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On Reliability of Independent Silver Hake Abundance Indices in the Scotian Shelf Area

by

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ABSTRACT

The reliability of commercial fishery and research indices of hake abundance has been studied. The reserches were based on assumption, that statistically significant relation between independent indices series appears to be a reliability criterion for the latter. A statistically significant correlation was revealed between commercial fishery and research abundance indices for hake at age of 2 years old and between scientific (at age of 1 year old) and commercial fishery indices of the latter (at the age of 2 years old). The possible reason for variability of estimates presented are discussed. The need is stated to reject utilization of research and commercial fishery indices for all age groups fished in the analytical models and to restrict them only to those for age groups 1 and 2 respectively.

INTRODUCTION

The hake population discussed appears one of the most investigated one in the North-West Atlantic area and possibly in the world according to such factors as duration, regularity, methodical level and comprehensiveness of observations. In such conditions the choise of appropriate analytical method to assess hake stocks seems to be very easy. Actually, however, annual attempts of NAFO Scientific Council to provide steady and reliable retrospective estimates by means of various methods, including adaptive approach as the most advanced one (Gavaris, 1978), has failed to reach the results desired. The structure of the latter model includes separate and pooled abundance indices of Canadian trawling surveys and commercial catches per trawling hour. Since the reliability of other input data (total catch statistics, catches at age) within the period discussed (1977-1990) is considered to be sufficiently high the above mentioned abundance indices apparently appear suspicious. In this paper an attempt is made to highlight the situation developed to improve the state of silver hake population assessment.

MATERIAL AND METHODS

The information used in the paper covers the period from

1977 to 1991 inclusive. Standard catch per unit effort, abundance indices for Canadian July surveys differentiated by ages, and data of young fish trawling surveys annually carried out according to joint programme with Canadian scientists, were taken as indices characterizing hake abundance. (Waldron et al., 1992) The correlation analysis was used as a main research method with input data presented in Table 1. One or two asterisks under correlation coefficient value mean statistical significance level of 5% and 1% respectively.

RESEARCH RESULTS

The analysis presented is based on the assumption that statistically significant relation evidences the reliability of the above mentioned abundance indices. The results of calculation of correlation coefficients between CPUE and research indices (of Canadian July surveys) for age groups 2, 3 and 4 forming the bulk of fishery, are shown in Table 2. Exclusion of commercial indices for 1982, 1990 and 1991 from calculation in one version is caused by the fact that CPUE for 1982 appeared to be unreasonable high, and catches in 1990-1991 were anomally low and did not seem to reflect actual stock state. In the latter case the environmental conditions at the Scotian Shelf were anormal during fishery season. (Sigaev, 1991, 1992). The dynamics of several biological characteristics for silver hake differed significantly from that one in 1989 in the area, assigned for foreign fishery (Rikhter, 1991).

Data, shown in Table 2, suppose that CPUE and July abundance indices for fish of age 2 sufficiently precisely characterize hake stock state for the period discussed with three above mentioned years excluded. However, some doubt remains concerning the date rejection procedure. The latter seems to be rather subjective one due to the lack of clear, scientifically substantiated criteria of data exclusion for particular year. The residual value utilization as a reliability criterion seems sufficiently convincing from the mathematical point of view, but unfortunately does not explain sharp interannual variations of commercial and research abundance indices, which sometimes have opposite direction. Residual analysis could not explain environmental factors and biological state of hake effect on fish availability for fishery and research hauls during surveys (See "Discussion"). The additional information on the problem discussed is shown in Table 3. High relation between CPUE (age 2) and abundance indices for July surveys (age 1) seems to confirm the above supposition on reliability of CPUE values for fish at age 2 and hence of abundance indices for hake at age 1. If this conclusion is true we obtain criteria to judge on other indices correlation with the actual stock state.

The above conclusions may be illustrated with correlation coefficients, shown in Table 4.

Based on the data available we may suppose that abundance indices for July surveys from age 2 and CPUE from age 4 are not reliable characteristics of hake stock state.

As to the data, shown in Table 3, it should be noted that inspite of the apparent relation reveiled between estimates for O-group and other abundance indices for fish at age 1 (July surveys) and at age 2 (CPUE), statistically significant correlation levels could not be obtained most likely due to short series of observations (8 and 9 pairs of points respectively).

DISCUSSION

The results of correlation analysis define to some extent the conditions of independent abundance indices utilization in analytical models, but could not reveal the base for absolute preference of any index series. The lack of statistically significant relation evidenced only that one or both index series do not reflect the actual stock state. The availability of such relation suggests that values correlated are sufficiently reliable abundance indices for population. Actually reliability of both commercial and research indices are most likely varied by years.

Catches per unit effort do not always correspond to the stock size due to extremely restricted site of hake catch (about 10% of entire area). The fishery success within it strongly depends on distribution and behaviour peculiarities of fish concerned, which is in turn defined by environmental conditions within each year. Oceanographic factors seem to play a major role.

The above statements suppose that catch per unit effort may considerably vary by years even at similar stock size. It may be concluded that CPUE is unreliable hake abundance index, though some differences at ages may exist.

Now let us consider the data of Canadian surveys in July aimed mainly to assess stocks of such demersal species as cod, haddock and flownder, All species mentioned are spring spawners (Leim and Scott, 1966), and in July they are at the same biological stage (feeding), relatively evenly distributing over the survey area. The annual dynamics of adult hake biological state is somewhat different. The beginning of major hake spawning coinsides with survey period. In July dense spawning aggregations of hake are forming over restricted areas, which increases variability of trawl catches (Doubleday, 1991) and results in low reliability of abundance estimates. It is likely confirmed by high coefficients of variation in fish at age 3 and older in most cases (Waldron et al., 1989). Concerning one-year-old and partly two-year-old fishes, the latter are in the stage of feeding in July. It supposes that July surveys provide reliable abundance indices only for hake at age 1 and 2. Certainly some variations are likely in this case also, resulted, for example, from vertical distribution peculiarities of a particular fish cohort. As to adult hake it seems that July is not the best month to assess this part of population abundance. Taking in account spawning period, seasonal distribution of hake, weather conditions, etc., we may suppose October to be the most appropriate period for such researches. Certainly this statement needs a comprehensive scientific substantiation, including economical one, and could not be realised immediately.

Now we have the last series of independent abundance indices left for comments, that of juvenile hake trawling surveys, carried out according to the joint programme with Canadian scientists. Those surveys results are lacking of disadvantages, inherent in the indices discussed above. Qualitative relation between abundance estimates for O-group, one-year-old fish data from July surveys and CPUE (age 2) is apparently revealed. Nevertheless one specific disadvantage of juvenile fish surveys is that development of estimated generation abundance has not yet been finished in the survey period (October-November) (Sherstyukov, 1991) and a mortality rate during the subsequent period, caused, for example, by cannibalism, (Waldron, 1989) may be significant.

The results of researches suppose that the necessary condition of reliable estimates of hake stock in the Scotian Shelf area is an improvement of quality (reliability) of input information, which requires critical approach to appropriate input data utilization (abundance indices in the case discussed).

As a preliminary recommendation we may suggest to reject pooled or differentiated by all age-groups fished commercial (CPUE) and research (July surveys) abundance indices in analytical models, restricting with the appropriate values only for fishes at age of 2 and 1 year old respectively.

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Table 1 Data utilized in the correlation analysis

Year	CPUE Age 2	CPUE Age 3	CPUE Age 4	CPUE All groups (1-6)	Abundance indices for July surveys Age 1	Age 2	Age 3	Age 4	All groups (1-6)	Abundance indices for 0-group
1977	3.541	6.497	2.452	13.402	0.774	2.766	2.142	0.459	6.564	
1978	4.615	4.471	2.163	14.105	2.674	2.326	1.627	0.887	8.757	
1979	2.769	3.486	1.754	10.540	8.944	15.271	6.700	2.005	34.968	
1980	2.881	2.868	1.305	8.526	1.773	5.564	9.725	4.586	23.467	
1981	1.168	5.053	1.741	8.774	3.284	8.472	13.142	6.047	22.454	
1982	4.584	6.566	5.919	22.078	19.202	29.342	8.035	6.049	67.337	
1983	6.966	4.039	2.106	14.595	11.427	10.896	3.821	1.934	29.591	232.2
1984	2.595	11.717	4.695	23,719	18.897	7.037	20.872	3.793	53.028	43.4
1985	6.344	4.770	6.226	20.172	10.273	17.258	3.440	7.119	41.588	284.8
1986	4.802	15.657	5.747	31.878	55.260	8.432	7.062	2.262	75.052	198.0
1987	19.337	10.327	4.893	27.896	14.601	26.668	4.609	1.898	49.030	102.0
1988	3.734	15.776	2.333	23.599	6.974	8.951	8.146	1.671	27.709	204.8
1989	7.463	11.116	6.949	27.480	17.210	6.381	2.415	1.341	28.064	131.5
1990	9.245	6.301	1.818	18.242	11.709	12.595	4.233	1.302	30.448	187.4
1991	7.110	12.210	2.810	23.460	6.668	8.474	3.528	1.324	20.895	78.6

Table 2 Relation between CPUE and abundance indices for July surveys

Age	r: All years included	r: Excluding 1982, 1990 and 1981
2	0.52 *	0.75 **
3	0.16	0.21
4	0.25	0.10
All age groups	0.57 *	0.65 *

Table 3 Correlation coefficient matrix for CPUE and research abundance indices

	CPUE (age 2)	July surveys (age 1)	Young fish surveys (o-group)
CPUE (age 2)	1.000	0.897 *	0.688
July surveys (age 1)	0.897	1.000	0.704
Young fish surveys (0-group)	0.688	0.704	1.000

Table 4 Relation between abundance indices for various age groups of the same hake generations

Items	Age 1 and 2	Age 1 and 3	Age 2 and 3	Age 2 and 4
July surveyes	0.49	0.15		
CPUE			0.67 *	0.52