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An Alternate Method of Assessing the Capelin Stock in Divisions 2J+3K, using SCAM and Catch-per-unit-effort

by

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INTRODUCTION

Since the development of sequential capelin abundance models (SCAM) (Carscadden et al. 1978; Carscadden and Miller 1979; Miller and Carscadden 1979), it has been possible to gain an understanding of historical patterns of capelin abundance in the Northwest Atlantic. Such models are particularly sensitive to p, the proportions mature at age, and the inability to estimate p with time and age has caused concern in interpreting the output from such models. However, two methods have now been developed to estimate p (Carscadden and Miller 1980; Winters et al. 1980) and one method using empirical fish length data, has been used as a basis for an assessment of the Div. 2J3K capelin stock (Carscadden and Miller 1980). The assessment of the same stock in this paper uses the values of p developed by Winters et al. (1980) in SCAM and in addition presents an alternate method of estimating the strengths of recent year-classes in the stock.

METHODS AND RESULTS

The SCAM presented by Miller and Carscadden (1979) is used as the basic model. Catch data, mean weights-at-age during the fishery and at the beginning of the year and spawning mortalities from Carscadden and Miller (1980) were used. Estimates of p, the proportions mature-at-age, were from Winters et al. 1980.

Initial runs of the model, using partial recruitment values from Carscadden and Miller (1980) were made. Examination of the distribution of F with age for the years 1972-76 (a period relatively insensitive to values of F_T) was made and the values of F for each age in these years were averaged and expressed as a proportion of the largest to provide new estimates of partial recruitment. These new estimates differ substantially from those provided by Carscadden and Miller (1980) especially in the younger age-groups (Table 1). Carscadden and Miller (1980) have suggested that the partial recruitment values used in their analysis may have been incorrect because of relatively small sample sizes of research data obtained during the autumn of 1979. In addition, their method assumes that research vessel catches are representative of the entire population, including immatures whereas it appears that most of the capelin taken in the fall period in Div. 2J3K are mature and therefore maturation rate is approximately equal to partial recruitment (Winters et al. 1980). As a result, partial recruitment would be expected to increase with age such that the partial recruitment of ages 5 and 6 would be 1.00.

The model was run using a series of F_T's. Regressions were calculated to investigate the relationship between numbers at age (N_T) at the beginning of September as predicted from the model and adjusted catch-per-unit-

effort for that year-class at that age (C/E_p) in the same year. This relationship was examined for ages 2 (1970-74 year-classes) and 3 (1969-74 year-classes). The most significant regression occurred when $F_T = 0.10$ (Fig. 1) for age 2 and when $F = 0.12$ (Fig. 2) for age 3. These regressions were then used to predict the 1975 and 1976 year-classes at ages 2 and 3. The catch-at-age was added to provide an estimate of the numbers of these age-classes at ages 2 and 3 at the beginning of the fall fishery (Table 2). The numbers in the 1975 and 1976 year-classes at age 2 were also estimated from the numbers of these year-classes at age 3 by working back through the SCAM (Table 2). A final estimate of the numbers at age 2 for the two year-classes was provided by averaging the estimates. This provided estimates of $9,604,180 \times 10^3$ for the 1975 year-class and $8,291,348 \times 10^3$ for the 1976 year-class at age 2 at the beginning of the fall fishery (Sept. 1).

When $F_T = 0.100$ (Fig. 1 for 2-year olds), the number of 2-year-olds in the 1975 and 1976 year-classes are calculated from SCAM when $F_3 = 0.0140$ and $F_4 = 0.015$ in 1979. Corresponding partial recruitments are $PR_3 = 0.14$ and $PR_4 = 0.15$ when PR_5 and PR_6 are both equal to 1.00.

The size of the 1977 year-class was estimated using $C/E = 49.28$ from Table 3 of Winters et al. (1980) and mean $p = 0.24$ from Table 5 (Winters et al. 1980) with the regression in Fig. 1. The value of $C/E/p$ is 205.33 and the size of the 1977 year-class is $25,070,700 \times 10^3$. The standard deviation of $p = 0.24$ is 0.15 and substituting $p = 0.39$ and $p = 0.09$ results in estimates of the 1977 year-class ranging from $16,586,400 \times 10^3$ to $61,838,800 \times 10^3$ individuals. The corresponding values of F, partial recruitment and biomass levels for the estimated values of the 1977 year-class are given in Tables 3 and 4.

The relationship between estimated biomass on Sept. 1, and catch per hour (USSR, BMRT-A class trawlers) from Seliverstov and Serebrov (1979) was plotted and the highest value for r^2 occurred when $F_T = 0.10$ (Fig. 3).

The predicted biomass for 1979 when $C/E = 1.34$ was 290,400 tons. This corresponds to a predicted biomass of 178,400 tons for the 1977 year-class or $8,875,620 \times 10^3$ individuals on Sept. 1, 1979 and $10,840,700 \times 10^3$ individuals on Jan. 1, 1979. This estimate of the strength of the 1977 year-class is well below the strength of that year-class estimated using the C/E and proportions mature data. Since the 1977 year-class was virtually the only year-class available to the fishery in Div. 2J-3K in 1979 (Carscadden and Miller 1980), it is possible that the partial recruitment pattern in 1979 was not only influenced by the proportion mature, but also by the pattern of fishing of the commercial fleet in concentrating on this year-class. Thus, the CPUE of the 1977 year-class at age-group 2 in 1979 may be biassed upwards.

REFERENCES

Carscadden, J.E. and D.S. Miller. 1979. Biological aspects of capelin and a sequential capelin abundance model for the Division 3LNO stock. ICNAF Res. Doc. 79/33, Ser. No. 5359, 20 p.

Carscadden, J.E. and D.S. Miller. 1980. Analytical and acoustic assessments of the NAFO Div. 2J3K capelin stock, 1979. NAFO SCR. Doc. 80/

Carscadden, J.E., D.S. Miller and G.H. Winters. 1978. Biological aspects of the Div. 3NO capelin stock in 1979 and a capelin sequential abundance model. ICNAF Res. Doc. 78/52, Ser. No. 5217, 20 p.

Miller, D.S. and J.E. Carscadden. 1979. Biological characteristics and biomass estimates of capelin in ICNAF Div. 2J3K using a sequential capelin abundance model. ICNAF Res. Doc. 79/32, Ser. No. 5358, 15 p.

Winters, G.H., J.E. Carscadden and D.S. Miller. 1980. An indirect method of estimating maturation rates of cohorts of capelin. NAFO SCR. Doc. 80/

Table 1. Comparison of partial recruitment factors (a) derived in this paper, and (b) given by Carscadden and Miller (1980).

Age	a	b
2	.10	.24
3	.37	1.0
4	.57	1.0
5	1.0	1.0
6	1.0	1.0

Table 2. Numbers (10^3) of capelin in the 1975 and 1976 year-classes, predicted from the regressions in Fig. 1 and Fig. 2 (a from regression, b from SCAM).

	Age 2		Age 3
Year-class	a	b	a
1975	8,929,460	10,278,900	7,029,360
1976	5,508,895	11,073,800	3,848,360

Table 3. Results of SCAM when F_T = 0.100 and PR_2 = 0.059.

TOTAL POPULATION AT START OF YEAR

YEARS AGE	1972.	1973.	1974.	1975.	1976.	1977.	1978.	1979.
2	18516832.	27127956.	23954712.	70522634.	17788311.	11734691.	9929445.	77556369.
3	23555617.	13500420.	18855226.	16781099.	46971049.	12427349.	8544023.	7120681.
4	7889140.	13153259.	7616024.	9626322.	7999745.	18494176.	6484748.	5148946.
5	1055972.	2169999.	3993599.	2614039.	1551265.	1485737.	3773146.	1829732.
6	77011.	133507.	240734.	580641.	225056.	125177.	230314.	298310.
BIOMASS	719815.	836987.	912889.	1336020.	1256304.	780788.	555575.	942943.

MATURE POPULATION AT START OF YEAR

YEARS AGE	1972.	1973.	1974.	1975.	1976.	1977.	1978.	1979.
2	.	.	.	.	.	.	.	.
3	5606237.	1660552.	3601348.	3725404.	16674723.	2199641.	683522.	3667151.
4	5443507.	6247798.	3617612.	8086111.	6399795.	11466389.	4020544.	5148946.
5	902856.	1692599.	2715647.	2352635.	1438023.	846870.	3037383.	1816924.
6	73469.	127365.	192587.	580641.	225056.	71351.	215344.	295327.
BIOMASS	234087.	222674.	253733.	361632.	526053.	341924.	217692.	209278.

TOTAL POPULATION-START OF FISHING (SEPT 1)

YEARS AGE	1972.	1973.	1974.	1975.	1976.	1977.	1978.	1979.
2	15160300.	22210492.	19612459.	57739050.	14563837.	9607552.	8129542.	63497785.
3	15838965.	10032294.	13223226.	11448804.	28204937.	8822303.	6575022.	3575338.
4	2824675.	6597579.	3820143.	2482602.	2276756.	7486113.	2624911.	777861.
5	204845.	539873.	1285376.	421138.	219314.	597616.	869794.	170443.
6	9368.	16241.	56374.	51118.	19813.	50351.	31215.	28442.
BIOMASS	708753.	919105.	861432.	1423220.	966861.	680896.	340142.	1391619.

TOTAL FISHING MORTALITY RATES

YEARS AGE	1972.	1973.	1974.	1975.	1976.	1977.	1978.	1979.
2	.016	.064	.056	.106	.059	.017	.033	.006
3	.086	.176	.217	.258	.322	.208	.144	.014
4	.164	.402	.279	.370	.327	.585	.261	.015
5	.328	.708	.695	.527	.461	.854	.970	.100
6	.328	.708	.695	.527	.461	.854	.970	.100

Table 4. Results of SCAM for 1979 when $F_T = 0.100$ for two different values of PR_2. Results for 1972-78 remain the same as in Table 3.

Age	$PR_2 = 0.15$	$PR_2 = 0.23$
Total Population at Start of Year		
2	30642054	20062455
3	7120681	7120681
4	5148946	5148946
5	1829732	1829732
6	298310	298310
Biomass	530097	436996
Mature Population at Start of Year		
2		
3	3667151	3667151
4	5148946	5148946
5	1816924	1816924
6	295327	295327
Biomass	209278	209278
Total Population Start of Fishing (Sep 1)		
2	25087592	16425749
3	3575338	3575338
4	777861	777861
5	170443	170443
6	28442	28442
Biomass	619574	445471
Total Fishing Mortality Rates		
	PR	PR
2	0.015 (0.15)	0.023 (0.23)
3	0.014 (0.14)	0.014 (0.14)
4	0.015 (0.15)	0.015 (0.15)
5	0.100 (1.00)	0.100 (1.00)
6	0.100 (1.00)	0.100 (1.00)

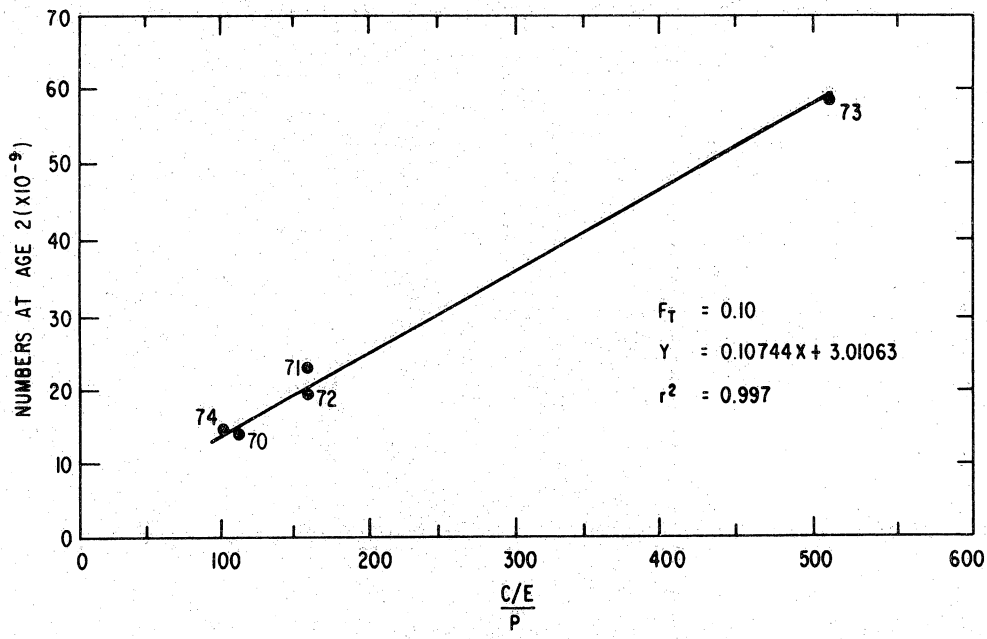

Fig. 1. Relationship between numbers-at-age 2 ($x10^{-9}$) predicted from SCAM and catch-per-effort for that year-class at age 2, F_T = 0.10.

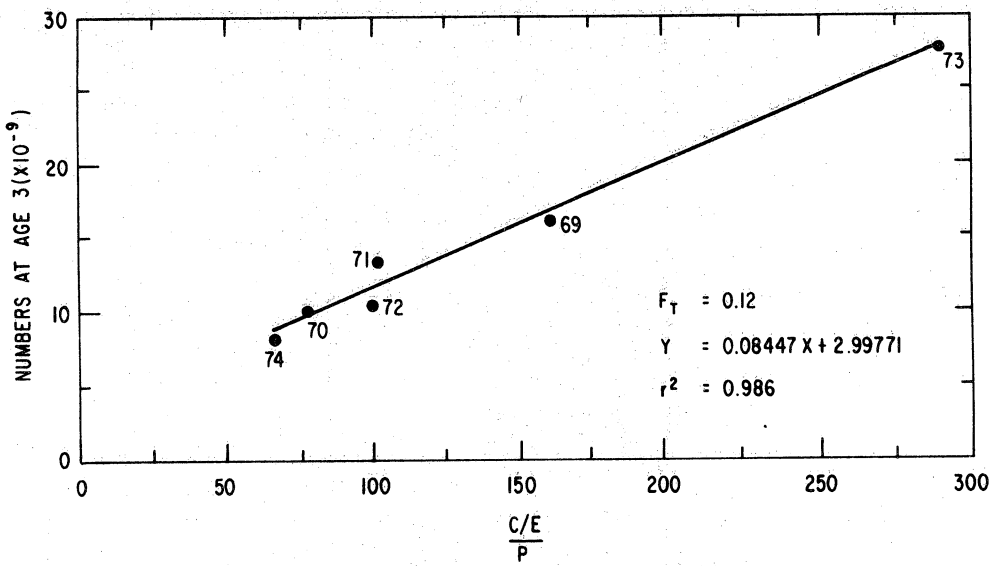

Fig. 2. Relationship between numbers-at-age 3 ($x10^{-9}$) predicted from SCAM and catch-per-effort for that year-class at age 3, F_T = 0.12.

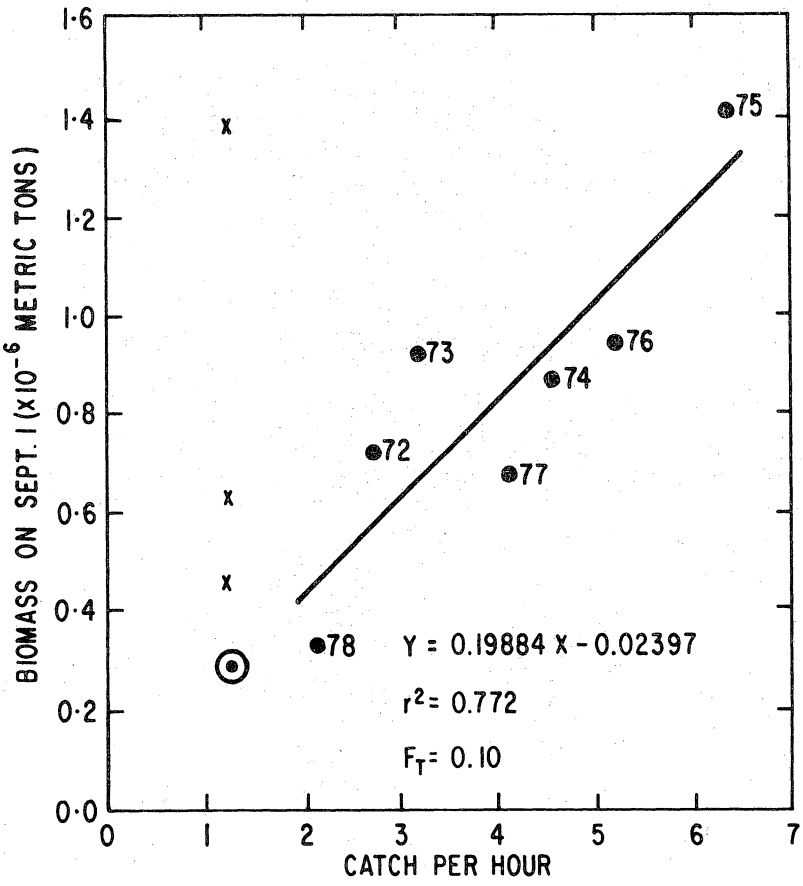

Fig. 3. Relationship between biomass of capelin, Sept. 1 predicted from SCAM and catch per hour of USSR BMRT-A trawlers, F_T = 0.10.

X = 1979 biomass predicted when 1977 year-class is estimated using catch per effort data (Fig. 1) and mean value for p ± 15.0.

⊙ = 1979 biomass predicted from the regression using a 1979 value for C/hr = 1.34.