RESTRICTED

International Commission for the Northwest Atlantic Fisheries

Serial No. 3284
(D.c.3)

ICNAF Res.Doc. 74/64

ANNUAL MEETING - JUNE 1974

A forecasting method and an approximate estimate of total allowable catch of red hake from Southern New England in 1974-1975

by

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ABSTRACT

In the present paper a method of forecasting of possible catches two years ahead is considered. This method enables to estimate total allowable catch of red hake from the southern New England in 1974 and 1975.

INTRODUCTION

A stock of red hake inhibiting the southern New England area (to the west of 69°W) is the object of the presented investigation. A problem of a long-term forecasting the possible catches arose simultaneously with the origin of specialised red hake fishery by the Soviet fishermen in 1965. Beginning from that time the corresponding studies have been carried out. As a result of these studies, a relatively large series of observations was obtained by 1973, which allowed to work out a scheme of forecasting two years ahead on the basis of different well-known investigation methods.

METHODS

The abundance of year-classes at the age of their first entering the fishery (two years for red hake) was estimated by means of a virtual population analysis (Schumacher, 1970). This method was used in estimating the abundance of the 1968-1970 year-classes, which will be represented in the 1974

catches by fish of 4-6 years old. Since the bulk of the catch constitutes 2-3 year old fish, it was also necessary to estimate the 1971-1972 year-classes abundance. According to the data of quantitative trawling surveys carried out according to the ICNAF Program, a 1971 year-class was considered to be a strong one and was equated in abundance with the 1969-1970 year-classes. The 1972 year-class abundance was estimated as an arithmetical mean of the 1964-1970 year-classes.

For estimation of total commercial removal from every year-class during the whole exploitational period at the optimum fishing intensity (Rikhter, 1970) a method by Kutty (1968) was used, which allows to model the dynamics of catches at the natural mortality value (M) changing with age and under the influence of fishery. The mean correlation of age groups in catches by weight in per cent calculated according to the data of the previous years allowed to determine an approximate contribution of every year-class to a catch of 1974. The total allowable (optimum catch for 1974 was estimated by summing up the figures of catches from the year-classes of 2-6 years old.

A joint survey carried out at the end of 1973 enabled to obtain an approximate estimate of the 1972 year-class abundance, which appeared to be higher as compared with that for the 1967 year-class, but lower than that for the 1971 year-class (judging from the abundance indices of the young of the year fish and of fish aged 1+). For calculations a mean figure of these two year-classes abundance was taken. The abundance of the 1973 year-class was estimated as an arithmetical mean of the 1964-1972 year-classes.

The total allowable catch for 1975 was estimated by means of the yield per recruitment (Yw/R) ratio and the mean correlation of age groups in catches by weight in per cent, which were calculated before.

THE RESULTS OF STUDIES

A scheme of calculations used in the present paper is not original. A similar method of the catch forecasting was utilised and described by T.F. Dementjeva (1952, 1964), who took into account the dynamics of recruitment of the commercial part of the stock stipulated by differences in the growth rate of the year-classes by years. In this paper a possible influence of growth rate is not allowed for. It is assumed, that the recruitment of the commercial part of the red hake stock is begun and finished in the third year of the life cycle, thus, determining the recruitment value by the two year old fish abundance. A principal difference of up-to-date methods of forecasting from the classical ones lies in obligatory estimation of the natural mortality value, the knowledge of which is absolutely necessary at present for forecasting the possible catch. In other respects the difference of up-to-date methods is confined to substitution of new mathematical methods and models in a well-known scheme.

In estimating the stock size by the virtual population analysis three values of natural mortality (M=0.8; 0.6 and 0.4) were used at a constant value of fishing mortality (F=0.7).

These variants of natural mortality values were accepted based on the assumption that the M value is reduced as a result of intensive fishing. In the first two variants (M=0.8 and 0.6) the M values for all the age groups remain constant. In the third variant for 2 year old fish M=0.6 is taken, since the fishing intensity of this age group is not too high yet, and for 3-6 year old fish M is reduced to 0.4.

The results of calculations are given in tables 1-3. So, we had three series of abundance estimates at our disposal, from which the best ones were to be chosen. A comparison with the stock abundance indices calculated by means of a catchability coefficient served as a decision of the problem.

Table 1

The estimation of the abundance of red hake from the southern New England by a virtual population analysis (in millions). version: 1:M=0.8; F=0.7

Age, Years	Year-classes 1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	-	-	-	-	838.98*	490.00*	808.50*	607.50*	555.00*	701.00*	576.00
3	-	-	-	436.92	484.88	199.24	345.82	237.14	234.78	257.63	-
4	-	-	158.48	173.02	178.26	93.90	99.16	89.86	88.27	-	-
5	-	67.35	32.37	163.07	66.25	4.98	40.45	32.82	-	-	-
6	16.55	12.14	9.10	1.10	0.28	2.48	15.17	-	-	-	-

* The abundance of these age groups was estimated by a formula $N_i = \frac{N_{i+1}}{e^{-z}}$

Table 2

The estimation of the abundance of red hake from the southern New England by a virtual population analysis (in millions) Version 2: M=0.6; F=0.7

Age, years	Year-classes 1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	-	-	-	-	549.89*	688.01*	445.50*	327.00*	350.99*	543.18	529.46
3	-	-	-	320.91	293.01	358.78	237.75	164.00	183.74	238.44	-
4	-	-	130.54	121.63	119.23	397.24	68.52	69.95	50.00	-	-
5	-	57.39	26.55	40.51	50.12	3.70	31.66	30.38	-	-	-
6	15.30	11.23	8.42	1.02	0.26	2.30	14.04	-	-	-	-

* The abundance of these age group was estimated by formula $N_i = \frac{N_{i+1}}{e^{-z}}$

Table 3

The estimation of the abundance of red hake from the southern New England by a virtual population analysis (in millions)

Version 3: for two year old fish M=0.6; for other age groups M= 0.4 ; F...=0.7

Age, years	Year-classes										
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	-	-	-	-	514.00*	401.80*	331.50*	243.90*	276.00*	500.00*	529.50
3	-	-	-	237.99	195.28	189.79	173.14	116.15	143.90	220.00	-
4	-	-	107.54	88.22	81.48	298.96	47.29	55.35	47.90	-	-
5	-	49.11	21.83	32.39	37.30	2.78	24.79	28.03	-	-	-
6	14.10	10.36	7.77	0.94	0.24	2.12	12.96	-	-	-	-

* The abundance of these age groups was estimated by a formula $N_i = \frac{N_{i+1}}{e^{-M}}$

Table 4

The stock size estimates calculated by the virtual population analysis (3 variants) and by means of a catchability coefficient (thous. tons)

Years	Virtual population analysis			Catchability coefficient
	M = 0.8	M= 0.6	M = 0.4	
1966	305	222	187	140
1967	212	183	119	81
1968	211	153	100	88
1969	160	103	151	144
1970	149	99	73	120
1971	271	144	122	98
1972	130	113	108	86

From the table it is evident that the third variant (M=0.4) provides in general quite good correspondence with the estimates determined by a direct calculation method. A marked discrepancy can only be observed between the stock size estimates for 1970. The abundance index obtained according to the 1969 survey data* is most probably overestimated. It should be noted that in the last column of table 4 more precise stock size estimates are given, which were calculated by means of abundance indices multiplied by correction factors (Rikhter, 1973). In further calculations the third variant of the estimates was used as most reliable.

For estimation of each year-class contribution to the 1974 catch, first the yield per recruitment (Yw/R) ratio was calculated, followed by the total catch ~~catch~~ taken from each year-class during the whole exploitational period. It was assumed that the value of M is increased with age (Rikhter, 1972) and reduced as a result of fishing. The following assumptions were taken: in the third year of the life cycle M is reduced by 25% under the influence of fishing; in the age of 3-6 years M is reduced by 50%; F for two year old fish is 0.3 and for the subsequent age groups it is 0.7.

Besides the values of F and M the data on mean weight ($\overline{W}_t$) of each age group participating in the fishery were needed. The results of calculations are presented below (table 5).

N_t is the abundance of age groups in relative units, $\overline{W}_t$ is the mean observed weight in grams, and a function $F_t N_t \overline{W}_t$ is the catch from each age group in grams. The values of M and F are transformed here into the annual loss factors (in %%). By means of a trapezoid rule the bottom line of the table is used to calculate the yield per recruitment ratio. Now, based

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* The surveys were conducted at the end of the year, therefore the stock size estimated according to these surveys data referred to the beginning of the following year.

Table 5

The calculation of yield per recruitment (Yw/R) ratio according to Kutty

Age, years	2	3	4	5	6	Yw/R
N_t	1.0	0.5	0.19	0.07	0.02	
W_t	114	198	274	352	428	
$F_t N_t W_t$	29.6	49.5	26.0	12.3	4.3	104.7

on the recruitment value (the abundance of two year old fish) and the Yw/R ratio (104.7) it is easy to estimate total catch from every year-class during the whole exploitational period. The abundance of two year old fish from the 1968-1972 year-classes constitutes accordingly 276, 500, 530, 500 and 399 millions. Based, on the data on the mean correlation of age groups in catches in per cent, the catch of every year-class and total allowable catch of red hake in 1974 can be estimated (table 6).

Table 6

An approximate catch estimate according to age groups and total optimal catch of red hake in the area westward of 69°W in 1974

Age, years	2	3	4	5	6	Optimum catch
Total catch during exploitational period (thous. tons)	41.8	52.6	55.5	52.6	41.8	
The share of every age group (%%)	18.3	35.5	28.7	13.9	3.6	
The catch of every age group (thous. tons)	7.6	18.6	15.9	7.3	1.0	50.4

Thus, the estimate of the optimum catch in 1974 approximates to 50 thous. tons, which well agrees with that obtained at the beginning of 1973 by means of another method (Rikhter, 1973).

The initial parameters used in the calculations are expected to be true, and a given scheme of forecasting together with the methods used provides the estimate of possible catch which approximates to a real one.

The calculation of total allowable catch of red hake in 1975 according to a given scheme is shown in table 7.

Thus, the estimate of the optimum catch in 1975 approximates to 45 thous. tons. It is evident from the table that some reduction observed as compared with the previous year is determined by a 1972 year-class, which is less numerous than the previuos one according to the preliminary data.

Table 7

An approximate estimate of the optimum red hake catch in the area westward of 64°W in 1975

Age, years	2	3	4	5	6	Optimum catch
	1973	1972	1971	1970	1969	
Total catch taken from the year-classes during exploitational period (thous. tons)	39.5	38.9	52.6	55.5	52.6	
The catch taken from every age group (thous. tons)	7.2	13.8	15.1	7.7	1.9	45.7

SUMMARY

A scheme of forecasting the total allowable catch used in the present paper is characterized, in our opinion, by greater flexibility, and must in principle give better results than the methods requiring the application of a catchability coefficient. If the corresponding information is available, the scheme described will permit to forecast the estimate of possible catch two years ahead. Thus, the calculations made at the end of 1973 give for 1975 a figure of total allowable catch approximating to 45 thous. tons.

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