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Yield-per-recruit Analyses for Cod in Div. 3NO

by

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Introduction

The most recent yield-per-recruit analysis conducted for this stock (Bishop et al. 1987) estimated $F_{0.1}$ and F_{max} at 0.15 and 0.25 respectively with corresponding yields per recruit at 1.24 and 1.32 kg. Prior to this analysis an $F_{0.1}$ value of 0.18 had been used, based on a similar analysis in 1980. This paper provides some further analyses for this cod stock using data from the commercial fishery and from research vessel surveys.

Methods and input data

The Thompson-Bell method of yield per recruit analysis as presented in Rivard (1982) was used. Input data for this method are basically that of average weight and partial recruitment to the fishery at age for an appropriate range of ages. The current analysis considered average weights-at-age data from the commercial fishery and research vessel surveys, along with partial recruitment estimates from the commercial fishery.

Canadian research vessel survey average weights-at-age were available by year from 1960 to 1987. Prior to 1971 surveys were conducted on a line transect basis as compared to the stratified-random approach since that time. In general the average weights over the whole period showed random fluctuations about the overall mean but there were shorter periods when within which certain trends were observed. In recent years there appeared to be a declining trend in average weight-at-age for the major age groups in the population. Average weights for older age groups ($\geq$15 years) were more variable mainly because of smaller sample sizes.

Average weights from the commercial fishery were considered only over the period 1977-86. It was in this period that the commercial fishery was affected by the introduction of the 200 mile fishery zone and sampling was generally improved. Partial recruitment to the fishery was estimated by averaging selectivities observed from the 1977-86 period (Bishop and Baird 1987).

Results

A comparison of average weights from research vessel catches over the periods 1960-87 and 1977-87 (Table 1) suggested that cod of ages 7 and older were larger at age in the latter period. Average weights at age for commercial and research catches over the period 1977-87 were similar with the exception of those for ages 3 to 6. These younger cod were larger in the commercial fishery because of the different selectivities.

Because average weights at age from both research and commercial catches were similar in the 1977-86 period, yield per recruit analysis was conducted using only the commercial average weights at age.

The age structure of the research and commercial catches over the entire period (1960-87) indicated that cod as old as 20 years were not uncommon and ages >20 were occasionally encountered. For this reason ages used in the yield per recruit analysis were those ranging up to 20.

In the analysis natural mortality (m) was assumed to be 0.2.

This yield-per-recruit analysis indicated (Table 2, Fig. 1) $F_{0.1}$ and F_{max} levels of 0.15 and 0.25 respectively with corresponding yields of 1.244 and 1.325 kg. These values are very similar to those presented previously (Bishop et al. 1987).

Discussion

Yield per recruit values obtained from any analysis are influenced to varying degrees by the input parameters. One of these parameters which has a significant influence on values obtained is the age range. Past population structures from commercial catches and surveys suggest that cod up to age 20 years have not been uncommon. Fishing at $F_{0.1}$ level over a long term should, in principle, permit an increase in the proportion of older fish in the population than if higher levels of fishing mortality exist. The proportion at age that might be expected in a commercial catch by number and weight over the long term at $F_{0.1} = 0.18$ is shown in Fig. 1 and 2. Ages >15 would make up approximately 1.6% and 5.6% of the catch by number and weight respectively.

Cohort analyses conducted for this stock (Bishop and Baird 1987) suggest that fully recruited fishing mortalities have not been as low as $F_{0.1}$ over the period considered. Age compositions of the commercial catch over the period 1959-86 indicated that the percent caught in numbers for the age group >15 years ranged from almost nil to about 2% with larger values occurring mainly in the earlier years. These are not inconsistent with the value derived from a long-term catch at $F_{0.1} = 0.18$ (1.6%). This would suggest that it is appropriate to consider ages ranging from 3 to 20 in yield per recruit analyses for this stock.

A yield per recruit analysis using data in Table 1 for ages 3-15 (1977-86) estimated $F_{0.1} = 0.18$ and $F_{max} = 0.29$. These values are similar to those used for this stock since about 1980. The corresponding yield per recruit values were 1.22 and 1.29 kg.

References

Bishop, C. A., and J. W. Baird. 1987. Assessment of the cod stock in NAFO Divisions 3NO SCR Doc. 87/53. Ser. No. N1342. 20 p.

Bishop, C. A., J. W. Baird, and R. Wells. 1987. Yield per recruit analysis for the cod stock in NAFO Divisions 3NO. NAFO SCR Doc. 87/97. Ser. No. N1401. 3 p.

Rivard, D. 1982. APL programs for stock assessment (revised). Can. Tech. Rep. Fish. Aquat. Sci. 1091: 146 p.

Table 1. Average weights at age from the commercial fishery and research vessel surveys along with average partial recruitment estimates for Div. 3NO cod over varying time periods.

	Ave. Weight			Partial Recruitment	
	Research		Commercial		
Age	1960-87	1977-87	1977-86	1959-86	1977-86
3	0.30	0.29	0.70	0.12	0.06
4	0.67	0.66	1.07	0.46	0.32
5	1.22	1.22	1.58	0.76	0.69
6	1.97	1.99	2.33	0.88	0.86
7	3.06	3.17	3.48	1.00	1.00
8	4.28	4.92	4.85	1.00	1.00
9	6.03	6.78	6.73	1.00	1.00
10	7.69	8.75	8.37	1.00	1.00
11	9.22	10.30	9.56	1.00	1.00
12	9.95	12.36	11.41	1.00	1.00
13	12.39	14.08	12.60	1.00	1.00
14	12.88	13.52	14.82	1.00	1.00
15	14.71	16.61	16.17	1.00	1.00
16	16.02	17.25	14.82	1.00	1.00
17	16.39	19.01	18.85	1.00	1.00
18	17.54	19.64	16.14	1.00	1.00
19	16.05	19.34	18.75	1.00	1.00
20	17.20	19.26	22.65	1.00	1.00

Table 2. Results of a yield per recruit analysis for cod in NAFO Div. 3NO.

YIELD PER RECRUIT ANALYSIS

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	0.1000	0.226	1.087	4.806	1.299
F0.1---	0.1487	0.292	1.244	4.260	1.000
	0.2000	0.345	1.310	3.800	0.783
FMAX---	0.2496	0.385	1.325	3.442	0.634
	0.3000	0.418	1.316	3.147	0.524
	0.4000	0.468	1.269	2.709	0.379
	0.5000	0.506	1.215	2.403	0.290
	0.6000	0.535	1.166	2.180	0.232
	0.7000	0.558	1.123	2.011	0.192
	0.8000	0.578	1.087	1.881	0.162
	0.9000	0.595	1.056	1.777	0.140
	1.0000	0.609	1.030	1.693	0.123
	1.1000	0.621	1.008	1.623	0.110
	1.2000	0.633	0.989	1.564	0.098
	1.3000	0.643	0.973	1.514	0.089
	1.4000	0.652	0.958	1.470	0.082
	1.5000	0.660	0.945	1.432	0.075

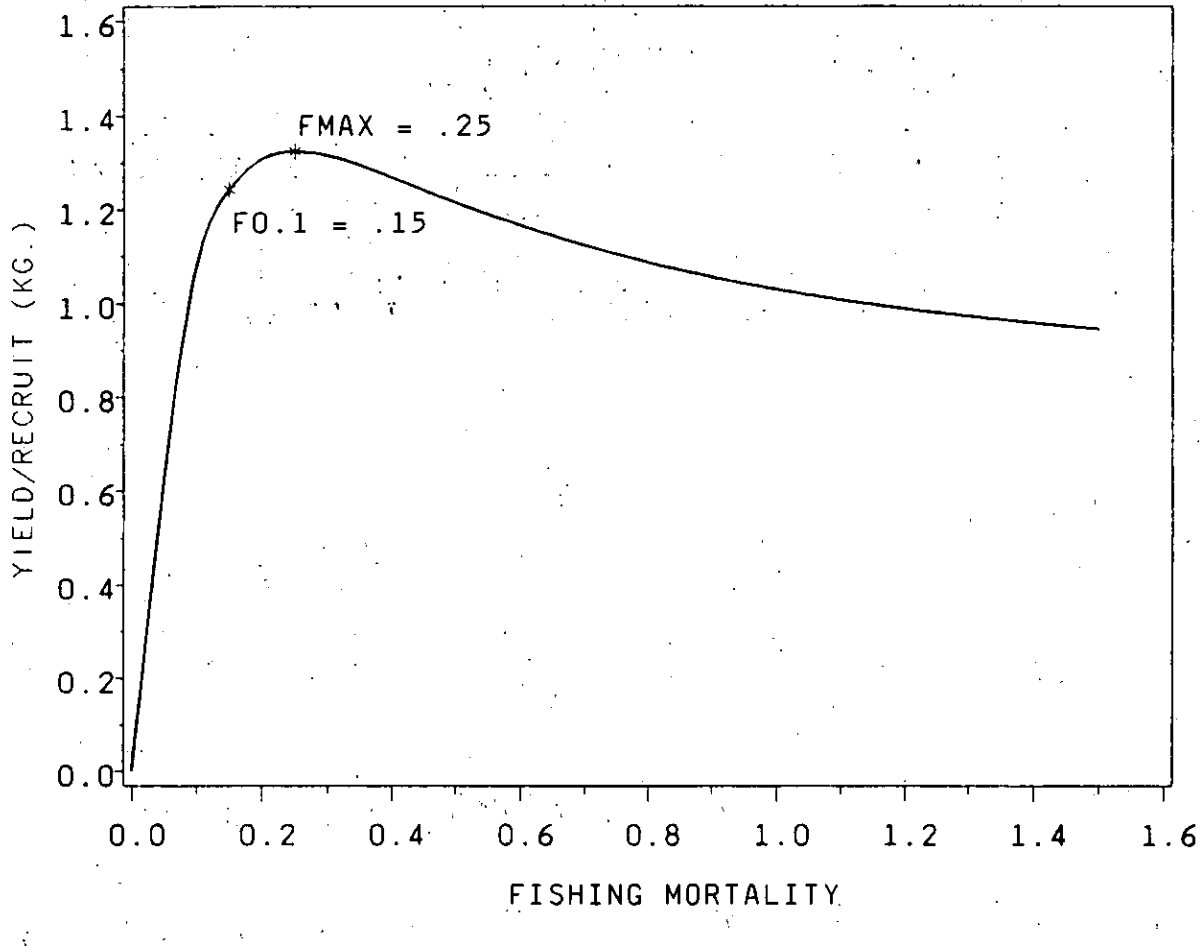

FIG 1. YIELD PER RECRUIT FOR A RANGE OF FISHING MORTALITIES FOR COD IN DIVISIONS 3NO.

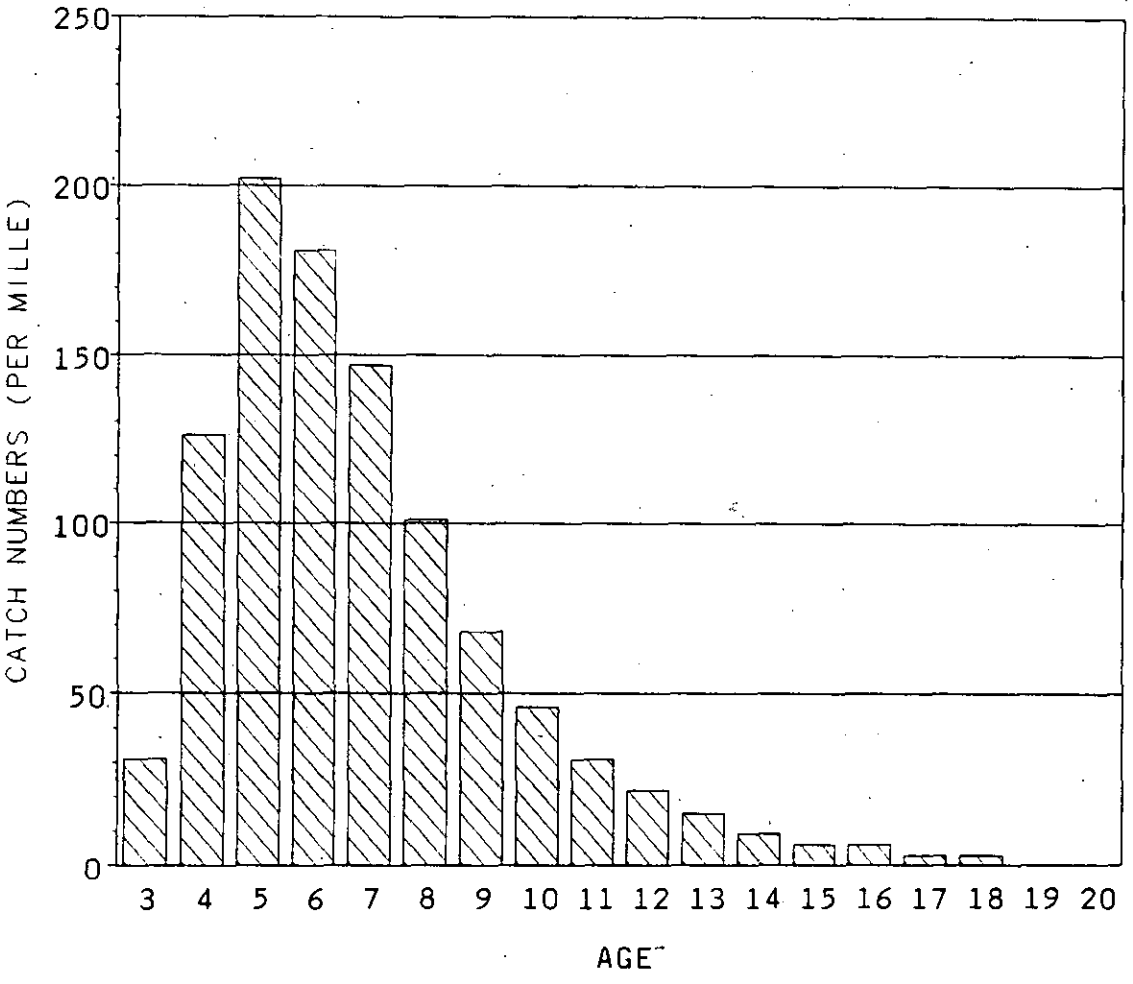

FIG. 2. PER MILLE AGE COMPOSITION BY NUMBER OF LONG TERM F0.1 CATCH FOR COD IN DIVISIONS 3NO.

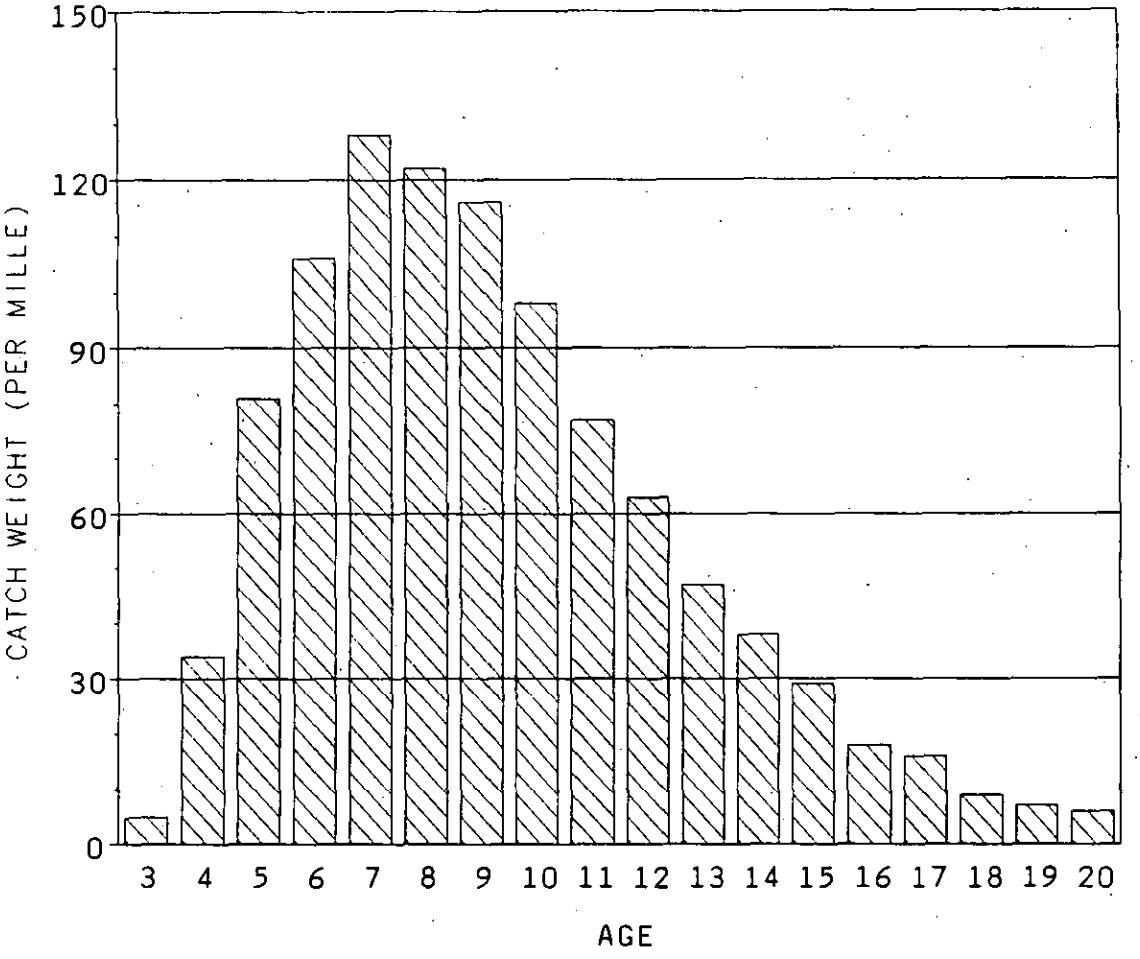

FIG. 3. PER MILLE AGE COMPOSITION BY WEIGHT OF LONG TERM FO.1 CATCH FOR COD IN DIVISIONS 3NO.