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Correlation Between Trends to Change of Sea-Surface Temperature, Biomass and Catch-per-unit Effort of Scotian Shelf Silver Hake (Div. 4VWX) in 1977-87

by

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ABSTRACT

Trends to changes of the sea surface temperatures (SST), biomass size and silver hake catches per effort on the Scotian Shelf are studied for the 1977-1987 period.

Possible use of SST for forecasting the stock state and silver hake catches per effort are considered.

SPECIAL SESSION ON ENVIRONMENTAL CONDITIONS

INTRODUCTION

Early eighties have been characterized by growth of abundance, biomass and catches per unit effort of silver hake in the Northwest Atlantic. As the fishing intensity was not high during the considered period, the appearance of strong silver hake year classes could evidently be attributed to environmental conditions, one of which, the sea surface temperature (SST), seems to be the most readily available index. Correlations between SST, Scotian Shelf silver hake abundance, biomass and catches per unit effort in 1977-1987 are considered.

MATERIALS AND METHODS

To analyse longterm changes of thermal regime of the waters in the silver hake fishing ground, monthly means of the sea surface temperature in the center of a 5-degree square between 40-45°N and 60-65°W were used (adopted from the data of the Hydrometcenter of the USSR).

Longterm means taken as a standard were estimated on a monthly basis and used as a starting point for assessment of anomalies, which were then successively summed and summarized by year. The obtained integral values of the SST anomalies were compared to biomass and catch per fishing effort values for the Scotian Shelf silver hake. The data used were: mean biomass of one year old and older (1+) fish, two year old and older (2+) fish, biomass in the beginning of the year (1+) and standardized catcher per hauling hour (Fanning et al., 1987), biomass in the beginning of the year (Noskov, 1987) and catches per vessel-day by the vessels of BMRT class (table 1). The parameters of regression equations and correlation factors for the above-stated values were estimated. Many parameters for 1982 appeared to be too high and were rejected as well as extraordinarily high biomass (1+) values for 1986.

RESULTS

Two periods can be identified from the analysis of the sea surface temperature changes on the Scotian Shelf (center of the 5-degree square between 40-45°N and 60-65°W) for 10 recent years.

1. In the course of 6 years from 1974 to 1982, the water temperatures changed insignificantly within the range of mean values for the considered period.

2. The 1983 to 1986 period was characterized by a trend to substantial rise of the water temperatures.

The maximum intrayear amplitude of the SST anomaly fluctuations was observed in 1983-1984, and within 5 years (1983-1986) integral SST values achieved a markedly higher level compared to 1977-1982.

As is evident from the comparison of the SST with the dynamics of biological and fishery parameters, the mean biomass of the Scotian Shelf silver hake aged 1+, 2+ and the biomass of 1+ fish for the beginning of each year (Fanning et al., 1987; Noskov, 1987) changed within 143-187, 112-150, 158-193 and 3332-376 thous. tons, respectively, during the 1977 to 1981 period. The fluctuation range and biomass level considerably increased in 1983-1986 and amounted to 262-817, 209-299, 255-888 and 329-676 thous. tons respectively. Similarly, the catches per vessel-day and hauling hour went up from 20.9-29.5 and 1.21-1.90 to 30.5-44.3 and 1.75-4.23 tons (see table 1). In fig. 1 the biomass values for 1+ and 2+ fish are plotted against integral SST values for the 1977 to 1986 period and with one year backward shift.

It should be noted that during the 1977-1981 period dots (1+ fish biomass) keep to the left of the nearly straight line, on which dots for 1982-1985 are plotted, i.e. the biomass was more stable but smaller during the first period, while during the second period its increase was actually directly proportional to that of integral SST values.

Values of biomasses 1+ and 2+ plotted against integral SST values with one year backward shift also revealed a similar trend in biomass growth.

High correlation factors (table 2) show that a real correlation exists between the above stated parameters. No reliable correlation was found between SST and indices of silver hake 0-group abundance, which can be attributed to both large catchability fluctuations by year and changed methods for survey routine. According to the trawling survey data and VPA results (Fanning et al., 1987), there exists just a qualitative correlation between SST and one year old fish abundance ($r=0.18$ and $r=0.37$, respectively, with rejected 1986 data), which implies that weak year classes predominated in the years with low SST values and vice versa.

DISCUSSION

Considering the question on reasons of fluctuations of abundance of the Scotian Shelf silver hake year classes it should be noted that during the 1977 to 1981 period, when the water temperatures changed insignificantly and the SST values were relatively low, the silver hake stock size also remained at a realtively low level, despite a sharply reduced fishing intensity following the introduction of the 200-mile zone. Strong year classes were not available during that period.

Appearance of strong year classes in 1983, 1985 and 1986 and considerable increase of the silver hake biomass in 1983-1986 coincided with large SST values.

An assumption suggests itself that the fluctuations of the silver hake year class abundance are mostly caused by thermal regime. In this context, the events of the eighties come back to the memory when a dramatic drop of the silver hake abundance coincided with a sharp decrease of the Shelf water temperatures (Sigaev, 1979), and a scanty spawning stock yielded strong year classes in late sixties and early seventies. Similar situation set in in early eighties, though the spawning stock was at a higher level at that time compared to the sixties. There seems to be a correlation between a trend to water temperature increase in the investigated area and intrusion of warm Gulf Stream waters onto the Scotian Shelf, which has lead to improved environmental conditions, and the intensification of the frontal zone resulting from interaction of these waters with underlying cold Labrador waters has promoted the increase of commercial aggregation density (catches per effort). As to the influence of the fishery on the stock, the heavy fishing in the first half of the seventies might have contributed to a certain degree to appearance of poor year classes in the subsequent years. However the danger is not imminent at present. Moreover, as abundance and biomass of the silver hake population have achieved, perhaps, the highest level throughout the observation period, it could have been reasonable to increase the rate of commersial yield so as to avoid possible negative influence of extraordinarily high abundance on subsequent year classes.

CONCLUSION

The results of studies suggest that oceanographic factors are one of the major reasons of fluctuations of the Scotian Shelf silver hake population abundance. Due to interaction of warm Gulf Stream waters intruded onto the Shelf and underlying cold Labrador waters favourable conditions are established for appearing strong silver hake year classes. In this connection, the development of the methods of longterm forecasts of oceanographic conditions is very important.

The found correlations may be helpful for assessment of stock state and prospective fishery for the nearest years at the level of trends.

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Table 1 Initial data for assessment of correlation between integral SST values, biological and fishery indices for Scotian Shelf silver hake

Indices	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Sum of SST anomalies, °C	5.1	-0.3	1.0	2.0	-0.8	-0.5	9.9	26.5	36.8	4.07	36.3
Mean 1+ biomass, thous.t	187	143	173	164	161	234	262	335	378	817	
Mean 2+ biomass, thous.t	150	112	127	143	132	158	209	235	299	282	
1+biomass in the begin. of the year, thous.t (Fanning et al., 1987)	193	185	158	180	164	187	255	316	361	888	
Biomass in the begin. of the year (Noskov, 1987)	353	372	376	359	332	320	329	418	523	676	
Catch per vessel day, t	29.5	23.5	27.4	20.9	26.6	37.2	30.5	38.4	38.2	44.3	34.6
Catch per trawling hour, t	1.90	1.59	1.68	1.21	1.45	4.18	1.75	3.09	2.15	4.23	3.03

Table 2 Correlation factors and parameters of regression equations describing linear dependence between sum of SST anomalies, biomass and catch per effort of Scotian Shelf silver hake for 1977 to 1986 period

Compared indices	In current year			With one year backward shift of SST		
	r	A[1)]	B[2)]	r	A[1)]	B[2)]
SST - 1+ biomass	0.98	6.12	163.1	0.75	7.08	193.0
SST - 2+ biomass	0.96	3.97	136.9	0.83	6.86	189.0
SST - biomass in the begin. of the year	0.98	5.20	176.0	0.83	-	-
SST - biomass (Noskov, 1987)	0.91	-	-	0.98	8.38	338.0
SST - catch per trawling hour, t	0.84	0.068	1.6	-	-	-
SST - catch per vessel day, t	0.94	0.420	26.6	-	-	-

1) A - inclination

2) B - intersection

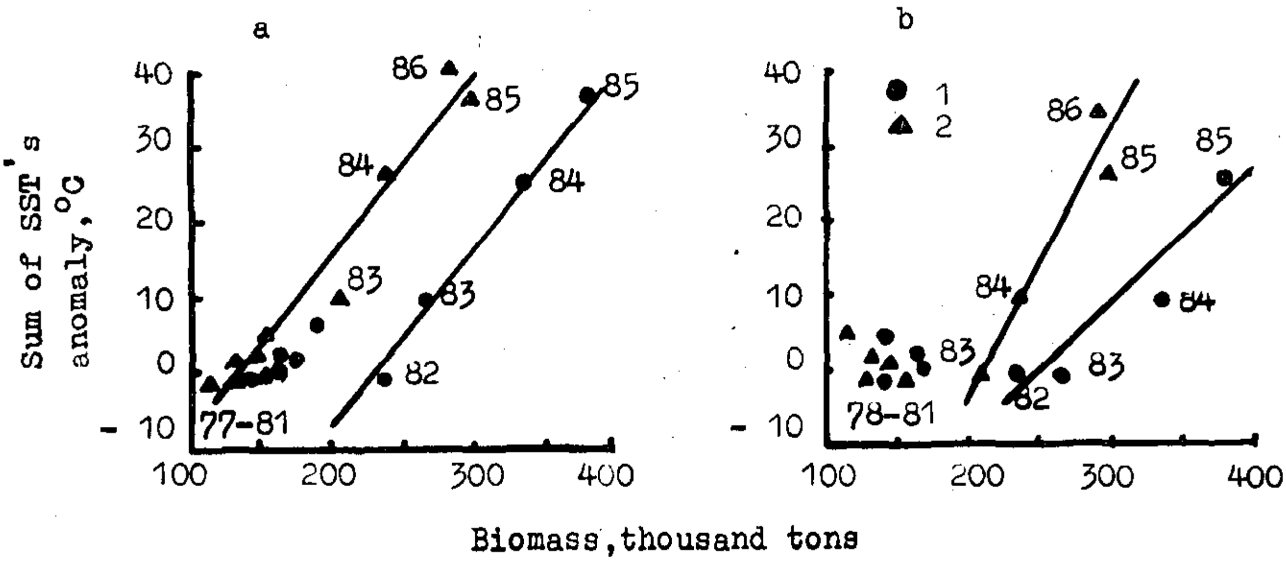

Fig. 1. Sum of anomalies of surface sea temperature (SST) against silver hake population biomass by year (a) and one year backward shiff of SST (b)

1 - 1+

2 - 2+