



Serial No. 2827
(D.c.3)

ICNAF Res.Doc. 72/109

ANNUAL MEETING - JUNE 1972

Combined Virtual Population Assessment for ICNAF
Divisions 2J, 3K and 3L Cod

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Introduction

A virtual population assessment of 2J cod has been presented by Pinhorn (1971) and has been updated at the present meeting (Res. Doc. 72/3). In addition, a similar assessment for Divisions 3K and 3L cod is contained in a document to the 1972 Annual Meeting. The combined assessment for Divisions 2J-3L is presented here.

Materials and methods

The basic data used and the method of treatment of the data to produce the individual virtual population assessment for 2J, 3K and 3L are presented in the relevant documents. In deriving the assessment for 2J-3L combined, numbers of cod caught at each age (Table 1) were combined for the three divisions and a separate VPA was determined using the combined data. Natural mortality of 0.2 was again used and $E(1-e^{-Z}) = 0.506$ was assumed for the oldest age-groups. Average weight-at-age data were derived from growth curves and length-weight curves for the most recent period available for each division and these were weighted by the average numbers caught in each division for the same period to produce average weight-at-age values for 2J-3L.

Results

Fishing mortality

Fishing mortality estimates (F) for ages 3-13 fluctuated around 0.3-0.4 during 1961-66 except for 1965 when F was 0.46 (Table 2). The F in 1968 was 0.56, the highest value during the period. F-values for fully recruited age-groups of 1.20 for 1969 and 0.68 for 1970 were estimated from stock sizes at the beginning of each year and the catch in that year as shown below. Cod from this stock complex are fully recruited at 7 years of age with very few 3-year-olds being taken, the 50% recruitment being about 5.4 years.

<u>Age</u>	<u>1969</u>	<u>1970</u>
4	0.05	?
5	0.16	0.13
6	0.42	0.24
6+	1.20	0.63

Stock size

Numbers present in the stock at the beginning of the year (Table 3) indicated that the total stock size of fish 4 years old and older decreased from 2200 million in 1961 to 1800 million in 1964 but increased to 2400-2500 million in 1968-69, due to better recruitment from the year-classes of the early 1960's. The numbers of fully recruited fish (6+) decreased from 643 million in 1961 to 320 million in 1969.

Yield per recruit

Yield per recruit calculations incorporating the partial recruitment estimates shown in Table 2 produced an almost flat-topped curve with a point of maximum sustainable yield per recruit at an F-level of about 0.4 and an optimum fishing level according to the definition of the Midterm Assessment Subcommittee Meeting (1972) at a level of 0.28 (Fig. 1). The level of F in fully recruited age-groups during 1961-66 fluctuated around the level of maximum yield per recruit except for 1965 when it was beyond it, but the F during 1967-70 was estimated to be well beyond the maximum level. Considerable reduction in fishing effort below the recent levels is necessary to even return to the point of maximum sustainable yield and as indicated by the Assessment Subcommittee at its Midterm Meeting (1972) fishing at a point somewhat below the maximum level is more practicable in cases of flat-topped yield curves. Such a reduction would not impair the long-term yield but would result in increased catch per unit of effort.

Predicted yields in 1973

Probable yields in 1973 for any likely combination of F in 1971-73 are shown in Fig. 2 and 3. These are calculated in a similar manner to those calculated in recent years for Subarea 1 cod (Redbook 1971, Part I). Recruitment of the 1967 and 1968 year-classes in 1971 and 1972 was estimated from USSR survey data in Division 3K as presented in Konstantinov (1971) and in 1972 Midterm Assessment Subcommittee Report (Res. Doc. 72/1). Recruitment from the 1969 year-class in 1973 was assumed to be at the same level as the 1968 year-class in 1972. Since the recruitment pattern (pattern of fishing) in 1969 and 1970, as is shown by the above text table, was different from the average recruitment pattern for 1961-68, probably because of severe ice conditions in the north and since ice conditions were reported to be more severe than usual in this area in 1971 and 1972, two sets of calculations were performed; those shown in Fig. 2 using the average recruitment pattern for 1971-73 and those shown in Fig. 3 using the 1969-70 recruitment pattern for 1971 and 1972 and the average recruitment pattern for 1973.

References

- Pinhorn, A. T. 1971. Virtual population assessment of ICNAF Division 2J cod. ICNAF Res. Bull. No. 8: 75-85.
- Konstantinov, K. G. 1971. The status of stocks and prospectus of cod fisheries in the Northwest Atlantic. ICNAF Annual Meeting, Res. Doc. 71/11, 14 p.

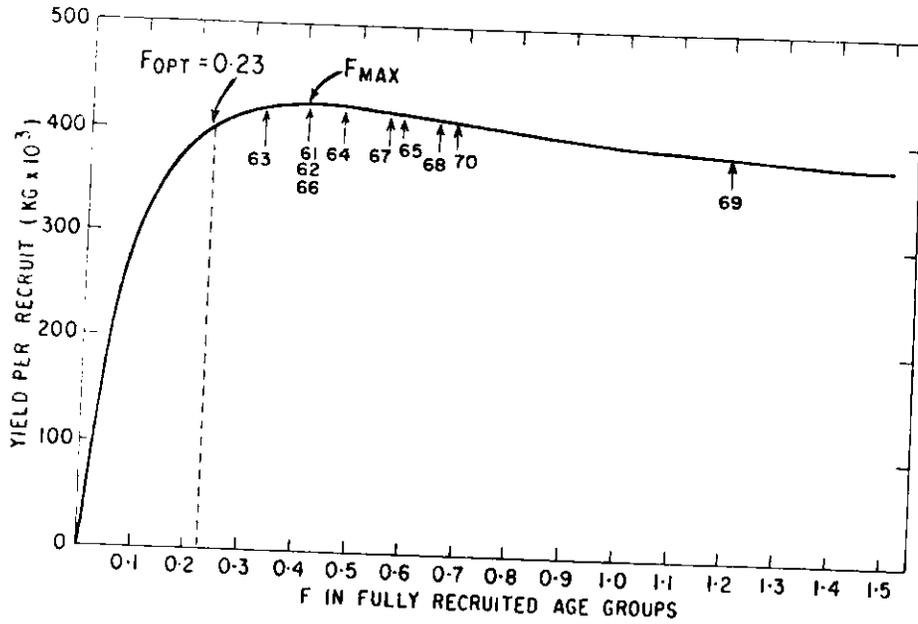


Fig. 1. Yield per recruit for 2J-3L cod.

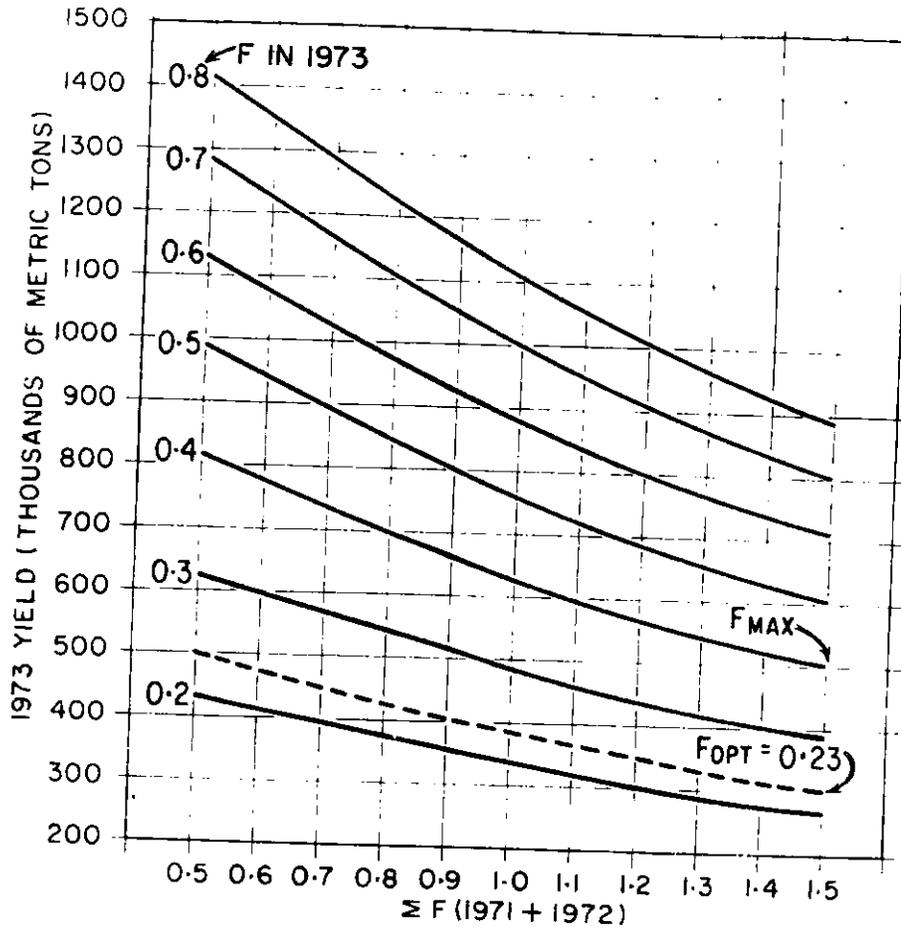


Fig. 2. Estimated yield in 1973 for likely combinations of F in 1971-73 assuming average recruitment pattern in 1971-73.

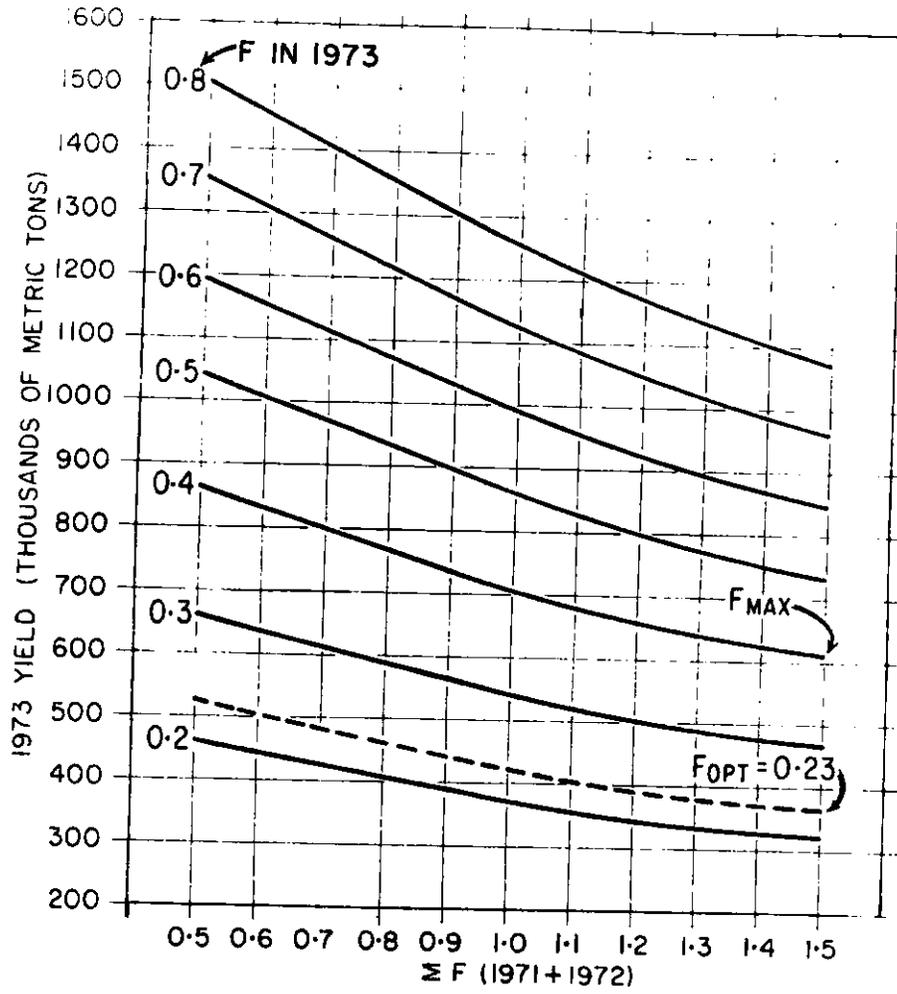


Fig. 3. Estimated yield in 1973 for likely combination of F in 1971-73 assuming recruitment pattern in 1971 and 1972 to be same as in 1969-70 and average recruitment pattern in 1973.

Table 1. Number of cod caught per year and age-group, ICNAF Divisions 2J-3L, 1961-70 ($\times 10^{-3}$).

Age	Year									
	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
3	1,543	8,866	5,644	18,183	5,042	14,177	15,587	5,993	4,192	17,053
4	32,268	26,682	27,069	26,676	28,034	66,290	78,450	91,606	38,098	57,228
5	45,692	65,820	59,173	56,321	45,633	94,234	100,904	199,044	96,366	77,311
6	58,462	59,973	115,864	58,957	65,481	63,221	97,204	144,998	153,370	93,961
7	45,345	48,635	57,875	98,050	62,862	59,771	55,252	80,902	100,645	78,789
8	34,903	28,389	28,760	49,825	67,106	30,656	38,820	37,891	49,342	26,873
9	29,480	20,748	15,186	20,191	33,353	24,045	17,190	22,431	18,370	9,981
10	22,169	18,599	11,371	11,792	14,674	8,828	16,103	7,647	11,540	3,576
11	12,793	10,767	8,061	8,433	6,845	4,652	5,962	5,374	6,002	1,876
12	12,025	9,755	4,117	6,111	3,680	2,254	3,360	3,362	4,190	1,129
13	9,766	8,038	3,855	4,811	3,881	1,836	2,113	1,902	2,820	478
14	7,398	5,954	2,872	3,869	3,672	1,194	1,523	1,302	1,479	215
15	4,026	4,798	2,864	2,615	2,685	972	683	802	598	210
15+	4,941	11,321	5,060	5,407	4,012	2,331	1,094	1,010	852	349
Total	320,811	328,345	347,771	371,241	346,960	374,461	434,245	604,264	487,921	375,510

Table 2. Fishing mortality estimates for ICNAF Divisions 2J-3L, 1961-68.

Age	Year									Change in F with age as % of fully recruited age-groups 1961-68
	1961	1962	1963	1964	1965	1966	1967	1968	\bar{F} 1961-68	
3	0.003	0.014	0.012	0.026	0.006	0.012	0.015	0.006	.01	2
4	0.042	0.059	0.055	0.070	0.050	0.10	0.08	0.11	.07	15
5	0.11	0.11	0.18	0.15	0.15	0.23	0.22	0.31	.18	38
6	0.24	0.20	0.30	0.27	0.27	0.31	0.39	0.56	.32	67
7	0.33	0.33	0.31	0.45	0.51	0.43	0.50	0.66	.44	100
8	0.35	0.35	0.33	0.48	0.64	0.50	0.56	0.78	.50	100
9	0.39	0.37	0.32	0.41	0.69	0.50	0.58	0.77	.50	100
10	0.44	0.46	0.35	0.44	0.59	0.39	0.75	0.56	.50	100
11	0.31	0.39	0.37	0.47	0.50	0.37	0.51	0.60	.44	100
12	0.42	0.41	0.25	0.53	0.39	0.30	0.49	0.61	.43	100
13	0.58	0.56	0.28	0.52	0.77	0.34	0.50	0.59	.52	100
Avg. ages 4-13	0.32	0.32	0.27	0.38	0.46	0.35	0.46	0.56		
Avg. ages 7-13	0.40	0.41	0.32	0.47	0.58	0.40	0.56	0.65		

Table 3. Number of fish present in the stock at the beginning of the year ($\times 10^{-6}$), ICNAF Divisions 2J-3L, 1961-68.

Age	Year								
	1961	1962	1963	1964	1965	1966	1967	1968	1969*
4	811	482	566	429	630	764	1,092	948	903
5	484	666	396	439	347	499	565	833	707
6	301	360	501	272	309	257	329	369	491
7	177	192	241	297	171	189	155	183	173
8	129	104	112	143	155	85	99	76	77
9	100	75	61	66	73	67	42	46	29
10	68	55	42	36	36	30	33	20	17
11	53	36	29	24	19	16	16	13	9
12	38	32	20	16	13	10	9	8	6
13	24	21	17	13	8	7	6	5	4
14	25	15	11	11	8	3	4	3	2
15	13	15	11	7	6	4	2	2	1
15+	16	26	20	15	11	8	4	2	2
Total ages 4-15+	2,239	2,079	2,027	1,768	1,786	1,939	2,356	2,508	2,421
Total ages 7-15+	643	571	564	628	500	419	370	358	320

*Estimated from stock at beginning of 1968 and F in 1968.