NOT TO BE CITED WITHOUT PRIOR
REFERENCE TO THE AUTHOR(S)

Northwest Atlantic Fisheries Organization

Serial No. N2083 NAFO SCR Doc. 92/35

SCIENTIFIC COUNCIL MEETING - JUNE 1992

On Relationship Between Silver Hake Weight Growth and Abundance of Fishery Population on the Nova Scotian Shelf

by

V. A. Rikhter and V. I. Vinogradov

Atlantic Scientific Research Institute of Marine Fisheries
and Oceanography (AtlantNIRO)
5 Dm. Donskoy Str., 236000, Kaliningrad, Russia

ABSTRACT

Some biological characteristics, such as growth rate and condition can, possibly, serve as indirect indices of the fishery stock state. To check this correlation analysis using data on the Scotian Shelf silver hake was made. Such growth index as mean weight by age group was proved to vary depending on the fishery stock abundance. In some cases statistically reliable negative correlation between hake weight and commercial (standardized catches-per-unit-effort) and research (data of Canadian July bottom species survey) indices was obtained. However some uncertainties don't allow to draw an undisputed conclusion concerning relationship between silver hake growth and abundance.

INTRODUCTION

In the history of the Scotian Shelf silver hake fishery and investigation cases of abundance increase and decrease occurred repeatedly. Relevant fishery and research vessel indices prove this. However, estimates of stock size and variances between the highest and lowest biomass levels sometimes seem not to be quite reliable. Meanwhile, it can be assumed, that sharp variations of the population abundance are connected with food availability-dependent biological characteristics. Growth rate and condition are meant primarily in this respect. This paper provides an attempt to establish relation of abundance to relevant biological characteristics.

MATERIALS AND METHODS

Data collected from 1977 to 1990 inclusive were used. Standardized catches per unit of effort (CPUE) and abundance indices of Canadian July surveys by age group (Waldron et al., 1991) were used to characterize hake abundance. Mean weight of hake for the years 1977-88 (Waldron et al., 1989) and 1989-90 (taken from AtlantNIRO) as well as averaged values for all age-groups were used as growth indices. Preference was given to weight due to close relation of the latter to food availability. Weight of the specimens having the similar length is known to be quite different just for this reason.

Relative condition, i. e. relation of specimen weight to the mean multiannual weight value of fish of the relevant length taken for 100% (Noskov, 1956) was chosen to estimate food availability situation during the previous years. Positive weight deviation from the average is assigned condition factor exceeding 100%. Negate weight deviation should be considered as condition less than 100%.

Correlation analysis was used as a basic method of studies. Initial data are presented in Table 1. Signs * or ** under correlation coefficient show statistical significance at 5 and 1% levels. CPUE values for 1982 and 1990 were rejected from the calculations of relation between weight and CPUE as they didn't reflect the actual state of hake stock in those years. Number of specimens collected in July and used to calculate mean weight by size group for all years is shown below:

Length, cm	26-27	28-29	30-31	32-33	34-35
Number of specimens	1164	1480	1861	2220	2649

RESULTS

Subsequent analyses were based on the hypothesis assuming feedback between population abundance and fish weight. Relevant correlation coefficients obtained for age-groups 2,3 and 4, which make the bulk of the catches are presented in Table 2.

The results obtained turned out to be rather contradictory. If in one case the hypothesis suggested got a certain proof, in the other one correlation between indices discussed was not found. So, the question appeares regarding reliability of the abundance indices used in the study. This problem seems to be studied separately. Within the present paper we tried to reveal coincidence rate between CPUE and research vessel indices, assuming that statistically significant correlation proves reliability of the indices mentioned (Table 3). One can see from data presented that reliable correlation with probability of 99% is available for the fish aged 2 and 1978 and 1981 year-classes. If to compare results obtained with the previous data one can suggest that CPUE is a reliable abundance index for the specimens aged 2, excluding 1982 and 1990 year-classes, and the relationship between hake weight and abundance is an actual factor.

Correlation coefficients were also calculated between mean weight values and hake abundance indices, which characterize fishery part of the population since age-group 1:

Characteristics		r
Weight and survey indices	-	0.22
Weight and CPUE	-	0.73

Using data for all age groups their relationship in the catch should be taken into account. Thus, it was decided to check on the following hypotheses:

a) there is a feedback between abundance of fish at age 2 (in per cent) and mean weight of silver hake in the catch;

b) there is a direct relationship between abundance of fish at age 3 and 4 (in per cent) and mean weight of silver hake in the catch.

The results of the relevant calculations are presented below:

Characteristics		r
Weight and abundance of fish at age 2 (%) (1977-1990)	-	0.51
Weight and abundance of fish at age 3 and 4 (%) (1977-90)	-	0.24

Basing data mentioned above we may conclude that silver hake age structure in the commercial catches only partly influences mean weight value by year. High correlation coefficient between weight and CPUE (r= -0.73) shows the influence of the other factors. And again a supposition rises in the mind concerning abundance impact on the interannual variations of mean weight values.

Reverting to the question of relationship between CPUE and survey abundance indices it should be mentioned that correlation between these values often appears to be unauthentic and attention should be paid to the strong variations of the characteristics discussed from year to year. These variations possibly result from the factors not referring to abundance.

Attempts to increase the level of reliability rejecting some indices for these and those years seem to be questionable as in this case we can trace some elements of subjectivity. To avoid the latter and obtain more clear view of the tendencies concerning abundance and mean weight variations for the years 1977-90 inclusive method of the sliding means for the 3-year period was applied (Table 4).

Figures 1 and 2 show tendencies of abundance variations based on the above-mentioned data. Curves in Fig. 1 allow to single out the following periods:

a) low hake abundance: 1977-83 (periods from 1 to 5);

b) abundance increase and stabilization at high level: 1984-89 (periods from 6 to 11);

c) possible start-point for some abundance decrease: 1990 (period 12).

The situation looks a little bit different in Fig. 2. For some periods evident contradictions with the tendencies desribed earlier can be found. Comparing fishery data with juvenile hake abundance indices allows to conclude that picture in Fig. 1 is more real.

Correlation coefficient between sliding CPUE mean values and research vessel indices are given below:

Age (yr)	2	3	4	All groups
r	0.48	-0.26	0.10	0.63

It is evident that as compared with the data presented in Table 3 we have no improvement of the situation excluding value of the correlation coefficient for "all groups".

Thus, application of sliding means method didn't help to decrease discrepancy between independent abundance indices. And now we should check whether it is expedient to apply the method mentioned for analysis of relationship between weight growth and abundance (Table 5).

As we can see in this case commercial abundance indices for all age-groups allow to obtain reliable correlation coefficients. As for research vessel indices we haven't got improvement as compared with the previous results (Table 2).

In conclusion let us analyse data on silver hake weight by [image analysis] size-group and year (Table 6) and then compare them with the total abundance indices not broken down by size-groups. Relationship between characteristics is shown in Table 7.

It can be noted that fish length-dependent condition exceeded mean value in 1978, 1979 and 1982 (Table 6) when fishery stock was rather low. Mean value of stomach index in those years turned out to be rather high. Euphasiids prevailed in the silver hake diet (Table 8). Since abundance increase silver hake condition dropped down and in 1984, 1985 and susequent years was found to be below the everage.

DISCUSSION

Taking into account some uncertainties regarding estimate of the stock state the results obtained, possibly, do not allow to make an undisputed conclusion on the relationship between silver hake weight growth and abundance, though some facts prove real existence of this relationship. It is not difficult to trace the logical chain in this case (abundance - food availability - weight growth), Some examples of feedback between fish abundance and growth rate are given in the book by G. V. Nikolsky (1974). Feedback between lake herring (*Coregonus artedii*) density and linear growth rate was found by Bowen et al. (1991). Possibly, such biological characteristic as mean weight of fishes belonging to one or another age or size group can be used as inderect index for the state of abundance of fishery stock.

Scarcity of food results in growth inhibition in males (Becker, 1959) and reciprocal influence of contiguous year-classes on fish growth (Shatunovsky, 1965). Probably, this is the case with silver hake. In our opinion the studies should be continued untill more definite results are obtained.

REFERENCES

1. Becker, V. E. 1959. On impact of fish population density on their growth and reproduction (taken goldfish as an example). Mosrybvtuz Transactions. Issue X, pp. 210-218. (In Russian).

2. Bowen, S. H., D. J. D'Angelo,,S. H. Arnold, M. J. Keniry and R. J. Albrecht. 1991. Density-dependent maturation, growth and female dominance in Lake Superior lake herring (Coregonus artedii). Can. J. Fish. and Aquat. Sci. Vol. 48. No. 4. pp. 569-576.

3. Nikolsky, G. V. 1974. Theory of fish population dynamics. Moscow. Pishcheprom. 447 p. (In Russian).

4. Noskov, A. S. 1956. On estimation of fish condition. Trudy BaltNIRO. Issue 2, pp. 90-94. (In Russian).

5. Shatunovsky, M. I. 1965. Peculiarities of flounder (Pleuronectes flesus L.) growth in the Western Baltic Sea. Questions of Ichthyology. Vol. 5. Issue 3 (36), pp. 518-531. (In Russian).

6. Vinigradov, V. I. 1988. Feeding and some peculiarities of the silver hake fishery on the Scotian Shelf in 1977-1985. Theses of the Reports for the All-Union Conference "Marine Fishes Feeding and Utilization of Food Supply as an Element for Fishery Prognosis". Murmansk. pp. 85-86. (In Russian).

7. Waldron, D. E., M. C. Bourbonnais and M. A. Showell. 1989. Size of the Scotian Shelf silver hake population in 1988 with projections to 1990. NAFO SCR Doc. 89/48. Serial No. N 1626. 36 p.

8. Waldron, D. E., M. A. Showell and G. Harrison. 1991. Status of the Scotian Shelf silver hake (whiting) population in 1990. NAFO SCR Doc. Serial No. N1922. 34 p.

Table 1 Data used to analyse relationship between silver hake weight growth and abundance

Year	mean weight, kg			CPUE			Abundance index obtained in Canadian surveys			All age groups		
	Age			Age			Age			Mean weight (1-9)	CPUE (1-6)	Research vessel index (1 - 6)
	2	3	4	2	3	4	2	3	4			
I977	0,I80	0,260	0,340	3,54I	6,497	2,452	2,766	2.I42	0,459	0,220	I3.402	6.564
I978	0.I50	0.230	0.270	4.6I5	4.47I	2.I63	2.326	I,627	0.887	0,2I2	I4.I05	8.757
I979	0.I90	0.240	0.290	2.769	3.486	I.754	I5.27I	6.700	2.005	0.23I	I0.540	34.968
I980	0.I40	0.220	0.280	2.88I	2.868	I,305	5,564	9.725	4.586	0.2II	8.526	23.467
I98I	0.I70	0.2I0	0.280	I.I68	5.053	I.74I	8.472	I3.I42	6.047	0.234	8.774	33.454
I982	0.I70	0.230	0.280	4.584	6.566	5.9I9	29.342	8.035	6.049	0.234	22.078	67.337
I983	0.I30	0.200	0.240	6.966	4.039	2.I06	I0.896	3.82I	I.934	0.I76	I4.595	29.59I
I984	0.I50	0.I80	0.220	2.595	II.7I7	4.695	7.037	20.872	3.793	0.I77	23.7I9	53.028
I985	0.I40	0.I80	0.2I0	6.344	4.770	6.226	I7.258	3.440	7.II9	0.I80	20.I72	4I.588
I986	0.I50	0.I90	0.2I0	4.802	I5.657	5.747	8.432	7.062	2.262	0.I76	3I.878	75.052
I987	0.I20	0.I70	0.220	I9.337	I0.327	4.893	26.668	4.609	I.898	0.I5I	27.896	49.030
I988	0.I40	0.I90	0.230	3.734	I5.776	2.333	8.95I	8.I46	I.67I	0.I86	23.599	27.709
I989	0.II6	0.I99	0.269	7.463	II.II6	6.949	6.38I	2.4I5	I.34I	0.206	27.480	28.064
I990	0.I06	0.I7I	0.240	9.245	6.30I	I.8I8	I2.595	4.233	I.302	0.I66	I8.242	30.448

Table 2 Relationship between abundance and weight for silver hake aged 2-4

A g e	CPUE and weight	Survey abundance index and weight
2	-0.62 *	-0.04
3	-0.53	-0.20
4	-0.55	-0.17

Table 3 Relationship between CPUE and research vessel abundance indices

A g e	r	Year-class	r
2	0.75 **	1976	0.43
3	0.21	1977	0.69
4	0.10	1978	0.99 **
All age groups	0.56 *	1981	0.98 **
		1983	0.42

Table 4 Sliding means for silver hake weight, CPUE and research vessel abundance indices by age group

No.	Years	Mean weight, kg			CPUE			Research vessel indices		
		2	3	4	2	3	4	2	3	4
I.	I977-I979	0,I73	0,243	0.300	3.642	4.8I8	2.I23	6.788	3.500	I.II7
2.	I978-I980	0.I60	0.230	0.280	3.422	3.608	I.74I	7.720	6.0I7	2.493
3.	I979-I98I	0.I67	0.223	0.283	2.273	3.802	I.600	9.769	9.856	4.2I3
4.	I980-I982	0.I60	0.220	0.280	2.878	4.829	2.988	I4.459	I0.300	5.56I
5.	I98I-I983	0.I57	0.2I3	0.267	4.239	5.2I9	3.255	I6.237	8.333	4.677
6.	I982-I984	0.I50	0.203	0.247	4.7I5	7.44I	4.240	I5.758	I0.909	3.925
7.	I983-I985	0.I40	0.I87	0.223	5.302	6.842	4.342	II.730	9.378	4.282
8.	I984-I986	0.I47	0.I83	0.2I3	4.580	I0.7I5	5.556	I0.909	I0.458	4.393
9.	I985-I987	0.I37	0.I80	0.2I3	I0.I6I	I0.25I	5.622	I7.452	5.037	3.760
I0.	I986-I988	0.I37	0.I83	0.220	9.29I	I3.920	4.324	I4.683	6.606	I.944
II.	I987-I989	0.I25	0.I86	0.240	I0.I78	I2.406	4.725	I4.000	5.057	I.637
I2.	I988-I990	0.I2I	0.I87	0.246	6.8I4	II.064	3.700	9.309	4.93I	I.438

Table 5 Relationship between abundance indices and weight (sliding means) for the silver hake aged 2 - 4

A g e	CPUE and weight	Research vessel index & weight
2	-0.81 **	-0.33
3	-0.86 **	-0.05
4	-0.66 *	-0.07

Table 6 Silver hake mean weight (kg) and condition (per cent of multiannual mean) by size group and year

Length, cm	1978		1979		1980		1981		1982	
	Weight	Condition	Weight	Condition	Weight	Condition	Weight	Condition	Weight	Condition
26-27	0,I75	I35	0,I25	97	0,I28	99	0,I04	80	0,I29	I00
28-29	0,207	I26	0,I78	I08	0,I66	I0I	0,I48	90	0,I7I	I04
30-3I	0,226	I09	0,22I	I07	0,I98	96	0,I8I	88	0,206	I00
32-33	0,276	II2	0,272	II0	0,244	99	0,257	I04	0,256	I04
34-35	0,33I	II2	0,305	I04	0,293	99	0,280	95	0,323	II0

Table 6 (continued)

Length, cm	1984		1985		1986		1987	
	Weight	Condition	Weight	Condition	Weight	Condition	Weight	Condition
26-27	0,I26	98	0,I25	97	0,I27	98	0,I25	97
28-29	I34	88	0,I59	97	0,I58	97	0,I59	97
30-3I	0,I88	9I	0,208	I0I	0,2II	I02	0,222	I07
32-33	0,2I0	86	0,226	92	0,237	96	0,242	98
34-35	0,262	89	0,276	94	0,29I	99	0,288	98

Table 7 Relationship between abundance indices and weight of different silver hake size groups

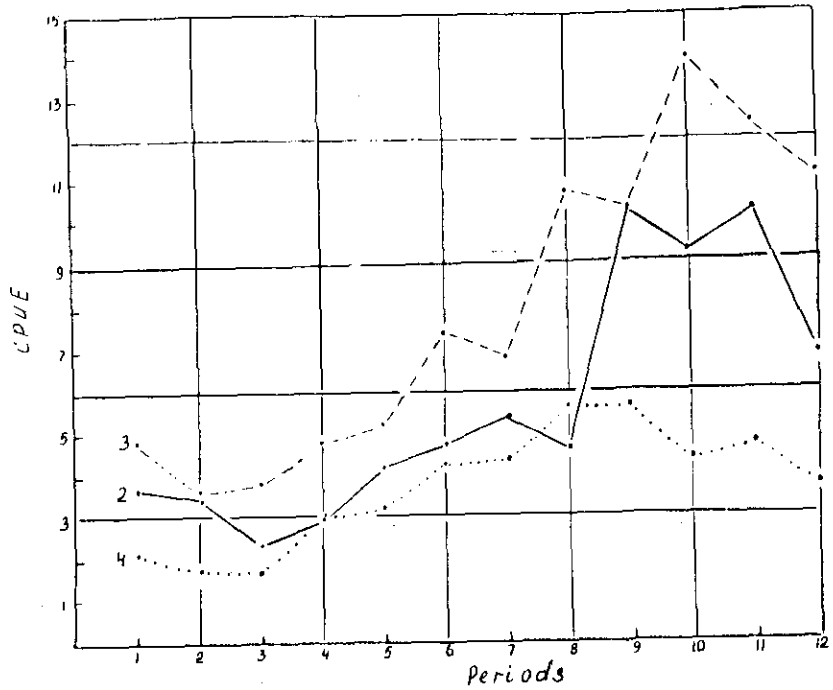
Length, cm	CPUE and weight	Research vessel index and weight
26-27	- 0,002	- 0,07
28-29	- 0,36	- 0,53
30-3I	0,23	- 0,I3
32-33	- 0,57	- 0,48
34-35	- 0,3I	- 0,25

Table 8 Food composition and feeding intensity for the Nova Scotian silver hake by year

Month	Feeding indices	Year 1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
April	Type of food	-	-	-	Euphausiids	-	shrimp	shrimp	-	-	-
	Mean value	-	-	-	1.63	-	0.88	0.95	-	-	-
May	Type of food	euphausiids	euphausiids	-	-	euphausiids	shrimp	calanus	fishes	-	euphausiids
	Mean value	1.80	1.56	-	-	0.20	1.09	1.14	1.05	-	1.14
June	Type of food	euphausiids	-	-	-	euphausiids	shrimp	calanus	fishes	euphausiids	euphausiids, calanus
	Mean value	1.50	-	-	-	1.42	1.94	0.92	1.37	1.91	1.43
July	Type of food	-	euphausiids	-	-	euphausiids	shrimp	calanus	fishes	euphausiids, gammarids	euphausiids
	Mean value	-	0.69	-	-	1.11	1.39	0.88	1.56	1.00	1.51
August	Type of food	-	euphausiids	-	-	euphau-	-	calanus	fishes	-	myctophids
	Mean value	-	0.27	-	-	1.5	-	1.45	1.33	-	1.34
April-August	Type of food	euphausiids	euphausiids	-	euphausiids	euphausiids	shrimp	calanus	fishes	euphausiids	euphausiids
	Mean value	1.65	0.84	-	1.63	1.06	1.32	1.07	1.33	0.96	1.48

Table 8 (continued)

Month	Feeding indices	YEAR 1988	1989	1990
April	Type of food	*shrimp*	*shrimp*	-
	Mean value	0.95	0.29	-
May	Type of food	shrimp euphausiids	shrimp	euphausiids
	Mean value	1.74	1.09	1.09
June	Type of food	shrimp euphausiids	gammarids	euphausiids
	Mean value	1.43	0.56	1.43
July	Type of food	shrimp	shrimp	-
	Mean value	2.39	0.45	-
August	Type of food	-	-	-
	Mean value	-	-	-
April-August	Type of food	shrimp	shrimp	euphausiids
		1.63	0.60	1.48



FIGURES

Fig. 1. Dynamics of CPUE sliding means by age-group (2, 3 and 4) and period.

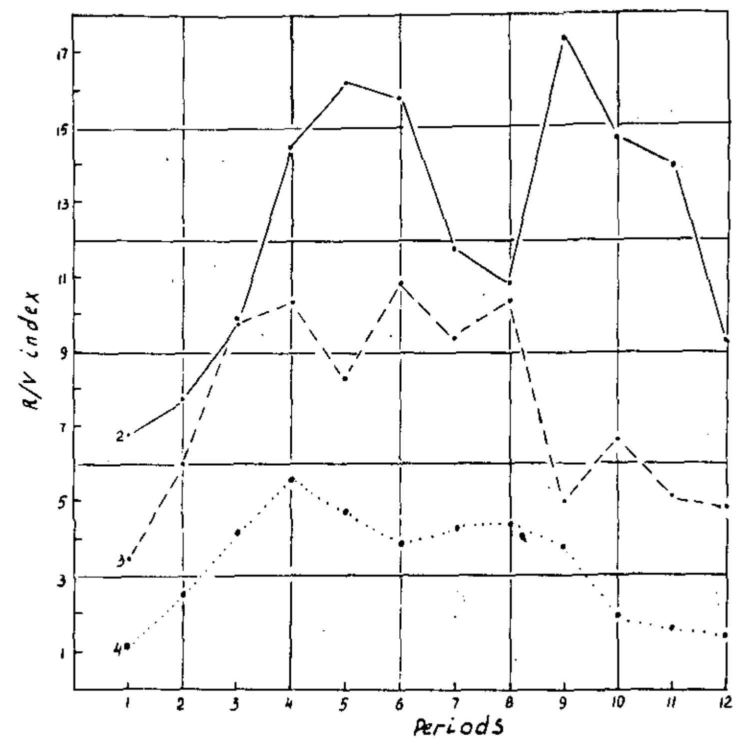


Fig. 2. Dynamics of mean sliding indices for July surveys by age group (2, 3 and 4) and period.