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Virtual population assessment of ICNAF Division 3Ps cod

by

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Introduction

As part of a continuing effort to assess the state of the various cod stocks in the ICNAF area, an assessment has been performed for 3Ps cod using the Gulland and Jones modifications of the "virtual population" technique. The results of this assessment are presented here.

Materials and methods

The basic data used were length frequencies, age-compositions and age-length keys published in ICNAF Sampling Yearbooks for 1959-70 and the nominal catches published in ICNAF Statistical Bulletins for the same period.

In addition age-length keys from Canada (Nfld.) research vessel cruises to the area as well as those from the inshore fishery were used where necessary.

Compilation of length composition of otter trawl catches

The procedure used to obtain representative length composition of the total catch by otter trawl (Fig. 1) was identical to that used by Pinhorn (1971) for 2J cod and consisted of adjusting the $^o/_{oo}$ frequency of each country for each month to the estimated number of fish caught by that country in that month and then combining into semi-annual and annual frequencies. However, for this assessment, because of the relative scarcity of discard data and the low level of discards indicated by the few data available, no adjustment from landings to catches was made but the numbers estimated are numbers landed rather than numbers caught. In two years, 1963 and 1964, no length frequencies were reported in the Sampling Yearbooks and the only available data were Canada (Nfld.) research frequencies. These were adjusted to the minimum regulation mesh size in use at the time. However, it was found in years in which both research and commercial frequencies were available, that even after adjusting to the minimum regulation mesh size, the research frequencies still contained more smaller fish and less larger fish than the commercial frequencies. By combining years conversion factors between research and commercial frequencies for each length group were derived and these were applied to the adjusted research frequencies in 1963 and 1964. Also, this procedure was used in 1969 where the available commercial frequencies were not considered representative of the fishery.

Compilation of numbers caught at each age

The method used to estimate numbers of cod caught at each age was similar to that described by Pinhorn (1971) for 2J cod and consisted of applying semi-annual age-length keys from various countries to the semi-annual otter trawl length frequencies derived above and then averaging countries and combining into annual frequencies. To these were added the estimated numbers landed by Canada (Nfld.) inshore gears and by other gears. In obtaining the latter, the following gear groups were used:

(a) Canada (Nfld.) codtrap + handline + jigger.
(b) Canada (Nfld.) gillnet.
(c) Canada (Nfld.) linetrawl + longline + Danish seine + Canada (M) longline + dory vessel + Portuguese dory vessel + St. Pierre and Miquelon small boats.

The landings were divided into the various inshore gear groups from information contained in a manuscript series of the St. John's Biological Station on Breakdown of Cod Catch by Type of Gear in the Newfoundland Inshore Fishery. In each of these gear groups the Canada (Nfld.) inshore age-compositions were used to estimate the numbers landed at each age and these were combined with otter trawl numbers to provide estimates of total number landed from the stock in each year (Fig. 2).

No estimate of M is available for this stock at present but calculations for Subarea 1 cod and for Division 2J cod indicate that M is likely to be in the range of 0.15 to 0.20. An estimate of 0.2 was therefore used for this VPA and a few trial calculations indicated that E = 0.7 and $E(1-e^{-Z}) = 0.343$ were probably close to the actual values.

Results

Fishing mortality

Table 1 shows estimates of numbers of cod caught per year and age-group during 1959-70. Table 2 shows fishing mortality estimates (F) for ages 3-11 calculated from the figures in Table 1.

Fishing mortality estimates (F) for ages 3-11 fluctuated only moderately between 0.3 and 0.4 during 1959-68 except for 1966 when the estimate of F was unusually high especially for cod older than 6 years (Table 2). There is some reason to doubt the validity of the estimates for this year since neither the effort nor the catch increased significantly. The cod in this area are fully recruited at 7 years of age with very few 3-year-olds being taken, the 50% recruitment age being approximately 4.5 years.

Stock size

Numbers present in the stock at the beginning of the year (Table 3 and Fig. 3) indicated that the total stock size of fish 3 years old and older decreased from about 200 million fish in 1959 to a low of 100 million in 1964 and then increased to 175 million in 1968. This resulted from poorer recruitment from the 1956-60 year-classes and better recruitment from the 1961-65 year-classes. The numbers of 6+ fish have declined fairly steadily from 34 million in 1959 to 14 million in 1967 and 17 million in 1968.

Yield per recruit

Yield per recruit calculations incorporating the partial recruitment estimates shown in Table 2 produced a curve almost identical to that presented by Pinhorn and Wells (1970) (Fig. 4). The point of maximum sustained yield per recruit was at an F-level of 0.3. The level of F for fully recruited age-groups prevailing in the 1960's was between 0.3 and 0.55 and thus was beyond this level of maximum sustained yield per recruit, being in the range of 90-100% of the maximum (Fig. 4). The general conclusion therefore is the same as from the previous catch/effort assessment that further increases in fishing effort on this stock will not result in long-term increases in yield and may result in long-term decreases in catch per unit effort. In fact some reduction in fishing effort would probably not impair the yield and may result in an increased catch per unit of effort.

References

Pinhorn, A.T. 1971. Virtual Population Assessment of ICNAF Division 2J Cod. ICNAF Res. Bull. No. 8. pp. 75-85.

Wells, R. and A.T. Pinhorn. 1970. Growth and mortality changes in Cod from ICNAF Subareas 2 and 3. ICNAF Annual Meeting. Res. Doc. 70/38.

Table 1. Number of cod caught per year and age-group ICNAF Division 3Ps, 1959-70 (X10^{-3}).

Age \ Year	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	-	-	-	-	-	-	12	-	-	55	-	-
3	1001	567	450	1245	961	1906	2314	949	2871	1143	774	756
4	13940	5496	5586	6749	4499	5785	9636	13662	10913	12602	7098	8114
5	7525	23704	10357	9003	7091	5635	5799	13065	12900	13135	11585	12916
6	7265	6714	15960	4533	5275	5179	3609	4621	6392	5853	7178	9763
7	4875	3476	3616	5715	2527	2945	3254	5119	2349	3572	4554	6374
8	942	3484	4680	1367	3030	1881	2055	1586	1364	1308	1757	2456
9	1252	1020	1849	791	898	1891	1218	1833	604	549	792	730
10	1260	827	1376	571	292	652	1033	1039	316	425	717	214
11	631	406	446	187	143	339	327	517	380	222	61	178
12	545	407	265	140	99	329	68	389	95	111	120	77
13	44	283	560	135	107	54	122	32	149	5	67	121
14	-	27	58	241	92	27	36	22	3	107	110	14
14+	-	83	33	148	192	206	129	53	52	399	110	167
Total	39280	46494	45236	30825	25206	26829	29612	42887	38388	39486	34923	41880

Table 2. Fishing mortality estimates by year and age-group for cod in ICNAF Division 3Ps, 1959-68. Estimates in brackets not used in calculation of averages.

Age \ Year	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	$\bar{F}$ 1959-68	Change in F with age as % of F in fully recruited age-groups, 1959-68
3	0.02	-	0.01	0.03	0.03	0.03	0.03	0.01	0.03	0.02	0.02	4
4	0.16	0.13	0.14	0.21	0.14	0.21	0.21	0.25	0.18	0.20	0.18	38
5	0.26	0.43	0.40	0.34	0.35	0.26	0.33	0.49	0.40	0.33	0.36	77
6	0.40	0.39	0.59	0.31	0.35	0.47	0.26	0.48	0.47	0.32	0.40	85
7	0.38	0.34	0.38	0.44	0.29	0.34	0.62	0.72	0.48	0.53	0.45	100
8	0.20	0.52	(1.07)	0.24	0.45	0.36	0.43	0.73	0.42	0.54	0.43	100
9	0.43	0.35	0.57	0.51	0.25	0.56	0.42	(0.87)	0.59	0.30	0.44	100
10	0.60	0.56	(1.17)	0.34	0.36	0.29	0.70	0.76	0.35	(1.14)	0.50	100
11	0.39	0.39	0.68	0.46	0.13	0.93	0.23	0.97	0.72	0.45	0.54	100
Average Ages 3-11	0.32	0.39	0.40	0.32	0.26	0.38	0.36	0.55	0.40	0.34		
Average Ages 7-11	0.40	0.43	0.54	0.40	0.30	0.50	0.48	0.80	0.51	0.46		

Table 3. Number of cod present in the stock at the beginning of the year $(X10^{-6})$, ICNAF Division 3Ps, 1959-68.

Age \ Year	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
3	50	(50)	50	47	36	71	87	105	108	64
4	104	47	47	40	37	31	56	68	79	81
5	36	73	35	34	26	27	22	37	43	51
6	24	23	39	19	20	15	17	13	19	24
7	17	13	13	18	11	11	8	11	7	10
8	6	9	8	7	9	7	6	3	4	3
9	4	4	5	2	4	5	4	3	1	2
10	3	2	2	1	1	3	2	2	1	1
11	2	1	1	-	1	1	2	1	1	1
12	2	1	1	-	-	1	-	1	-	-
13	-	1	1	-	-	-	-	-	-	-
14	-	-	1	-	-	-	-	-	-	-
2+	254	224	203	168	145	172	204	244	263	237
3+	198	174	153	121	109	101	117	139	155	173
3-6	220	193	171	140	119	144	182	223	249	220

843 ——— 1018

+21%

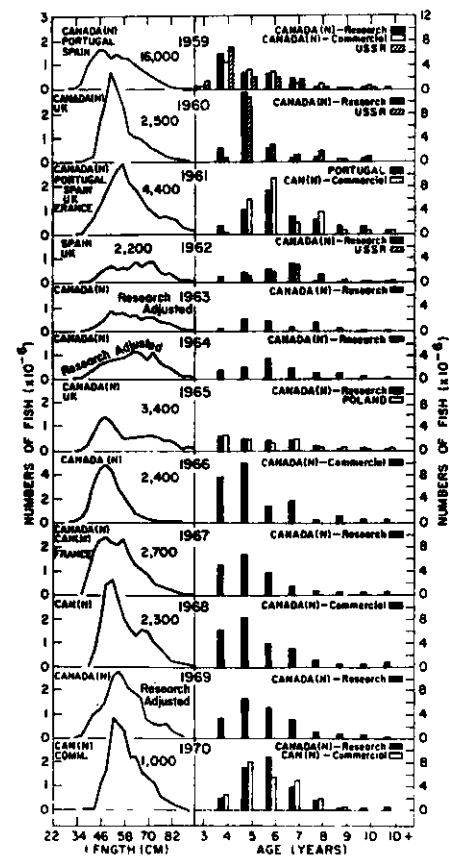|										
6+	34	31	32	28	26	28	22	21	14	17

151 ——— 102

-32%

Fig. 1. Length and age distributions of otter trawl catches used in 3Ps cod assessment, 1959-70.
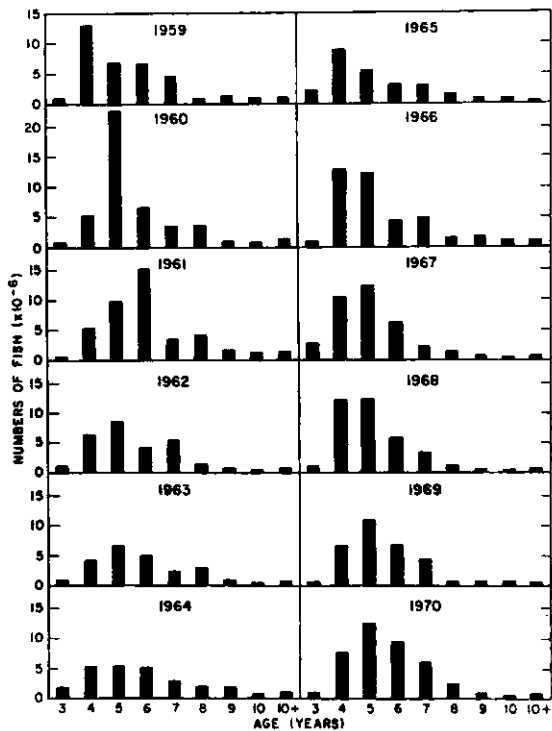
Fig. 2. Total numbers of cod caught per year and age-
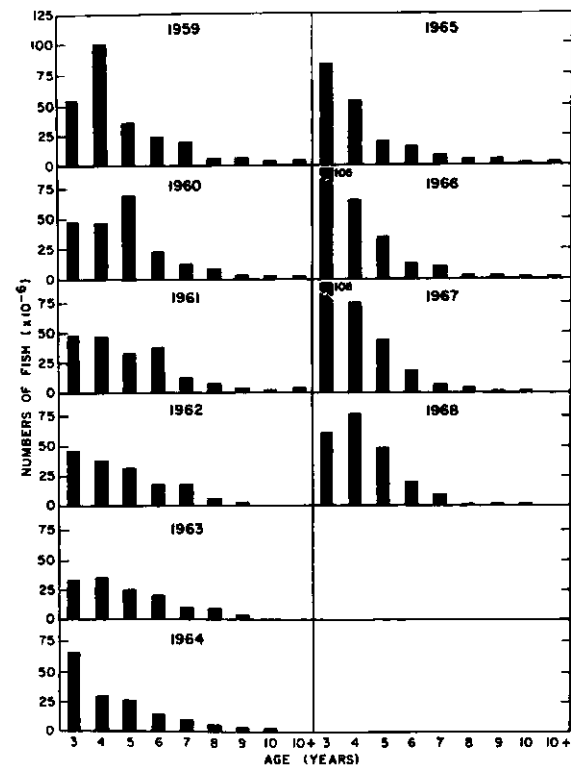group by all gears, ICNAF Div. 3Ps, 1959-70.

Fig. 3. Numbers of cod per age-group present in the stock at the
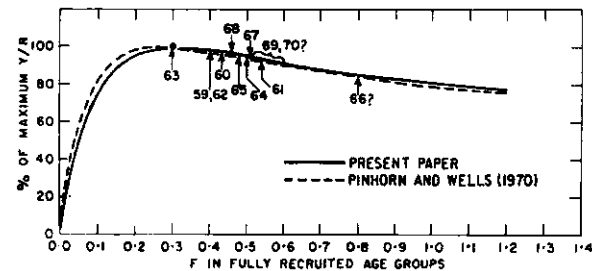beginning of the year, ICNAF Div. 3Ps, 1959-68.

Fig. 4. Yield-per-recruit curves for ICNAF Div. 3Ps cod incor-
porating partial recruitment estimates. Arrows indicate
levels of F in various years. Circled points represent
level of maximum sustained yield per recruit.

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APPENDIX TO RES DOC 72/4

3 Ps COD

PREDICTED YIELDS IN 1973 AT VARIOUS LEVELS OF F IN 1971-73