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An assessment of the cod stock in Subdivision 3Ps

by

C.A. Bishop
Department of Fisheries and Oceans
P.O. Box 5667
St. John's, Newfoundland
A1C 5X1

Nominal catches

Catches of cod in Subdivision 3Ps have declined since the early 70's and have been below TAC levels with the exception of 1978. The TAC's and corresponding catches are as follows:

	1973	1974	1975	1976	1977	1978	1979
TAC('000 tons)	70,000	70,000	62,400	47,500	32,500	25,000	25,000
Catch('000 tons)	52,641	44,877	35,373	37,133	32,376	26,255	

Abundance indices

Survey data results from Subdivision 3Ps were tabulated on the basis of biomass estimates per strata for the years 1972 to 1979. A summary of biomass estimates per strata are shown in Table 1. Where surveys were incomplete for all strata, several methods of estimation were used (Bishop, 1977; ICNAF Res. Doc. 77/VI/17). The results of four methods plus an average shown in Table 1, indicate that the biomass has increased substantially.

Catch compositions

Catch compositions at age and by gear for Can (N) were derrived from commercial sampling. Catches by France in 1978 were unavailable and as such a TAC of 3,900 tons was assumed. Catch at age was obtained using an inshore-offshore breakdown as in 1977 and Can (N) age compositions, where

applicable (Table 2). Can (M) catches were adjusted using Can (N) age compositions. The total age composition for all countries is shown in Table 3.

Fishing mortality

Using fishing mortality data from a previous cohort analysis and standardized effort data for the corresponding year, an estimate of Terminal F in 1978 was obtained (Table 4). Regressions of the total fishing mortality (F_{4+}) from a series of cohort runs against effort was obtained for the years 1964-77. From the regression values a predicted F_{4+} value at each terminal F was calculated using the effort value in 1978. The best regression relationship and equation which gave the best prediction of F_{4+} at $F_t = 0.25$.

Regressions of standard C.P.U.E. against total biomass from a series of cohort runs at different terminal F values indicated a good relationship at $F_t = 0.25$ (Table 5).

A terminal F of 0.25 in 1978 was used in a cohort run.

Recruitment

Estimates of recruitment at age 3 in 1978, 79 and 80 were obtained (Table 6) from regressions of ages 1, 2 and 3 by year-class against cohort biomass at age 3 ($F_t = 0.25$). Estimated recruitment values at age 3 in 1978, 79 and 80 are 5566, 5137 and 5016. An average of these (5200) was used as the recruitment value for projections to 1987.

Yield per recruit

Estimates of yield per recruit were obtained using two methods (Table 7). In one the percent age composition in 1978 from surveys and the commercial fishery were compared while in the other F values from a cohort run (Table 8) were averaged from 1976-77. Figure 1 compares the two sets of values obtained

with the historical partial recruitment used in the cohort run. From F values in the cohort run (Table 8) it would seem that the partial recruitment had changed in recent years. The partial recruitment values obtained from averaging Fs in 1976-77 were considered more representative for use in yield per recruit estimates and catch projections. Using these partial recruitment values and average weights at age obtained from commercial cod sampling in 1977 yield per recruit values were obtained (Table 9). The F_{max} and $F_{0.1}$ values were 0.27 and 0.17 respectively. The average weight at age data for 1978 sampling were not used because they produced values lower than for 1977 and were considered to be less representative.

Projection of catches

A cohort run using Terminal F = 0.25, catch at age in 1978 and previous years data is shown in Table 8. The population size in 1978 from this run with calculated recruitment levels (Table 6) for 1978, 79, 80-87 were used to project catches up to 1987. The fishing mortality necessary to obtain a catch of 25,000 tons in 1979 was found to be 0.20. It is anticipated that given a good inshore fishery in 1979 the total catch in 3Ps could be as high as 30,000 tons. The fishing mortality for the catch would be 0.25. The $F_{0.1}$ level for this stock has been calculated at 0.20 in previous years. Using recent data a value of 0.17 has been derived for $F_{0.1}$. Projections were run (Tables 10-11) using the options of Terminal F at $F_{0.1}$ = 0.17 and 0.20 in 1980 to 87 and for catch of 25,000 and 30,000 tons in 1979 and with average weight at age data from the 1978 commercial fisheries. Table 10 shows the results of a projection assuming a TAC catch of 25,000 in 1979 and fishing at $F_{0.1}$=0.17 in 1980 and beyond. Table 11 gives a summary of projected catches under the different options.

Table 1. Comparison of cod biomass estimates (weights in metric tons on a per mille basis) obtained from stratified random research cruises in Subdivision 3Ps.

	Method					
Year:	1	2	3	4	Average 1-4	Standard CPUE (WP 79/59)
1972	167	153	193	190	176	1.44
1973	122	114	190	173	150	1.21
1974	123	113	172	94	126	.94
1975	68	89	54	36	62	.86
1976	109	97	51	94	88	1.44
1977	85	82	67	71	76	1.34
1978	97	89	81	134	100	1.66
1979	229	263	192	207	223	1.84
	1000	1000	1000	999	1001	
M	95.15	103.89	32.90	123.33	88.48	
B	-2.62	-14.32	80.89	-40.55	6.45	
r	.62	.58	.16	.67	.54	
T	1.93	1.73	.41	2.24	1.56	
DF	6	6	6	6	6	

Table 2 A. Nominal catches by France (M+SPM) in 3Ps during 1979 and 78.

Month	1977 Offshore	1977 Inshore	1978 Catches	
J	83			
F	12		1653	
M	950		1336	
A	36		119	
M	161	7	162	
J	1	110	75	assumed inshore in 1978
J		237	110	
A		345	110	
S		112	43	
O	3	33	22	
N	11	1	137	
D	884		133	
	2141	845	3900	

B. Age composition of catch by France in 1978 bases on Can(N) sampling

Age	Quarter 1 (OT)	Quarter 2 + 4 (OT)	Inshore Gear*	Total
3			6	6
4	134	22	72	228
5	492	59	93	644
6	650	167	57	874
7	288	18	24	330
8	104	20	8	132
9	18	2	1	21
10	14	2	1	17
11	4	2	1	7
12	2			2
13	2			2
# '000s	1708	292	263	2263
Catch	2989	551	360	3900
Av. Wt.	1.75	1.89	1.37	1.72

*Based on age composition for Can(N) .HL

Table 3. Age composition of the 1978 catch of cod by country in Subdivision 3Ps

Age	Canada (N)	Canada M	France	Total
2	2			2
3	212		6	218
4	4015	30	228	4273
5	4548	99	644	5291
6	2914	164	874	3952
7	1371	53	330	1754
8	543	23	132	698
9	216	2	21	239
10	166	2	17	185
11	66		7	73
12	24		2	26
13	17		2	19
14	10			10
15	10			10
16	5			5
17	2			2
18	1			1
19				
20	1			1
21	2			2
22	1			1
NK	1			1
Number	14,127	373	2,263	16,763
Catch	21,688	667	3,920	26,255
Av. Wt.	1.54	1.79	1.72	1.57

Table 4. Regressions of Effort against Total F (F_{4+}) for different Terminal F values.

		F_{4+} at F_t				
YEAR	EFFORT	.15	.20	.25	.30	.35
1964	24271	.3095	.3095	.3095	.3095	.3095
5	23251	.2968	.2968	.2968	.2968	.2968
6	28420	.4134	.4134	.4134	.4134	.4134
7	33508	.3233	.3233	.3233	.3233	.3233
8	32551	.2951	.2951	.2951	.2951	.2951
9	28160	.2677	.2677	.2677	.2677	.2677
70	41050	.3728	.3736	.3741	.3745	.3747
1	40953	.4356	.4393	.4415	.4430	.4441
2	30678	.2570	.2618	.2647	.2667	.2682
3	43525	.3998	.4133	.4219	.4278	.4321
4	49928	.3834	.4127	.4326	.4470	.4578
5	40975	.3408	.3882	.4236	.4511	.4730
6	25719	.2433	.2925	.3329	.3667	.3953
7	24167	.1708	.2178	.2610	.3007	.3374
8	15813					
Predicted F_+ (1978)		.22	.23	.24	.25	.26
r		.68	.75	.77	.74	.69
Slope		5.95×10^{-6}	6.16×10^{-6}	6.15×10^{-6}	6.04×10^{-6}	5.86×10^{-6}
Intercept		.1235	.1306	.1418	.1545	.1678
T		3.2213	3.971	4.117	3.7753	3.2829
D.F.		12	12	12	12	12

Table 5. Regressions of catch per unit effort against VPA biomass for different Terminal F values.

		Total VP.A. Biomass (3^+) at F_t				
YEAR	STANDARD CPUE	0.15	.20	.25	.30	.35
1964	2.22	19884	19884	19884	19884	19884
5	2.21	20270	20270	20270	20270	20270
6	2.31	21593	21593	21593	21593	21593
7	1.86	21359	21359	21359	21359	21359
8	2.37	22518	22518	22518	22518	22518
9	2.24	22791	22776	22767	22761	22757
70	1.86	21919	21872	21843	21824	21811
1	1.56	20216	20096	20023	19975	19941
2	1.44	16938	16717	16585	16497	16434
3	1.21	16373	15937	15677	15503	15379
4	.94	15522	14659	14142	13798	13553
5	.86	16152	14497	13505	12845	12374
6	1.44	18536	15592	13827	12653	11815
7	1.34	23271	18543	15709	13822	12476
8	1.66	25461	19439	15829	13425	11711
9	1.84					
r		.63	.89	.88	.84	.81
Slope		3690	5129	5995	6570	6980
Intercept		13909	10321	8170	6738	5717
T		2.8916	7.0362	6.6679	5.5912	4.9612
D.F.		13	13	13	13	13

Table 6. Regressions of survey biomass (metric tons) by year-class against VPA biomass at age 3 along with estimates of recruitment at age 3 in 1978-80 using the regression values obtained.

YEAR CLASS	AGE 1	AGE 2	AGE 3	VPA BIOMASS AT AGE 3(F_t = o.25)
1978	992			
77	0	410		
76	6	300	611	
75	203	136	466	
74	198	2855	2197	6286
73	579	398	1855	7005
72	20	1753	1117	6804
71	28	834	1745	5078
70	-	732	1057	3500
69	287	-	1281	3504
68	18	5765	-	5903
67	174	1746	3219	3600
66	141	25634	9512	5574
65	-	5551	11601	7422
64	885	-	11512	10050
63	408	5062	-	8394
62	620	5527	23002	8247
61	68	3781	8368	6993
r	.66	.61	.63	
m	4.49	.4765	.19	
B	5171	4821	4960	
T	2.76	2.313	2.56	
DF	10	9	10	

YEAR	ESTIMATED RECRUITMENT			Average
1978	6082		5049	5566
1979	5198		5076	5137
1980		5016		5016
				5200

Table 7. Calculation of partial recruitment from comparison of survey and commercial age compositions in 1978 and from 1976-77 F values in the cohort (Table 8).

AGE	% COMM. AGE COMP.	% SURVEY AGE COMP.	COMM/ SURVEY	PARTIAL RECRUITMENT	PART. RECRUIT. FROM AVG. OF F^S in 1976-77
3	1.32	10.27	0.13	.10	.12
4	25.57	37.62	0.68	.51	.71
5	31.68	16.13	1.96	1.00	1.00
6	23.65	11.57	2.04	1.00	1.00
7	10.48	8.37	1.25	1.00	1.00
8	4.19	5.84	0.72	1.00	1.00
9	1.44	3.44	0.42	1.00	1.00
10	1.08	3.24	0.33	1.00	1.00
11	.42	1.12	0.38	1.00	1.00
12	.18	.40	0.45	1.00	1.00

Table 8.

COD 3PS 1964-78

NATURAL MORTALITY= 0.20

PARTIAL RECRUITMENT MULTIPLIER

0.0700	0.3900	0.7200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

ASSUMED FISHING MORTALITY FOR LAST AGES

0.5100	0.4900	0.6700	0.5600	0.6000	0.7700	1.0000	0.9400	0.8400	0.6300	1.0700	0.8200	0.2200	0.2300	0.2500

ESTIMATED POPULATION

AGE YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
3	6993.	8247.	8394.	10050.	7422.	5574.	3600.	5903.	3504.	3500.	5078.	6804.	7005.	6286.	1399.
4	3339.	5552.	6543.	6786.	7969.	5974.	4494.	2878.	4573.	2803.	2775.	4004.	5404.	5363.	5063.
5	2653.	2210.	3674.	4121.	4569.	5384.	4248.	2945.	1774.	3297.	1869.	1774.	2615.	3326.	3533.
6	1561.	1662.	1285.	1826.	2207.	2552.	3360.	2309.	1636.	1037.	1659.	960.	964.	1424.	1962.
7	1089.	809.	1034.	634.	917.	1278.	1440.	1868.	1233.	1018.	487.	924.	376.	529.	869.
8	680.	626.	369.	383.	306.	428.	634.	602.	786.	593.	481.	182.	225.	190.	348.
9	480.	386.	326.	158.	191.	132.	191.	297.	210.	404.	287.	176.	64.	139.	119.
10	225.	222.	206.	101.	75.	107.	37.	90.	127.	97.	150.	54.	36.	56.	89.
11	62.	126.	89.	75.	54.	23.	22.	11.	25.	62.	34.	32.	35.	25.	35.
12	90.	20.	73.	25.	27.	24.	14.	2.	2.	2.	33.	10.	11.	27.	15.

KNOWN CATCHES

AGE YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
3	191.	231.	95.	287.	114.	77.	76.	288.	73.	100.	170.	184.	411.	92.	22.
4	578.	964.	1366.	1091.	1260.	710.	811.	644.	494.	470.	550.	733.	1214.	949.	427.
5	564.	580.	1306.	1290.	1314.	1158.	1292.	857.	459.	1150.	630.	540.	792.	841.	529.
6	518.	361.	462.	639.	585.	718.	976.	727.	355.	400.	480.	454.	282.	328.	395.
7	294.	325.	512.	235.	357.	455.	637.	822.	460.	390.	240.	587.	130.	94.	175.
8	188.	206.	159.	136.	131.	176.	246.	313.	264.	220.	240.	72.	50.	40.	70.
9	189.	122.	183.	60.	55.	79.	73.	128.	83.	200.	200.	120.	14.	27.	24.
10	65.	103.	104.	32.	42.	72.	21.	54.	46.	50.	100.	10.	5.	12.	16.
11	34.	33.	52.	38.	22.	6.	18.	8.	20.	20.	20.	17.	2.	6.	7.
12	33.	7.	39.	10.	11.	12.	8.	1.	1.	1.	20.	5.	2.	5.	3.

ESTIMATE FISHING MORTALITY

AGE YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
3	0.0307	0.0314	0.0126	0.0321	0.0171	0.0154	0.0236	0.0554	0.0233	0.0321	0.0377	0.0303	0.0670	0.0163	0.0
4	0.2124	0.2130	0.2623	0.1956	0.1921	0.1408	0.2225	0.2841	0.1271	0.2050	0.2473	0.2281	0.2654	0.2176	0.0
5	0.2678	0.3425	0.4991	0.4246	0.3825	0.2714	0.4096	0.3880	0.3368	0.4870	0.4660	0.4101	0.4076	0.3277	0.0
6	0.4568	0.2745	0.5065	0.4890	0.3467	0.3724	0.3871	0.4276	0.2742	0.5557	0.3854	0.7391	0.4008	0.2937	0.0
7	0.3542	0.5865	0.7921	0.5271	0.5628	0.5003	0.6714	0.6662	0.5316	0.5505	0.7865	1.2118	0.4822	0.2188	0.0
8	0.3648	0.4521	0.6476	0.4975	0.6396	0.6069	0.5598	0.8541	0.4642	0.5275	0.8024	0.5765	0.2817	0.2651	0.0
9	0.5711	0.4292	0.9682	0.5445	0.3833	1.0781	0.5496	0.6478	0.5744	0.7911	1.4754	1.3933	0.2048	0.2416	0.0
10	0.3840	0.7187	0.8165	0.4290	0.9645	1.3742	0.9931	1.0845	0.5109	0.8464	1.3334	0.2307	0.1674	0.2718	0.0
11	0.9383	0.3429	1.0458	0.8290	0.5975	0.3330	2.3160	1.5645	2.1686	0.4371	1.0510	0.8678	0.0655	0.3107	0.0
12	0.5100	0.4900	0.6700	0.5600	0.6000	0.7700	1.0000	0.9400	0.8400	0.6300	1.0700	0.8200	0.2200	0.2300	0.2500

TOTAL F AGES 4 TO 11

0.3095	0.2968	0.4134	0.3233	0.2951	0.2677	0.3741	0.4415	0.2647	0.4219	0.4326	0.4236	0.3329	0.2610

POPULATION WTS AND NOS

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
WT	19884.	20270.	21593.	21359.	22518.	22767.	21843.	20023.	16585.	15677.	14142.	13505.	13827.	15709.	15829.
NO	17172.	19861.	21992.	24160.	23737.	21475.	18039.	16906.	13869.	12813.	12652.	14920.	16754.	17364.	13432.

POPULATION WTS AND NOS AGE 6 TO 12

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
WT	11534.	10285.	9266.	7635.	8665.	10263.	12489.	12171.	9892.	8579.	7696.	5724.	4068.	5534.	7840.
NO	4188.	3851.	3381.	3203.	3777.	4544.	5698.	5179.	4018.	3214.	3130.	2338.	1730.	2389.	3437.

Table 9(A) Yield per recruit analysis for Subdivision 3Ps cod.

FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AUG. WEIGHT (KG)	YIELD PER UNIT EFFORT
0.1000	0.259	0.670	2.583	1.000
0.1660 $F_{0.1}$	0.359	0.806	2.245	0.725
0.2000	0.398	0.836	2.100	0.624
0.2698 F_{max}	0.460	0.854	1.856	0.473
0.3000	0.482	0.852	1.768	0.424
0.4000	0.538	0.827	1.536	0.389
0.5000	0.579	0.794	1.371	0.237
0.6000	0.610	0.762	1.249	0.190
0.7000	0.634	0.733	1.157	0.156
0.8000	0.654	0.709	1.084	0.132
0.9000	0.671	0.688	1.026	0.114
1.000	0.685	0.670	0.987	0.100

(B) Input data - yield per recruit

AGE	PARTIAL RECRUITMENT	AGE WEIGHTS
3	.12	.55
4	.71	.68
5	1.00	1.30
6	1.00	1.86
7	1.00	2.67
8	1.00	3.42
9	1.00	4.19
10	1.00	4.94
11	1.00	5.92
12	1.00	6.76
13	1.00	8.98
14	1.00	10.90
15	1.00	11.20

Table 10. Catch and population projection (1978-87) of Subdivision 3Ps cod. (No's X 10^{-4})

POPULATION BIOMASS

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
3	2475.00	2340.00	2250.00	2340.00	2340.00	2340.00	2340.00	2340.00	2340.00	2340.00
4	3544.10	3138.20	2919.24	2807.69	2920.00	2920.00	2920.00	2920.00	2920.00	2920.00
5	3815.64	4060.95	3507.97	3268.26	3143.38	3269.12	3269.12	3269.12	3269.12	3269.12
6	3468.50	4228.26	4535.30	3926.28	3657.99	3518.21	3658.94	3658.94	3658.94	3658.94
7	2129.05	3105.06	4079.95	4385.76	3796.83	3537.38	3402.21	3538.30	3538.30	3538.30
8	1040.52	1656.61	2611.80	3439.30	3697.10	3200.64	2981.93	2867.99	2982.71	2982.71
9	487.90	909.98	1565.66	2473.79	3257.57	3501.75	3031.52	2824.37	2716.45	2825.11
10	459.24	391.33	789.34	1361.05	2150.50	2831.86	3044.12	2635.35	2455.26	2361.45
11	180.95	293.01	270.24	546.28	941.95	1488.31	1959.85	2106.75	1823.85	1699.22
12	108.00	160.98	281.25	259.96	525.50	906.11	1431.68	1885.28	2026.59	1754.46
	17708.90	20284.39	22810.74	24808.38	26430.81	27513.36	28039.37	28046.10	27731.23	27349.30

POPULATION NUMBERS

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
3	5500	5200	5000	5200	5200	5200	5200	5200	5200	5200
4	5063	4483	4170	4011	4171	4171	4171	4171	4171	4171
5	3533	3760	3248	3026	2911	3027	3027	3027	3027	3027
6	1982	2416	2592	2244	2090	2010	2091	2091	2091	2091
7	869	1267	1665	1790	1550	1444	1389	1444	1444	1444
8	348	554	874	1150	1236	1070	997	959	998	998
9	119	222	382	603	795	854	739	689	663	689
10	89	76	153	264	417	549	590	511	476	458
11	35	57	52	106	182	288	379	407	353	329
12	15	22	39	36	73	126	199	262	281	244
	17553	18058	18175	18430	18625	18740	18782	18762	18704	18650

Table 10 continued

CATCH BIOMASS

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
3	10	43	41	43	43	43	43	43	43	43
4	299	328	301	290	302	302	302	302	302	302
5	571	584	498	464	447	465	465	465	465	465
6	691	608	644	558	520	500	520	520	520	520
7	429	446	580	623	540	503	483	503	503	503
8	209	238	371	489	525	455	424	408	424	424
9	98	131	222	352	463	498	431	401	386	401
10	93	56	112	193	306	402	433	374	349	336
11	36	42	38	78	134	211	278	299	259	241
12	22	23	40	37	75	129	203	268	288	249
	2458	2500	2849	3126	3353	3506	3581	3582	3537	3483

CATCH NUMBERS

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
3	22	96	92	95	95	95	95	95	95	95
4	427	469	431	414	431	431	431	431	431	431
5	529	541	462	430	414	430	430	430	430	430
6	395	347	368	319	297	286	297	297	297	297
7	175	182	237	254	220	205	197	205	205	205
8	70	80	124	163	176	152	142	136	142	142
9	24	32	54	86	113	121	105	98	94	98
10	18	11	22	37	59	78	84	73	68	65
11	7	8	7	15	26	41	54	58	50	47
12	3	3	6	5	10	18	28	37	40	35
	1670	1769	1802	1819	1841	1857	1863	1860	1852	1844

FISHING MORTALITY

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
3	.004	.021	.020	.020	.020	.020	.020	.020	.020	.020
4	.098	.122	.121	.121	.121	.121	.121	.121	.121	.121
5	.180	.172	.170	.170	.170	.170	.170	.170	.170	.170
6	.247	.172	.170	.170	.170	.170	.170	.170	.170	.170
7	.250	.172	.170	.170	.170	.170	.170	.170	.170	.170
8	.250	.172	.170	.170	.170	.170	.170	.170	.170	.170
9	.251	.172	.170	.170	.170	.170	.170	.170	.170	.170
10	.251	.172	.170	.170	.170	.170	.170	.170	.170	.170
11	.248	.172	.170	.170	.170	.170	.170	.170	.170	.170
12	.248	.172	.170	.170	.170	.170	.170	.170	.170	.170

Table 11. Summary of catch projections - 3Ps cod

YEAR	$F_{0.1} = 0.20$		$F_{0.1} = 0.17$	
	catch in 1979 = 25000	catch in 1979 = 30000	catch in 1979 = 25000	catch in 1979 = 30000
1978	26000	26000	26000	26000
1979	25000	30000	25000	30000
1980	33000	32000	28500	27500
1981	35200	34300	31300	30300
1982	36830	36000	33500	32600

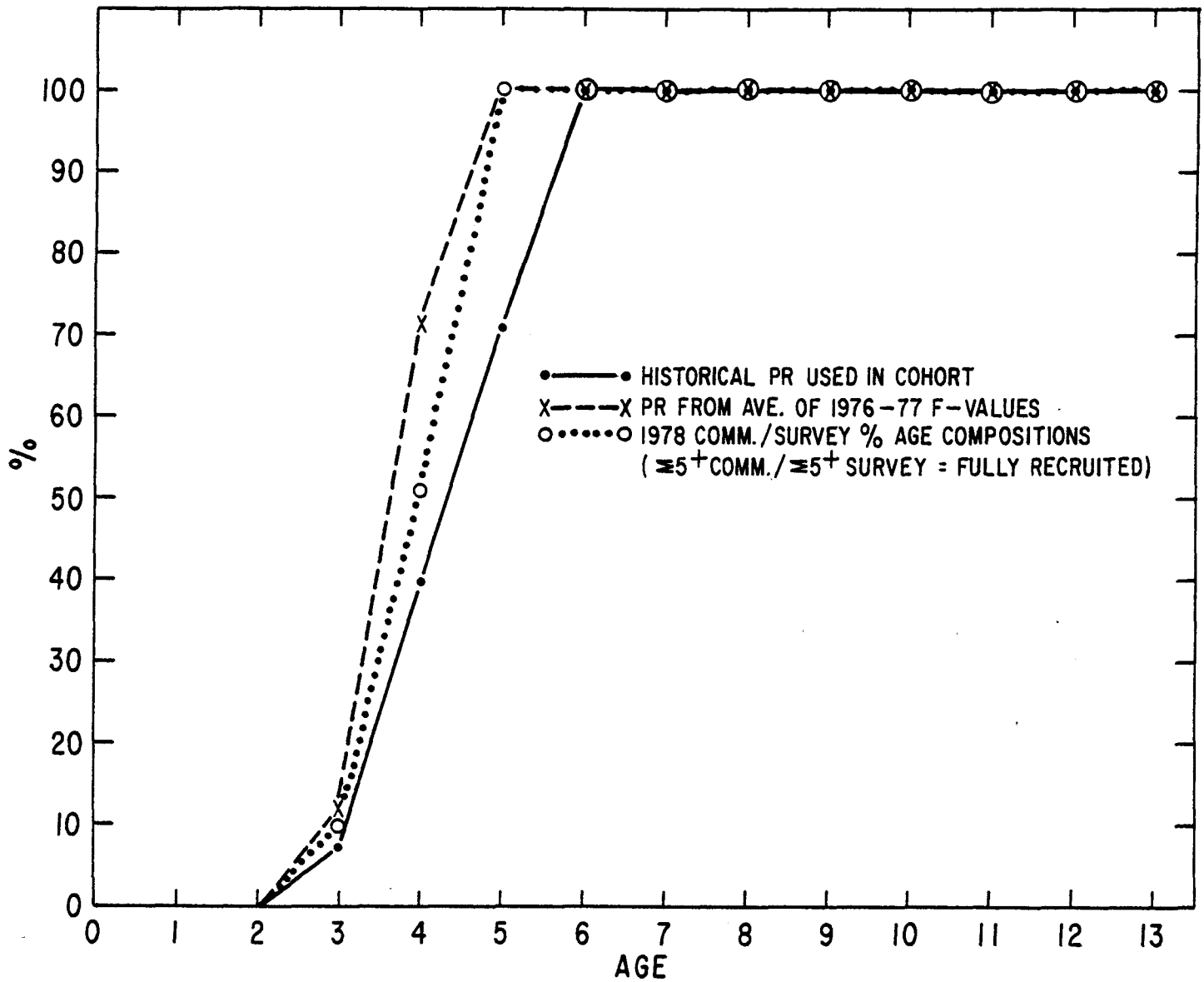

Fig. 1. Partial recruitment curves using three different methods for cod in Subdivision 3Ps.