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Results of Comparison of Some Biological Parameters and Abundance Dynamics of Silver Hake (*Merluccius Bilinearis*) from Scotian Shelf and Cape Hake (Merluccius Capensis) from Namibia Area

by

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ABSTRACT

The comparison was made of some biological characteristics and abundance dynamics of silver hake *(Merluccius bilinearis)* from Scotian Shelf (North-West Atlantic) and cape hake *(Merluccius capensis)* from South-East Atlantic area (between 18°-28°S). Differences in size composition, growth rate and length at maturity being most significant in late 1960s - first half of 1970s were revealed. During subsequent period the above parameters became more similar due to decrease of the latter values in cape hake. In general taking into consideration approximately similar rate of natural mortality both species may be defined as belonging to one type of abundance dynamics with high reproduction ability and strong fluctuation of abundance. During the period discussed (1968-1990) similarity of recruitment abundance trends and total biomass of southern and northern species was found which evidences synchronous pattern of general trends, mentioned above in southern and northern hemispheres under the impact of global climatic variations.

INTRODUCTION

Representatives of Merluccius are widely distributed both in northern and southern hemispheres and are among the major commercial species in European and other countries due to high abundance and nutritive value of the species. The most researched and well-known to both fishermen and scientists specimen of Merluccius are silver hake *(M.bilinearis)* in the North-Western Atlantic and cape hake *(M.capensis)* in the South-Eastern Atlantic, separated by a long distance. Nevertheless it is undoubtful that due to a close relationship of the species discussed, biological parameters and abundance dynamics of the latter should be rather similar. To our opinion comparison analysis of appropriate features, performed in this work, will facilitate a better understanding of processes, relevant to stocks size dynamics and management of silver and cape hakes fishery which futher will be named sometimes as northern and southern species.

MATERIAL AND METHODS

Two species of Merluccius discussed in the paper have been an important object of Russian fishery. Therefore, much attention was paid in AtlantNIRO to researches of both silver and cape hakes and significant scientific data were collected. Data on biology and abundance of both species from various published sources were also used. Comparison analysis of biological characteristics and abundance indices for both populations during 1968-1993 was the methodical basis of this work.

RESULTS AND DISCUSSION

At first we shall discuss the major features of both species distribution and behavious. The northern hake is the first to discuss. The population of interest to us distributes in the Scotian Shelf area between 42° and 45°N at the depth range 30-450 m (Vyalov, Karasev, 1967). Water temperature optimal to adult silver hake is 8°-10°C (Sigaev, 1994). Spawning season extends from June to September with a peak in July-August. Shallow waters off Sable island (30-60m) is the major spawning area. During winter cooling of water (January- April) fish aggregations mainly occure along the shelf edge at the depths of 200-450 m. In May- June hake gradually migrated towards shallower depths (100-200m). The southern hake area extends from 16 to 34 S. In reference to population structure of the latter no complete understanding of the problem is available at present. According to Vysokinskiy (1986) it seems most likely that a single stock of *M.capensis* distributes in ICSEAF zones 1.3, 1.4 and 1.5 (18°-28°S).

We have no reasons to adopt another point of view. Therefore the indices, presented individually by zones, were pooled and discussed as those characterizing the cape hake population in the area between 18° and 28°S. This species is found in the depth range 50-500 m (Arteaga, 1976) mainly at water temperature 6.5°-8.5°C. Spawning mainly occures at the depths of 150-250 m. Fishing aggregations are most often found at the depths of 250-400 m. Reproduction occures for all year round. The most intensive spawning is observed in winter (July-September). Offshore seasonal migrations are observed in fall and wnter and onshore in spring and summer.

As is seen, in general the similarity is observed in silver and cape hakes distribution and behaviour. However there are some differences. Spawning of the latter occures at more depths as well as fishing aggregations during the main part of the year. Differences revealed are likely to be stipulated by peculiarities of temperature conditions in the distribution areas of northern and southern hakes, considerably differed by latitude (see above) .

Now we shall consider biological characteristics of both populations. Table 1 shows the general picture of hakes size composition in commercial catches. The data presented show that the southern hake length unlike that of the northern one varies significantly by years. The largest specimen of maximum length 102 cm were caught in 1968-1975. During subsequent period the average length had dramatically decreased and in some years it was even less than that of silver hake. Since 1985 cape hake size in commercial catches again incrased slightly and if consider the major size groups, it actually overlaps similar indices of another species. Data on age composition are shown in Table 2.

Evidently, there are also differences in age composition of species discussed. Thus in 1968-1971 the southern hake was represented by older specimen while during subsequent period the population became considerably younger and since 1976 the average age of the latter appeared less than that of the northern hake. During the latest years of the period discussed the age again increased slightly. In general dynamics of cape hake age composition in catches, as may be expected, was similar to that of length composition. Concerning to the terminal age, according to published data (Kono. 1979) the latter may approach 15 years in cape hake and 11 years in silver hake (Noskov. 1976). However, as a rule , the bulk of catches of both species consisted from similar age groups.

Data on hake length and weight growth rate (Table 3) were obtained from Fuong (1989). Pshenichniy and Assorov (1969), Isarev (1983), Botha (1970), Draganik and Sacks (1987 a, b).

From the data presented it is evident that during the early observation years a growth rate of the southern hake starting from the second age group exceeded that of the northern hake. Besides, difference in length and weight increased with age and approached 30 cm and 1700 g respectively by the age of 9 years. However, during subsequent years the changes occured resulted in considerable decrease of the cape hake growth rate at the age of 1-4 years. As a result the average length of the first three age groups by the end of 1980s was almost similar to that of silver hake. Estimates of Berthalanfy's growth equation parameters, differed significantly as was expected, are shown below (Fuong, 1989; Botha, 1970)

Species	*Growth parameters*		
	L_{∞}	K	t_0
Silver hake	52.670	0.229	0.141
Cape hake	115.700	0.130	0.444

Wysokinski (1986) notes that fluctuations of age and growth rate of cape hake in a wide range of values are caused by different interpretation of otoliths annual rings by researches and sometimes by errors in species identification. However, data on length composition and length at maturity (see *below*) evidence the actual existence of fluctuations observed, although different approach to age determination certainly may affect the value of growth rate indices.

Now we shall compare rates of maturation which is rather difficult due to sharp variations of the latter in cape hake during the period discussed. Thus, according to Isarev (1983) in 1967 the length of first marutity was 34 cm while major maturity was observed at length of 60 cm. In 1970 the length of first maturity decreased to 23 cm. In 1980-1981 first maturity of males was observed at the lenth of 15 cm while major maturity occured at 21-26 cm in males and 23-28 cm in females. Unfortunately no data on the southern hake maturity rate by ages are available. We may only assume at high probability degree that the latter has changed towards age decrease, i.e. the process of maturation was accelerated considerably. Evidently that at such conditions it is reasonable to compare only the data for approximately the same period of observations (Table 4) (Arteaga, 1976. Doubleday and Halliday, 1975).

It is evident that in the first half of 1970s the northern hake reached maturity at significantly less length and likely at earlier age than the southern one. However later on after a sharp decrease of abundance caused by overfishing as Isarev supposed (1983) the length of cape hake maturity significantly decreased. The same seems true for the age as well. Accelerated maturation seems to facilitate the growth rate decrease which affected primarily the modal age groups (Table 3).

Thus, in the case discussed population abundance decrease and growth rate inhibition occured simultaneously. Nikolskiy (1974) consider such events as associated with climatic conditions transformation towards unfavourable ones for the population. Anyhow decrease of the growth rate coupled with direct removal of large fishes caused by fishery, and fleet effort transition to young age group fishing may result in such considerable decrease of cape hake length in catches during the second half of 1970s - early 1980s (Table 1).

Coefficient of instantaneous natural mortality (M) is an important parameter to describe the species abundance dynamics type. According to Assorov and Scherbich (1979) and Terre and Mari (1978) average coefficient of cape and silver hakes amounted 0.42 and 0.40 respectively, i.e. both values are approximately similar. However, there are other estimates as well. According to Rikhter (1988) M for silver hake amounts to 0.50 while Wysokinski (1986) estimates M for the southern hake as 0.20. The author explains this low value of natural mortality as a consequence of intensive fishery impact resulted in significant decrease of fishing stock of the cape hake. However, we think that maximal approaching of the situation to the actual one provides the assumption of natural mortality rate variability by age. Appropriate data are presented below (Table 5) (Lleonart et al., 1983; Rikhter, 1991; Wysokinski, 1986).

Taking in account a slightly longer life cycle of the cape hake, estimates of M for the modal age groups of the latter (3-4 age old) seem too high. Decrease of old fish mortality rate is doubtful. However, in average the rate of mortality of both species seems similar in spite of some discrepancies.

Estimates of one year old fishes abundance (recruitment) and total biomass (one year and older) of the northern and southern hakes, obtained from VPA method, were used as indices of stock dynamics. Since no regular stock size data are available for the whole observation period (1968-1993), estimates obtained by different researchers and in different time were used (Clay and Beanlands, 1980; Draganik and Sacks, 1987 a,b; Showell and Bourbonnais, 1994), including unpublished data of AtlantNIRO. Observation series for the cape hake is divided into 1968-1986 and 1987-1990, and that for the silver hake into 1968-1976 and 1977-1993. Taking into account differences in tuning methods and some input parameters it is non-correct to compare the absolute values of biomass and abundance. Therefore further the trends of the latter will be discussed (Fig. 1 and 2).

It is evident that curves of both figures are similar. Thus in 1968-1976 biomass of silver and cape hakes in general was at a high level due to appearance of several strong year-classes. During the second half of 1970s the oposite process is observed both in the North and South. Several weak year-classes result in sharp decrease of both populations. Recovery has started in 1982 when the stocks in both areas were recruited by a strong year-class of 1981. Subsequently abundance was retained at relatively high level till 1987. Afterwards another decrease occured in the North-Western Atlantic till 1993. Appropriate information for the South-East Atlantic after 1990 is unavailable.

Thus, qualitative similarity of trends in recruitment abundance and total biomass of silver and cape hakes is rather high. Evidently, it is unreasonable to expect total similarity (with several exceptions) of year-classes abundance variations by years which is confirmed by low correlation coefficient ($r = 0.28$), estimated for the period of 1977-1990 with the most reliable data on the silver hake. As the total biomass, the correlation for the same years is rather high ($r = 0.70$) and reliable at 99% probability. Comparison of silver hake population abundance in the Scotian area with near-bottom water temperature anomalies in the area discussed (Drinkwater et al., 1995) evidences the likely effect of the latter upon appropriate stock unit size variations.

During entire period discussed (1968-1993) the positive temperature anomalies are associated with strong year-classes occurence with subsequent increase of total and fishable biomass and vice versa. Relatively high positive correlation ($r = 0.72$) is found between water surface temperature (SST) and silver hake abundance (Sigaev and Rikhter, 1994). Before 200-mile zone enforcement in 1977, active fishery may affect abundance level. However, to our opinion the general trends are determined by a temperature factor. Relevant the cape hake there are evidences of year-classes abundance dependance on the water temperature conditions in the Southern hemisphere (Isarev, 1988; Kuderskiy and Galaktionov, 1991). Besides, similar to the northern hake, warming seems to facilitate strong year-classes formation, especially during major spawning period, and vice versa.

CONCLUSIONS

1. Results of comparison performed show that during observation period the

cape hake biological chracteristics varied considerably unlike those of the silver hake while in the late 1960s - first half of 1970s southern hake size composition, growth and maturity rate significantly differed from those of the northern hake , during subsequent years a trend for those parameters similarity occured. The reasons of variations relevant to the cape hake may be only supposed. In general both species seem to be of the same type of abundance dynamics, characterized by a high reproductive ability and significant abundance fluctuations.

2. Similarity of year-classes abundance variability trends and total biomass of the silver and cape hakes allows to assume synchronous pattern of the general direction of above trends for two populations of Merluccius in the southern and northern hemispheres under the impact of the global climatic variations. It does not mean the total coinsidence of strong and weak year-classes occurence time. The role of fishery which being rather intensive, may significantly affect the abundance variations amplitude, weakening the trend towards incraese and increasing the opposite one.

3. If further researches confirm the above said, the possibility seems to appear to use appropriate data in preliminary estimation and revealing up expected trends of both species abundance variations. Relevant to the fishery management the similar type of abundance dynamics assumes similarity of management principles for silver and cape hakes fisheries.

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Table 1

Indices of size composition (cm) of silver and cape hakes in commercial catches by years

Years	Silver hake			Cape hake		
	Range	Modal groups	Average length	Range	Modal groups	Average length.
1968	16-49	24-33	28.4	20-78	32-38	38.4
1969	10-47	23-33	27.8	22-88	32-44	41.8
1970	12-51	24-33	27.8	18-96	28-38	40.4
1971	21-51	24-33	28.4	20-98	36-46	44.6
1972	12-51	20-33	27.2	18-94	24-36	35.4
1973	12-53	24-33	28.1	16-102	34-44	40.8
1974	10-53	24-33	28.8	20-102	24-34	37.7
1975	12-53	24-35	29.6	14-92	26-40	37.2
1976	12-57	25-35	29.9	14-82	26-36	34.0
1977	10-57	26-35	30.6	18-70	34-42	36.6
1978	12-57	26-35	30.6	12-78	24-32	31.4
1979	12-53	25-35	29.6	10-88	24-34	35.7
1980	12-59	26-37	31.1	14-92	24-32	32.9
1981	16-63	28-37	31.5	12-82	18-26	30.4
1982	12-53	26-37	31.4	10-96	24-34	28.5
1983	16-53	28-35	29.4	10-84	18-28	25.1
1984	16-53	28-37	30.8	12-84	24-32	29.6
1985	14-51	26-35	30.1	10-102	32-42	35.3
1986	12-57	26-35	29.8	10-88	24-32	33.8
1987	12-51	22-35	28.4	14-86	24-32	30.9
1988	16-45	26-33	29.7	12-86	26-32	31.3
1989	14-51	26-35	29.6	10-70	22-32	28.6
1990	18-43	26-35	27.7	18-70	24-34	30.3
1991	16-51	26-33	29.1	-	-	-
1992	14-45	24-33	29.0	-	-	-
1993	14-43	26-33	29.1	-	-	-

Table 2

Indices of silver and cape hakes age composition (years) in commercial catches by years

Years	Silver hake			Cape hake		
	Range	Modal groups	Average length	Range	Modal groups	Average length
1968	1-8	2-4	2.9	1-7	3-4	3.3
1969	1-8	1-5	2.9	1-9	3-5	3.7
1970	1-9	1-5	3.0	1-9	2-5	3.5
1971	1-9	2-5	3.3	1-9	3-5	3.9
1972	1-10	2-5	3.3	1-9	2-4	3.0
1973	1-12	2-5	3.6	1-9	3-4	3.5
1974	1-10	2-4	3.2	1-8	2-5	3.2
1975	1-9	2-4	3.2	1-8	2-4	3.1
1976	1-7	2-4	3.3	1-9	2-4	2.8
1977	1-9	3-4	3.4	1-7	2-4	3.1
1978	1-10	2-4	3.4	1-8	2-3	2.4
1979	1-9	2-4	3.1	1-12	2-4	2.7
1980	1-10	2-4	3.4	1-10	2-5	3.0
1981	1-10	2-5	3.5	1-7	1-4	2.5
1982	1-10	2-5	3.6	1-7	1-3	2.2
1983	1-9	2-4	3.0	1-5	1-2	1.8
1984	1-9	2-5	3.4	1-8	2-3	2.3
1985	1-9	2-4	3.0	1-11	2-4	3.5
1986	1-10	2-4	3.1	1-9	2-4	3.3
1987	1-7	2-4	2.6	1-9	2-4	2.8
1988	1-8	2-4	2.8	1-9	2-3	2.5
1989	1-9	2-4	2.9	1-8	2-4	2.9
1990	1-8	2-4	2.6	1-8	2-4	3.0
1991	1-8	2-4	3.1	-	-	-
1992	1-7	2-4	2.9	-	-	-
1993	1-7	2-4	3.0	-	-	-

Table 3

Average length (cm) and weight (kg) of silver and cape hakes by ages

Age	Silver hake (first half of 1970s)		Cape hake			
			first half of 1970s		first half of 1980s	
	average length	average weight	average length	average weight	average length	average weight
1	20.3	0.048	19.3	-	20.1	0.050
2	26.9	0.118	31.0	0.149	26.8	0.145
3	30.2	0.185	39.0	0.300	33.6	0.290
4	32.6	0.252	48.0	0.597	42.6	0.573
5	36.1	0.360	54.0	0.965	52.5	0.928
6	38.9	0.446	61.0	1.343	60.3	1.470
7	42.4	0.591	68.0	1.807	67.4	2.900
8	45.9	0.803	74.0	2.275	77.0	2.920
9	50.3	1.186	80.0	2.883	85.0	3.846
10	-	-	85.0	3.275	92.0	4.975

Table 4

Silver and cape hakes length at maturity

Length (cm)	% of mature fishes	
	Silver hake	Cape hake
20	2.2	2
24	31.6	5
28	84.8	12
32	96.6	40
34	99.2	50
36	98.8	64
40	100.0	80
44	100.0	90
48	100.0	95
52	100.0	99
56	100.0	100

Table 5

Estimates of M by ages

Species	Age (years)								
	1	2	3	4	5	6	7	8	9
Cape hake	0.575	0.574	0.566	0.525	0.343	0.209	0.170	0.157	0.157
Silver hake	0.733	0.642	0.236	0.332	0.521	0.544	-	-	-

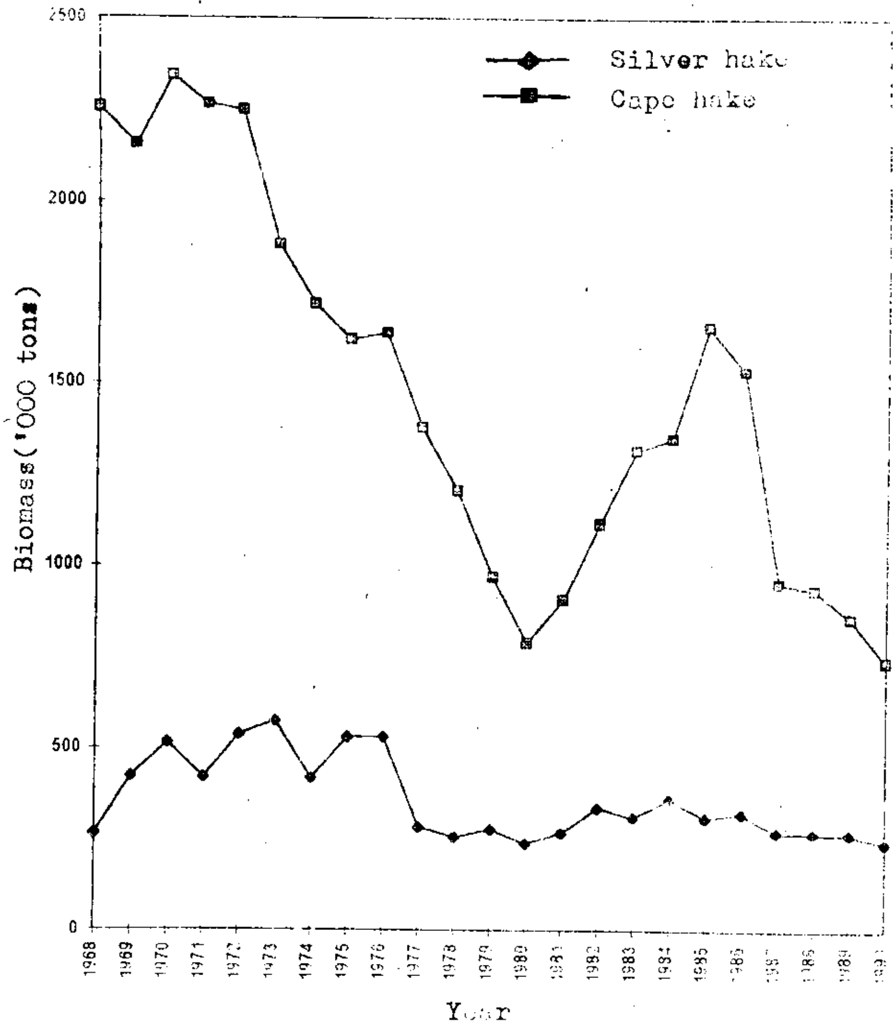

Fig. 1. Dynamics of one year old silver and cape hakes abundance.

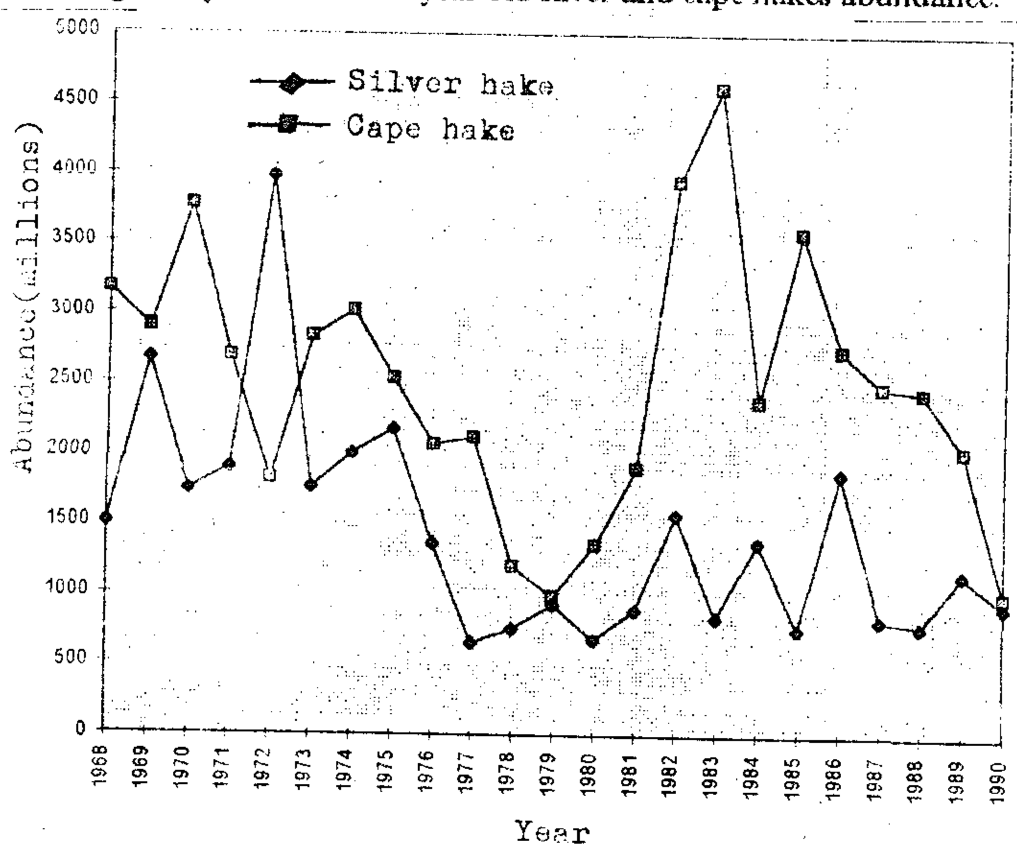

Fig. 2. Dynamics of silver and cape hakes total biomass.