fishing effort over the entire observation period is consistent with the above-mentioned statement that restrictions in silver hake fishery have affected the reliability of CPUE as abundance index.

The values of Z by year class against average fishing effort for corresponding years are given in table 4. Only fully exploited year classes, as per available information, were considered.

The data from table 4 show that although differences between arithmetical means and weighted values of Z by year class are very important in certain cases, no obviously unreal values are available. A low total mortality rate for the 1975 year class (weighted values), which entered the fishery following the introduction of the 200-mile zone in worth noting. Most probably, a decrease of the loss rate of this year class can be attributed to a sharp restriction of fishing effort beginning in 1977.

Estimated correlation of Z's by year class and average fishing effort against corresponding years is presented in table 5.

As is evident from the table, this time a high and statistically reliable correlation factor was obtained only for weighted values of "fishing" Z's with an enormous difference from the correlation factor for arithmetical means of Z.

Summary

The analysis of "fishing" Z's prior to 1977 and following this year shows that in the latter case the values of Z can be hardly used for practical aims (for example, for estimating F in the last year of fishery) due to possible large fluctuations of CPUE by year arising from causes other than changes in population size. Therefore, the data of the July silver hake survey are the only source of objective information based on which relatively reliable values can be derived. However, these data should be handled critically, as in some cases obvious discrepancies in abundance indices of adjacent age groups exist. That is why, the weighting procedure, although it gives more reliable results, was not always up to the requirement as shown above. Nevertheless, the data presented in this paper indicate that even in cases of mentioned discrepancies weighting can be used to correct some downwright unreal values.

Thus, at present, the July survey data are preferable for the analysis of the total and, accordingly, fishing mortality rates for silver hake in Divisions 4 VWX. This should be accompanied by the weighting procedure, which will help to obtain more reliable results at "normal" ratios of abundance indices of adjacent age groups.

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Table 1 Values of Z for silver hake by year and age group from the June survey data over 1972-1983

Age	Years										
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
2	1.63	2.23	2.34	0.75	1.66	0.57	-1.08	1.63	-1.81	1.54	1.02
3	-0.10	1.62	1.77	0.50	1.21	0.87	-0.20	2.15	-0.69	2.18	-
4	-0.63	1.45	0.59	0.15	-2.05	-0.46	-0.29	1.53	-0.69	1.92	0.48
5	-0.70	1.24	0.95	0.06	1.08	-0.67	0.19	1.31	-0.21	1.20	1.04
6	-0.21	2.17	1.90	1.30	0.73	0.15	-0.07	1.31	0.08	0.86	1.84
7	-1.59	1.67	1.55	0.91	0.06	0.64	0.19	1.25	0.56	0.85	1.71

Table 2 Arithmetical means and weighted values of Z by year against corresponding fishing effort.

Year	Survey data		Fishery data		Fishing effort
	Arithmetical mean Z	Weighted Z	Arithmetimean Z	Weighted Z	
1970	-	-	1.28	1.38	78 128
1971	-	-	1.19	1.35	80 214
1972	-0.27	1.19	0.40	1.82	64 488
1973	1.73	2.11	2.81	1.70	131 574
1974	1.53	2.22	0.75	1.91	64 233
1975	0.61	0.61	1.26	1.18	83 682
1976	0.36	1.24	0.16	0.53	50 894
1977	0.18	0.56	0.18	0.65	19 777
1978			0.36	0.35	32 197
1979	1.53	1.74	1.54	1.03	30 051
1980			0.89	0.19	38 269
1981	1.42	1.86			29 500
1982	1.02	0.87	1.52	1.24	15 907

Table 3 Correlation of the values of Z (by year) and fishing effort.

Z	± m	Critical values of at P=0.05
Survey data		
Arithmetical	0.21 ± 0.21	0.67
means	0.36 ± 0.19	
Fishing data (1970-1982)		
Arithmetical means	0.59 ± 0.15	0.58
Weighted values (1970-1976)	0.35 ± 0.29	
Arithmetical means	0.99 ± 0.01	0.75
Weighted values	0.58 ± 0.15	

Table 4 Arithmetical means and weighted values of Z by year class against corresponding fishing effort

Year class	Survey data		Fishing data		Average fishing effort
	Arithmetical mean Z	Weighted Z	Arithmetical mean Z	Weighted Z	
1970	0.88	1.55	0.80	2.17	69 108
1971	0.93	2.12	0.87	1.48	63 726
1972	0.90	2.11	1.09	1.83	46 806
1973	0.59	0.76	1.15	0.91	42 478
1974	0.47	1.37	0.79	0.83	33 448
1975	0.71	0.66	0.74	0.53	27 617

Table 5 Corrrelation of Z's (by year class) and fishing effort

Z	± m	Critical values of at P=0.05
Survey data:		
Arithmetical means	0.72 ± 0.16	0.81
Weighted values	0.63 ± 0.20	
Fishing data:		
Arithmetical means	0.05 ± 0.33	0.81
Weighted values	0.86 ± 0.08	