

Northwest Atlantic



Fisheries Organization

Serial No. N1177

NAFO SCR Doc. 86/60

SCIENTIFIC COUNCIL MEETING - JUNE 1986

Assessment of the Silver Hake (Merluccius bilinearis) Stocks
and Allowable Catch on the Scotian Shelf (Div. 4VWX) in 1987

by

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Abstract

In 1985 silver hake catches amounted to 56,3 th. tons against the established TAC of 100 thous. tons. Main portions of the catches were taken by the USSR and Cuba. Due to dense concentrations of silver hake in the areas open for foreign fishing, the fishing conditions were very favourable. The quota of 56.6 thous. tons allocated for the USSR was almost utilized. Assuming the silver hake catches to be more than 80 thous. tons based on estimates of stock size derived from VPA and recruitment from the results of trawl surveys on 0-group abundance in 1985, the exploitable stock is estimated at 1 million tons for 1987, and given the optimum fishing mortality total catch of 200 thous. tons can be recommended for 1987.

Materials and Methods

As in previous papers, the assessment of stock size was made using the VPA method. For this, massive measurements of silver hake were made, and otolith samples for ageing were collected by the observers on a regular basis aboard the USSR fishing vessels. The ageing method was preliminarily agreed with Canadian scientists. Catch statistics for 1985 were extracted from NAFO Secretariat monthly reports. Instantaneous total, natural and fishing mortality rates by age were determined from age composition of catches per effort and by the method of random search from the data over 1978-1985. The recruitment at age 2 in 1986

and 1987 was estimated from the results of trawl survey on 0-group abundance in 1984 and 1985.

Results

a. State of fishery

All countries silver hake catches in the Nova Scotia area made up 75.4 thous. tons in 1985 against the TAC of 100 thous. tons recommended by the NAFO Scientific Council. Total catch appeared to be 24.6 thous. tons (24.6%) below the TAC because Canadian allocation was not caught as in previous years. The majority of the catch was taken by the USSR (table 1). Fishing conditions in the area open for foreign fishery in spring and summer 1985 were very favourable. Due to good state of stocks and favourable hydrological conditions silver hake aggregations were dense and stable. Average catch per fishing day by the trawlers of BMRT (large freezer trawler) class amounted to 38.9 tons in 1985 compared to only 20.9 tons in 1980.

b. Age composition of catches

Fish aged 2, 3 and 4 predominated in age composition of the Scotian silver hake catches. Mean age ranged between 2.6 in 1976 to 3.6 in 1982 depending on the ratio of abundance of these three year classes (table 2).

Table 3 presents total catches in numbers over the 1975 to 1985 period. For assessment of stock and catch sizes for 1986 and 1987 the data on mean weight by age group for 1985 were used. (table 4).

c. Calculation of mortality rates

Total instantaneous mortality rates were calculated from the data on age composition of the catches per hauling hour of the BMRT class ships for a number of years separately by males and females and by both sexes (tables 5, 6 and 7).

Males appear to be fully exploited at age 3 on the average, and they are encountered in quantity in the catches up to 5 years. Total mortality rate averaged to 0.46 at age 3 to 4 years, to 2.00 at age 4 to 5 years and to 2.27 at age 5 to 6 years over the 1978-1985 period (table 5).

Females appear to be exploited in quantity one year later than males, i.e. at age 4. Total mortality rate on females constituted 0.69 at age 4 to 5 and 1.30 at age 5 to 6 (table 6). Females at age 7-8 and older are encountered in the catches. Mortality rate on both sexes averaged to 0.24 at age 3-4, to 1.13 at age 4-5 and to 1.53 at age 6-7.

On this basis, it may be concluded that mass loss of males occurs at age 3 to 4, and females at age 4 to 5. This may be explained by relatively high natural mortality during this period of their life. So, males attain massive sexual maturity at age 3, and females at age 4. From this it may be concluded that silver hake die in quantity after spawning, i.e. the species is assumed to belong to oligocyclic species (Noskov, 1985). To calculate natural mortality rates by age the computer analysis was made by the method of random search using the data on age composition of the catches per 100 hauling hours of BMRT class vessels and total fishing effort for 1977-1984 with the extreme values of natural mortality rate set at 0.10-1.50, and of fishing mortality at 0.01-2.00. The results of this analysis indicated that natural mortality rates were 1.16 ± 0.01 on 4 year-olds and 1.30 ± 0.02 on 5 year-olds. The results for other age groups appeared to be unreliable. For further analysis natural mortality rate was taken as 0.20 on 2 year-olds, as 0.50 on 3 year-olds and as 1.00 on 4 year-olds and older.

Terminal (start) fishing mortality rate was determined by Dorovskikh using a number of methods for tuning VPA among which are estimating the long-term average value for a given age group (Babayán et al., 1984), gamma-method, gamma modified method (Pope, Shepherd, 1983). For evaluation of a criterion for adequacy of methods, an attempt was made to use the value of correlation coefficient between the fishing mortality coefficient for a given age group over a number of years of fishing and standardized fishing effort, whereas the value of correlation coefficient between logarithms of abundance of a given age group and relative index of catch size per effort (or logarithm of this value, accordingly) was used for gamma-method and gamma-modified method. From all calculations the value of chosen criterion appeared to be not

high (about 0.4). Therefore, the preference cannot be given to any methods applied. So, on this basis, possible terminal F_t was found to be 0.01 to 0.05 for two year-olds, 0.03 to 0.20 for three year-olds, 0.15 to 0.35 for four year-olds and 0.15 to 0.35 for five year-olds and older. The calculations of several variants with different start values of fishing mortality coefficient indicated that the most real values of this coefficient may be assumed to be 0.05 for two year-olds, 0.10 for three year-olds, 0.15 for four year-olds, 0.25 for five year-olds and older (tables 8 and 9).

This option is mainly explained by the fact that with such values the abundance of the 1981 year-class is recovering at the level of strong year-class compared to the other year-classes which is confirmed by silver hake fingerling abundance indices estimated from the results of juvenile trawl survey for the 1978-1985 period and relatively high proportion of this year-class in the catches in 1983-1985.

The abundance of two year-olds for 1985-1987 was estimated from the results of trawl surveys of 0-group abundance conducted in October and November since 1978 (table 10). The abundance of the 1983 year-class at age 2 in 1985 is estimated to be at the average level of $2\,500 \cdot 10^6$ sp., and it will be $2\,000 \cdot 10^6$ in 1986 and $3\,000 \cdot 10^6$ in 1987.

d. Assessment of stocks and catches in 1985-1987

The results of VPA are given in table 9. As is evident from this table, the stock of silver hake at age 2 and older constituted 989 thous. tons in 1985 and appeared to be higher than in previous years. The assessments of stock and catches for 1986 and 1987 are given in table 11. It is supposed that the 1986 catch will be at the 1985 level and constitute no more than 80 thous. tons of the recommended TAC of 100 thous. tons. In this case, fishing mortality rate would be 0.30 on 5 year-olds and older, and 0.20, 0.15, 0.05 on 4, 3 and 2 year-olds respectively.

The stock size will be 1000 thous. tons for 1987, and given the optimum fishing mortality (ICNAF Res. Doc. 76/VI/57 and 76/XII/157) total catch of 200 thous. tons can be recommended.

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Table 1 Silver hake catches (thous. tons) in the Nova Scotia area in 1975-1985

Year	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
TAC	120	100	70	80	70	90	80	80	80	100	100
Total catch	116	97	37	48	52	45	41	60	36	74	75
USSR catch	113	81	33	44	45	41	40	47	27	57	56

Table 2 Age composition (%) of the Scotian silver hake catches in 1975-1985

Age, years	Year										
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	4.8	8.3	2.7	0.5	6.9	1.4	0.7	4.9	1.4	5.0	5.4
2	13.6	45.2	8.9	18.5	24.5	16.8	9.9	14.9	42.6	10.1	33.7
3	39.7	30.0	44.1	37.5	37.1	36.2	42.6	24.1	27.0	38.6	29.9
4	29.8	11.0	35.9	32.8	21.6	32.4	33.0	37.6	20.6	33.1	21.8
5	8.7	4.4	7.1	8.9	7.9	9.6	10.3	12.8	5.8	10.5	7.7
6	2.1	0.7	1.0	1.2	1.4	2.2	2.6	4.1	1.9	2.0	1.2
7	1.0	0.3	0.3	0.4	0.5	0.6	0.7	1.1	0.5	0.6	0.3
8	0.2	0.1	+	0.2	0.1	0.5	0.1	0.4	0.1	0.1	+
9	0.1	+	+	+	+	0.2	0.1	0.1	0.1	+	+
10	-	-	-	+	-	0.1	+	+	-	-	-
Mean ages, years	3.4	2.6	3.4	3.4	3.1	3.4	3.5	3.6	3.0	3.4	3.0
Fishing gear	trawl 815 hake	trawl 815 hake	trawl 815, hake	trawl 815, hake	trawl 815 hake	trawl 815, hake	trawl 815 hake	trawl 815 hake	trawl 815, hake	trawl 815, hake	trawl 815, hake
Mesh size, mm	60	60	60	60	60	60	60	60	60	60	60

Table 3 Scotian silver hake catches (10⁶ sp.) in 1975-1985

Age	Year										
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	110	299	14	43	58	29	14	27	67	37	100
3	227	194	71	67	76	65	74	50	47	137	116
4	157	64	58	59	53	60	59	89	36	117	89
5	45	23	12	19	22	17	18	27	13	38	36
6	11	4	2	4	4	4	5	10	4	7	5
7	5	2	0.3	1	1	1	1	2	1	2	1
8	2	0	0.1	0.7	0.2	1	0.4	1	0.4	0.3	0.1
Total	557	586	157.4	193.7	214.2	148	171.4	206	168.4	338.3	347.1
Thous. tons	112.6	81.6	33.3	44.4	45.1	41.0	40.2	45.8	27.4	55.7	56.3

Table 4 Mean weight (g) of Scotian silver hake by age groups in 1980-1985

Year	Age, years									
	1	2	3	4	5	6	7	8	9	10
1980	39	123	190	250	360	452	640	810	1236	1536
1981	47	112	171	229	329	406	564	862	1214	1501
1982	43	124	200	267	380	431	640	729	1087	1538
1983	44	136	188	246	362	476	588	848	1137	-
1984	44	110	156	207	307	392	454	709	874	-
1985	54	131	189	253	367	472	633	813	1178	1700

Table 5 Total mortality of silver hake males by catch per hauling hour by BMRT in 1978-1985

Years	Age						
	1-2	2-3	3-4	4-5	5-6	6-7	7-8
1978-1979	-3.00	-0.47	0.52	1.80	1.10	-	-
1979-1980	-1.53	0.52	0.97	2.48	2.97	-	-
1980-1981	-3.14	-1.53	0.10	1.94	0.43	0.69	-
1981-1982	-3.66	-1.47	-0.48	0.47	0.61	-	-
1982-1983	-1.60	-0.20	1.22	3.42	4.83	-	-
1983-1984	-2.92	-0.26	-0.36	1.00	-	-	-
1984-1985	-2.23	-0.68	1.23	2.92	3.68	-	-
Mean							
1978-1985	-2.58	-0.58	0.46	2.00	2.27	-	-

Table 6 Total mortality of silver hake females by catch per hauling hour by BMRT in 1978-1985

Years	Age						
	1-2	2-3	3-4	4-5	5-6	6-7	7-8
1978-1979	-2.17	-1.16	-0.34	0.72	1.50	1.85	2.73
1979-1980	-0.59	0.37	0.48	1.07	1.36	1.34	-0.14
1980-1981	-0.96	-1.33	-0.89	0.40	0.91	0.73	0.90
1981-1982	-3.63	-2.09	-0.85	-0.09	-0.12	-0.28	-0.59
1982-1983	-2.08	-0.47	-0.30	1.55	2.33	2.56	2.76
1983-1984	-2.12	-0.07	-0.93	0.01	0.73	0.57	1.49
1984-1985	-1.33	-1.15	0.50	1.18	2.41	1.89	3.14
Mean							
1978-1985	-1.84	-0.84	-0.33	0.69	1.30	1.24	1.47

Table 7 Total mortality (Z) of silver hake males and females by catch per hauling hour by BMRT in 1977-1985

Years	Age						
	1-2	2-3	3-4	4-5	5-6	6-7	7-8
1977-1978	-4.44	-1.16	1.20	1.99	1.84	0.56	-0.32
1978-1979	-2.43	-0.96	0.10	0.89	1.85	2.10	2.77
1979-1980	-1.21	0.34	0.79	1.35	1.59	1.14	-0.48
1980-1981	-2.40	-1.45	-0.38	0.70	0.84	0.67	0.78
1981-1982	-3.65	-1.59	-0.62	0.10	-0.07	-0.10	-0.55
1982-1983	-1.92	-0.44	0.43	1.93	2.45	2.40	2.45
1983-1984	-2.85	-0.09	-0.44	0.45	1.16	0.77	1.70
1984-1985	-1.53	-0.82	0.86	1.58	2.56	1.88	3.14
Mean							
1977-1985	-2.55	-0.77	0.24	1.13	1.53	1.18	1.19

Table 8 Fishing mortality rates (F) for the Scotian silver hake

Age	Years										
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	0.10	0.21	0.02	0.05	0.08	0.03	0.01	0.02	0.03	0.02	0.05
3	0.29	0.32	0.08	0.11	0.13	0.13	0.12	0.08	0.04	0.10	0.10
4	0.71	0.21	0.26	0.15	0.21	0.25	0.30	0.36	0.13	0.23	0.15
5	0.46	0.34	0.12	0.30	0.18	0.22	0.25	0.61	0.19	0.47	0.25
6	0.84	0.15	0.14	0.12	0.22	0.11	0.22	0.58	0.33	0.36	0.25
7	0.25	0.90	0.03	0.42	0.08	0.17	0.09	0.41	0.24	0.10	0.25
8	0.25	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

Table 9 Stock size (10^6 sp.) of the Scotian silver hake in 1975 - 1985

Age	Years										
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	1208	1753	1010	1032	865	1055	1041	1847	2306	1933	2500
3	1143	890	1166	814	806	656	838	840	1488	1827	1549
4	465	520	392	653	442	430	348	451	472	867	1003
5	187	84	153	111	206	132	124	95	116	153	252
6	30	43	18	50	30	63	39	35	19	35	35
7	37	5	14	6	16	9	21	11	7	5	9
8	12	0	1	5	1	6	3	7	3	2	1
Total	3082	3295	2754	2671	2366	2351	2414	3286	4411	4822	5349
Thous. tons	502	484	436	436	396	381	382	481	632	742	989

Table 10 Abundance of 0-group silver hake (10^7 sp.)
from results of trawl surveys, 1978-1985

Year	1978	1979	1980	1981	1982	1983	1984	1985
Abundance	48	12	5	110	2	34	11	62

