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Assessment of Stock Size and TAC of the Scotian (Div. 4VWX) Silver Hake for 1989

by

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INTRODUCTION

Though the knowledge of the silver hake population in 4VWX may be recognized as satisfactory, considerable difficulties have been faced with in the recent years in using analytical methods for assessment of its stock size. In 1987, however, these difficulties seem to have been coped with. In the present report an attempt is made to estimate the silver hake biomass and TAC for 1989 using the above-mentioned analytical methods.

MATERIALS AND METHODS

In 1987, the length-age sampling of silver hake was made, as usual, by the observers on board commercial ships during the period from May to July inclusive. Though, like in the previous years, the amount of collected materials markedly exceeded the minimum NAFO requirements (approximately 41.4 thous. of hake specimens), the Canadian data on the silver hake age distribution in the 1977-1986 catches, except for 1987 (Fanning et al., 1987), were used in the V.P.A. calculations. This was made to obtain estimates of higher precision. As is known, before 1987 the Canadian observers collected the materials almost on 50% of all foreign ships operating in the zone according to the International Observer Program (IOP) adopted in Canada. Certainly the collections of the Canadian observers considerably exceed those of the Soviet observers in volume and regional extension, for the Soviet observers usually work on two ships at most. No wonder that the differences

in silver hake age composition appear to be considerable between the Canadian and Soviet data. It is especially true for the fish at age 1, the proportion of which in the catches happens to be fairly high according to the IOP statistics.

Our knowledge on the silver hake age composition in 1987 was based only on the materials of the Soviet observers. The catch statistics was adopted from the NAFO Circular Letter 87/64. According to these data, the Soviet catch constituted 39.6 thous. tons in 1987. For preliminary calculations it was assumed that the total silver hake catch by all countries amounted to 60 thous.tons. The Soviet catches on age composition were converted to a supposed total catch value:

Age	1	2	3	4	5	6	7
Catch, mill. sp.	6.07	219.21	77.80	53.87	10.45	2.07	0.67
Catch, %	1.64	59.21	21.02	14.55	2.82	0.56	0.20
Mean weight, kg	0.440	0.117	0.187	0.262	0.384	0.459	0.652

Mean weight by age for the 1977-1986, standardized catches per unit effort, the fishing effort volume as well as the catch size by age group are adopted from the Canadian document (Fanning et al., 1987). According to the Soviet data, the silver hake older than 7 years old did not occur in the 1987 catches. For calculations the silver hake numbers at ages 8 and 9 were conventionally taken to be 0.01 mill. sp.

In the 1987 data, an extremely small abundance on the one-year-old fish in the catches can be noted, which can be attributed to inadequately representative initial materials. The NAFO Scientific Council will certainly have more complete and reliable information based on the IOP materials in June 1988.

Mean catch per unit effort and the extent of the fishing effort in 1987 with regard for the entire foreign fishery were approximately estimated at 3.03 tons/hour and 19776 fishing hours, respectively.

To forecast the TAC the data from the USSR-Canada surveys of the juvenile silver hake and the estimates of the one-year-old fish abundance from the V.P.A. were used. The partial recruitment

(PR) values for the preliminary calculations were adopted from the NAFO Scientific Council Report for 1987:

Age	1	2	3-9
PR	0.08	0.58	1.00

The next PR value was deduced according to the procedure suggested by the Canadian scientists (Waldron and Fanning, 1986). Terminal coefficients of the fishing mortality rate (F_t) between 0.10 and 0.30 at 0.05 intervals were determined using the retrospective values deduced from the V.P.A. analysis. For the oldest age group (9 years), the value of F was determined as the mean value of F at the age of 7 and 8; then the calculations were reiterated. The regression of the catches per unit effort against the biomass estimated by the V.P.A. was used for the V.P.A. tuning.

The analysis of the catch per recruit was made by the method of Thompson and Bell (1934) using the mean weight by age for 1977-1987 and mean PR values for the same period except for 1982.

STOCK ASSESSMENT

During the three recent years the silver hake stock size has been estimated by the Soviet scientists using the natural mortality rate (M) changing with age (Noskov, 1985, 1986, 1987). However, as they lacked a reliable scientific foundation, the Scientific Council rejected them. It should be mentioned that the latter recognises and accentuates the importance of studying the problem of the change of the natural mortality rate with age. However in the situation that has taken place now it seems to be reasonable to revert to utilization of the natural mortality rate, which is permanent for all ages. Till now the Scientific Council used the value of M = 0.4 in its work on assessment of the silver hake stock size (Terre and Mari, 1978). The specified value of M used in the present paper (Rikhter, 1988) appears to be somewhat higher (0.5).

For the V.P.A. tuning the estimates of both fished and total silver hake biomass for the 1977 to 1987 period, except for the year of 1982, were used (tables 1,2). The results are presented in table 3.

In this case the intersection value and correlation factor are the criteria of reality of F_t. The data suggest that when the total biomass is used the priority should be given to F_t= 0.20. The regression of catches per unit effort to the fished biomass does not give such an obvious picture. The highest correlation factor being obtained at F_t= 0.20, the minimum intersection value is produced at F_t= 0.30. Taking into account the fact that correlation factors appeared to be considerably lower in the case related to the fished biomass, it was decided to adopt the value of 0.20 for the terminal F for 1987. Retrospective estimates of fishing mortality rates, abundance and biomass at the given F_t value are shown in tables 4,5 and 6. The data from table 4 were used for calculating PR values for 1987 according to the method of Waldron, Fanning (1986). The calculations covered the 1977-1986 period excluding 1982. Mean PR values were as follows:

Age	1	2	3-9
PR	0.040	0.302	1.000

Another calculation of the V.P.A. with new PR values was made (tables 7,8,9). The resultant values appeared to be unchanged.

In table 8 a very large abundance of the 1985 year class can be noted. Certainly the data from the juvenile and adult silver hake surveys confirm their numerical strength. And still it is doubtful that it could have so much exceeded that of all preceeding year classes. Obviously the fishing mortality rate of the one-year-old fish in 1986 calculated with regard for the PR values was below the actual one.

The analysis of the catch per recruit was made using the above-mentioned PR, weight by age averaged for 1977-1987 and M = 0.50. The computation results are shown below:

Fishing mortality	Catch per recruit, kg
0.1	0.018
0.2	0.029
0.3	0.037
0.4	0.042
0.5	0.046
0.6	0.049
$F_{0.1}$ → 0.68	0.051
0.7	0.052
0.8	0.053
0.9	0.055
1.0	0.056

RECRUITMENT ASSESSMENT

The estimates of the youngs of the year abundance based on the data from the fry surveys that are carried out annually according to the joint USSR-Canada program give the initial idea of the silver hake year class abundance.

Year class	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Abundance (10^7 sp.)	48	12	5	110	2	34	11	62	32	20

The qualitative analysis shows a good agreement between the appearance of strong year classes and subsequent increase of the commercial biomass. However we have failed yet to obtain a quantitative relationship of the youngs of the year and one-year-old fish abundance (recruitment) being determined by the V.P.A., which can be evidently explained by a too short observation series. Another attempt has been made in the given case. In the considered observation series the estimates of the youngs of the year abundance for 1981 and 1982 are obviously far from actual abundance of these year classes, which was later confirmed by the data of the Canadian trawling surveys and by the catches per unit effort from the commercial ships. Nothing remains but to suggest that the peculiarities of the distribution and behaviour of the hake youngs of the year in 1981 and 1982 presented from accurate assessment of their abundance in those years. In this connection it has been decided

to omit the results of the fry surveys in 1981-1982 from the analysis.

The parameters of the regression equation were calculated for the following observation series:

Year class	1978	1979	1980	1983	1984	1985
Abundance of youngs of the year (10^7sp.)	48	12	5	34	11	62
Abundance of one year old fish *mill.sp.*	1203.60	780.51	1144.45	2757.38	1661.63	8024.25

Certainly, before 1980, the survey methods were somewhat different. Trawlings were only made in near-bottom layer. Naturally the question of competence of using the 1978 and 1979 data arises. However the comparison between the latter and the corresponding data on the one year old fish abundance in 1979 and 1980 (Waldron, Fanning, 1987) as well as the V.P.A. analysis (table 8) reveals an agreement between all considered values. It is obvious that abundance indices gained before 1980 generally reflect the actual level of abundance of considered year classes and can be used in the analysis.

Calculation results:

Correlation factor - 0.74

$y = 68.61 + x55.11$

where y is silver hake abundance at age 1 (mill. sp.)

x is abundance index of youngs of the year (10^7sp.)

The obtained data are suggestive of the availability of a real correlation between the considered characteristics, though the calculated value of *r* appeared to be below the critical one. The latter fact can be most likely attributed to a too short observation series (n=6).

As it has already been mentioned, the abundance of the one year old fish of the 1986 year class determined by the V.P.A. is low. From the indices of the youngs of the year abundance and the calculated dependence the 1986 year class size for the TAC calculation was estimated by the equation at 2890.63 mill. sp. The abundance of one year olds of the 1987 year class deduced from the equation constituted 1827.31 mill. sp. The 1988 year class size

was estimated as the geometrical mean of the one year old fish abundance for the period from 1977 to 1986 inclusive, i.e. 1569.64 mill. sp.

Forecasted TAC

The initial data used for the TAC assessment for 1989 were as follows:

Age	Abundance in 1987, mill. sp.	Mean weight, kg	PR
1	2890.63	0.055	0.040
2	4771.55	0.141	0.302
3	540.91	0.200	1.000
4	374.52	0.255	1.000
5	72.63	0.313	1.000
6	14.41	0.376	1.000
7	4.63	0.495	1.000
8	0.07	0.617	1.000
9	0.07	0.790	1.000

Four calculation versions were tried:

1) The fishing mortality in 1988 and 1989 will maintain at the level $F_{0.1}$= 0.68.

2) The 1988 catch will be 167 thous. tons, i.e. at the level of the TAC recommended by the Scientific Council, and in 1989 it will be at the level of $F_{0.1}$.

3) The 1988 catch will be 83 thous. tons, i.e. the maximum size will be reached since introduction of the 200-mile zone in 1977. In 1989 the fishing mortality will be at the level of $F_{0.1}$.

4) The fishing mortality in 1988 and 1989 will remain at the 1987 level.

The versions of lower fishing mortalities in 1989 were not considered, as the results would deliberately suggest under-exploitation of the stock which is in a very good state.

Forecasted stock size and TAC are shown below:

Versions	1987 stock, thous. t	1988		1989	
		Stock size, thous. t	TAC thous. t	Stock size, thous. t	TAC thous. t
1	922.3	956.6	300.2	640.5	197.8
2	922.3	956.6	167.0	777.1	251.9
3	922.3	956.6	83.0	867.3	287.6
4	922.3	956.6	106.6	843.4	99.2

As is evident from the above data, the 1988 catch in the first version considerably exceeds the TAC recommended by the Scientific Council and, consequently, should be rejected as unrealistic. At the same time the experience of fishing under the 200-mile zone conditions shows that actual catches markedly fall behind the levels of recommended TACs. No prerequisites for quota exemption can be expected in 1988. Therefore the second version has also to be rejected. As to the third version, the catch at the 83 thous. ton level at the TAC of 167 thous. tons is quite attainable at the existing and even extra limitations relative to the foreign fishery for the silver hake in the Canadian zone.

In this case however the 1986 TAC associated with the fishing mortality of $F_{0.1}$ will constitute 288 thous. tons. This value is likely to be overestimated and is to a considerable extent stipulated by the super strong 1985 year class, the actual size of which may appear to be much lower (say, at the level of the 1983 year class or slightly higher). Proceeding from these speculations we may expect that the real TAC for 1989 will be approximately 200 thous. tons. On the whole, digressing from specific estimates of the biomass and TAC, it should be said that, as the 1989 fishery will be based on two strong 1986 and 1985 year classes, the stock size in the considered year will evidently maintain at a high level of 1986-1988.

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Table 1 Total silver hake biomass at different F_t, thous. tons

Year	F_t				
	0.10	0.15	0.20	0.25	0.30
1977	317.7	310.5	306.7	304.5	302.9
1978	241.4	240.1	239.4	239.0	238.7
1979	289.9	288.8	288.2	287.8	287.5
1980	263.0	261.8	261.0	258.8	258.2
1981	247.7	244.4	242.2	237.5	236.1
1983	378.2	346.6	330.3	318.4	311.5
1984	622.4	517.0	464.0	430.6	409.1
1985	839.0	639.9	540.1	479.1	439.0
1986	1184.5	836.6	662.6	558.2	488.7
1987	1072.5	727.0	554.3	450.8	381.9

Table 2 Fished silver hake biomass at different F_t, thous. tons

Year	F_t				
	0.10	0.15	0.20	0.25	0.30
1977	198.1	191.3	187.6	185.5	184.0
1978	172.6	171.4	171.0	170.6	170.4
1979	143.7	142.7	142.2	141.8	141.6
1980	160.4	159.6	159.3	159.0	158.8
1981	144.1	143.4	142.9	142.8	142.6
1983	211.3	202.5	197.8	190.9	188.4
1984	230.3	216.3	209.1	203.2	200.1
1985	344.0	286.5	257.8	239.5	228.0
1986	502.4	371.0	305.3	251.7	220.5
1987	878.2	596.0	454.0	370.5	314.2

Table 3 Results of regression of catches per unit effort against biomass estimated by the V.P.A.

F_t	Total biomass			Fished biomass		
	slope	Intersection	r	slope	Intersection	r
0.10	0.002	0.939	0.89	0.003	1.400	0.66
0.15	0.004	0.512	0.90	0.004	1.086	0.68
0.20	0.006	0.031	0.91	0.007	0.704	0.69
0.25	0.008	-0.464	0.90	0.009	0.336	0.66
0.30	0.009	-0.937	0.88	0.012	-0.080	0.64

Table 4 Fishing mortality rates for silver hake at F_t= 0.20 and preset PR values

Age	Year										
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.0028	0.0348	0.0103	0.0103	0.0017	0.0140	0.0034	0.0467	0.0297	0.0370	0.0160
2	0.0992	0.2171	0.1033	0.1121	0.0543	0.0991	0.1068	0.0706	0.1494	0.0926	0.1160
3	0.3385	0.4303	0.3601	0.3582	0.4374	0.3730	0.1875	0.5199	0.2228	0.3003	0.2000
4	0.2957	0.4500	0.6099	0.4618	0.4051	0.7588	0.3791	0.6242	0.7620	0.5396	0.2000
5	0.1996	0.4630	1.0049	0.6074	0.4851	1.2672	0.4667	0.7088	0.6115	0.9237	0.2000
6	0.1718	0.5817	1.6574	0.9090	0.6896	0.9969	0.7892	0.5187	1.4729	0.9859	0.2000
7	0.0636	0.6672	1.3721	1.2212	0.3214	1.5880	0.4636	0.6036	1.1673	10.2685	0.2000
8	0.2266	0.5812	1.7331	0.4173	0.3853	2.2737	5.5538	0.1633	1.8080	2.2880	0.2000
9	0.0810	0.3716	1.2888	0.5274	0.1660	1.2732	2.7239	0.2062	0.8856	6.2782	0.2000

Table 5 Silver hake abundance, mill. sp., at F_t=0.20 and preset PR values

Age	Year										
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	968.42	1064.42	1203.60	780.51	1144.45	1798.06	1238.60	2757.38	1661.63	4330.44	486.03[1)]
2	583.20	585.73	623.51	722.57	468.57	692.95	1075.40	748.68	1596.11	978.37	2531.21
3	341.41	320.31	285.92	341.08	391.79	269.18	380.62	586.20	423.15	833.72	540.91
4	144.95	147.61	126.34	120.98	144.59	153.45	112.44	191.38	211.41	205.40	374.52
5	48.63	65.41	57.09	41.64	46.24	58.49	43.58	46.68	62.18	59.85	72.63
6	16.02	24.16	24.97	12.68	13.76	17.27	9.99	16.57	13.94	20.46	14.41
7	9.94	8.18	8.19	2.89	3.10	4.19	3.86	2.75	5.98	2.26	4.63
8	3.50	5.66	2.55	1.26	0.52	1.36	0.52	1.47	0.91	1.13	0.07
9	8.50	1.69	1.92	0.27	0.50	0.21	0.09	0.02	0.076	0.09	0.07

1) Uncorrected

Table 6 Silver hake biomass, thous. tons, at F_t=0.20 and preset PR values

Age	Year										
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987[1)]
1	60.04	52.16	73.42	32.00	41.20	100.69	66.88	173.71	127.95	268.49	21.39
2	85.73	64.43	96.02	101.88	67.01	101.86	139.80	110.06	248.99	155.56	296.15
3	71.70	55.73	57.18	72.65	75.62	60.03	77.27	111.38	87.17	167.58	101.15
4	42.03	33.36	30.95	33.87	35.86	44.35	27.66	47.65	50.74	47.04	98.12
5	19.30	18.51	16.27	13.41	14.70	19.24	13.20	12.98	17.16	16.28	27.89
6	8.27	7.95	8.59	4.64	5.08	6.89	3.62	6.07	4.54	6.14	6.62
7	6.63	3.13	3.37	1.50	2.08	2.01	1.50	1.25	2.50	0.91	3.02
8	3.77	2.82	1.32	0.76	0.28	0.79	0.34	0.88	0.55	0.55	0.00
9.	9.25	1.33	1.06	0.24	0.40	0.20	0.07	0.02	0.48	0.06	0.00

1) Uncorrected

Table 7 Fishing mortality rates for silver hake at F_t = 0.20 and preset PR values

Age	Year										
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.0028	0.0348	0.0103	0.0103	0.0017	0.0140	0.0034	0.0467	0.0297	0.0198	0.0080
2	0.0992	0.2171	0.1033	0.1121	0.0543	0.0991	0.1068	0.0706	0.1494	0.0926	0.0600
3	0.3385	0.4303	0.3601	0.3582	0.4374	0.3730	0.1875	0.5199	0.2228	0.3003	0.2000
4	0.2957	0.4500	0.6099	0.4618	0.4051	0.7588	0.3791	0.6242	0.7620	0.5396	0.2000
5	0.1996	0.4630	1.0049	0.6074	0.4851	1.2672	0.4667	0.7088	0.6115	0.9237	0.2000
6	0.1718	0.5817	1.6514	0.9090	0.6896	0.9969	0.7892	0.5187	1.4729	0.9859	0.2000
7	0.0636	0.6672	1.3721	1.2212	0.3214	1.5880	0.4636	0.6036	1.1673	10.2685	0.2000
8	0.2266	0.5812	1.7331	0.4173	0.3853	2.2737	5.5538	0.1633	1.8080	2.2880	0.2000
9	0.0810	0.3716	1.2888	0.5274	0.1660	1.2732	2.7239	0.2062	0.8856	6.2782	0.2000

Table 8 Silver hake abundance at F_t= 0.20 and calculated PR values

Age	Year										
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	968.42	1064.42	1203.60	780.51	1144.45	1798.06	1238.60	2757.38	1661.63	8024.25	968.52
2	583.20	585.73	623.51	722.57	468.57	692.95	1075.40	748.68	1596.11	978.37	4771.55
3	341.41	320.31	285.92	341.08	391.79	269.18	380.62	586.20	423.15	833.72	540.91
4	144.95	147.61	126.34	120.98	144.59	153.45	112.44	191.38	211.41	205.40	374.52
5	48.63	65.41	57.09	41.64	46.24	58.49	43.58	46.68	62.18	59.85	72.63
6	16.02	24.16	24.97	12.68	13.76	17.27	9.99	16.57	13.94	20.46	14.41
7	9.94	8.18	8.19	2.89	3.10	4.19	3.86	2.75	5.98	2.26	4.63
8	3.50	5.66	2.55	1.26	0.52	1.36	0.52	1.47	0.91	1.13	0.07
9	8.50	1.69	1.92	0.27	0.50	0.21	0.09	0.02	0.76	0.09	0.07

Table 9 Silver hake biomass, thous. tons, at F_t= 0.20 and calculated PR values

Age	Year										
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	60.04	52.16	73.42	32.00	41.20	100.69	66.88	173.71	127.95	497.50	42.61
2	85.73	64.43	96.02	101.88	67.01	101.86	139.80	110.06	248.99	155.56	558.27
3	71.70	55.73	57.18	72.65	75.62	60.03	77.27	111.38	87.17	167.58	101.15
4	42.03	33.36	30.95	33.87	35.86	44.35	27.66	47.65	50.74	47.04	98.12
5	19.30	18.51	16.27	13.41	14.70	19.24	13.20	12.98	17.16	16.28	27.89
6	8.27	7.95	8.59	4.64	5.08	6.89	3.62	6.07	4.54	6.14	6.62
7	6.63	3.13	3.37	1.50	2.08	2.01	1.50	1.25	2.50	0.91	3.02
8	3.77	2.82	1.32	0.76	0.28	0.79	0.34	0.88	0.55	0.55	0.00
9	9.25	1.33	1.06	0.24	0.40	0.20	0.07	0.02	0.48	0.06	0.00