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Status of the Cod Stock in Divisions 3N0

by

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INTRODUCTION

Cod catches in Divisions 3N0 which were restricted to a TAC of 15,000 tons, in 1978 have been as high as 227,000 tons (1967). This was considerably above the calculated MSY catch level of 100,000 tons, (Bishop and Wells, ICNAF Res. Doc. 78/VI/59). Catch rates (Spain PT-T.c.4) have declined from 1.7 tons per hour in 1967 to that of 0.2 tons per hour reported from the Spanish fishery in 1978. Catches in 1976 and 1977 of 24,283 and 14,700 tons were below the corresponding TAC's of 43,000 and 30,000 tons. The catch level at $2/3 F_{msy}$ effort was determined at 20,000 for 1978 and a TAC of 15,000 tons was set for 1978 to allow rapid rebuilding of the stock. The catch at $2/3 F_{msy}$ estimated using the catch and effort data up to 1977 was 25,000 tons.

Biomass estimates of cod in Divisions 3N and 30

Biomass estimates resulting from Canadian research surveys in 3N and 30 were calculated in a similar manner as abundance estimates presented in a previous paper (Bishop, ICNAF Res. Doc. 77/VI/17). The biomass estimates for 3N and 30 on a per mille basis for each year surveyed and for each estimating method used is shown in Tables 1 and 2. The results of a regression of Canadian (N) OT-(T.c.5) c/hr. on an average of the four methods is shown in Table 1 and Figure 1. The biomass values fluctuate over the period surveyed (1971-78) but are at present little different than those of the early 1970's.

A similar pattern of biomass estimates was found for Division 30 (Table 2). Data was available for fewer years than that for 3N and as such no regressions against CPUE are presented. Biomass values fluctuate but the recent values are not better than those of the early 70's.

Average abundance estimates in Numbers-at-age are shown in Tables 3 and 4. Only strata which had been fished in each of the years shown were compared. In both divisions there are indications that the 74 and 75 year-class may show some improvement over previous years.

Age composition in 1978.

The age composition derived for 1978 is shown in Table 5. Sampling data (frequencies and A/L Keys) were available from sampling of the Canadian commercial fishery for all four quarters in each of 3N and 30. The only other sampling data available were frequencies from three quarters from the Spanish fishery and one quarter from the gillnet fishery of Portugal. These were obtained through the Canadian operated Foreign Co-Operative Sampling unit and the frequencies obtained were adjusted using A/L keys from the Canadian sampling program.

Estimates of fishing mortality

Several methods were used to obtain an estimate of F which has been operating on the stock in recent years. Table 6 shows a regression of ln of average catch per hour at-age against age using Canadian (N) (OT-T.c.5) as the effort standard. The value of F obtained was .50. Similarly Table 7 shows a regression using a 'standard' effort derived from combining all effort data available for 3NO. The F value derived was .59. Regressions were also obtained from the ln of average per mille catch composition at-age for 1976-78 against age (Table 8) and from ln of catch composition in 1978 against age (Table 9). The F values obtained were .47 and .54 respectively. Table 10 shows catch compositions for 1974-78 with survival rates calculated for ages 6-10 and 7-11 with the effort standard being that of Canadian N OT-5. The F value for the 1977-78 period was .77.

Research survey data from 3N and 3O in the form of average abundance estimates from strata surveyed in consecutive years were used to obtain estimates of F. Survival rates for the ages 6-10 and 7-11 were obtained and these are shown in Tables 3 and 4. The F for the 1977-78 period in 3N was .55 while that in 3O was .24. An average value from these seven estimates is .52 and as such a value of .50 was used in Cohort Analysis as the terminal F in 1978, (Table 11). The partial recruitment values used were obtained from a trial run using the estimated fishing mortality values for 1973-75 from ages 3-11. The estimated population values for 1978 indicate a declining stock.

Yield per recruit

Using the average lengths calculated from commercial cod sampling in 1978 and partial recruitment values used in the V.P.A. (Table 12) a yield per recruit curve was plotted (Figure 2). The F max value produced was 0.19. Pinhorn and Wells (ICNAF, Res. Doc. 11, 107-110, 1975) showed a similar yield per recruit curve with an F max value of 0.20.

Discussion

The biomass estimates from surveys showed some relationship with Canadian (N) C.P.U.E. ($r = .79$). However, there was little evidence of significant improvement in the biomass. Abundance estimates indicated that 1974 and 1975 year-classes may hold some promise. The 1978 catch composition (Table 5) showed that four and five year-olds made up the bulk of the catch with a significant number of three year-olds as well.

The fishing mortality (F) was estimated to be approximately 0.50 which was used in a V.P.A. run. This indicated that the stock has shown a steady decline to a level approximately 20% of that shown for the early 1970's. Values of F max from the yield per recruit showed that the F in 1978 of 0.50 was well above the F max of 0.19. It can also be shown that to catch the TAC for 1979 of 25,000 tons the stock will have to be (Table 13) fished at $F = 1.09$. Assuming an average recruitment of 25 million and fishing at F (max) 0.19, the catch in 1980 is projected to be between 5 and 6,000 tons (Table 4).

NOTE: Subsequent to the presentation of the original paper at the April 1979 Meeting of the Assessments Subcommittee, the Appendix which follows together with Tables 15-24 and Fig. 3 were added.

APPENDIX

Additional estimates of terminal F were obtained and the best estimate provided a basis for catch projections. From regressions of total F on effort using catch per unit effort data from Can. N-OT-T.c 5 and total F (F_4^+) at different values of F_t (Tables 15-18), it was shown (Table 19) that $F_t=0.35$ had a high predictive value of F_t in 1978. Figure 3 indicates the relationship of effort and F_t using Spanish PT-Tc. 4 and standardized efforts. The F_t values produced were 0.51 and 0.41 respectively. New stock sizes at age 3 were calculated for 1977, 78, and 79 (Table 20) from regressions of a USSR index at age 2 (in 3N) on VPA abundance values at age 3 for different values of F_t . At $F_t=0.35$ the values for 1977, 78, and 79 were 40.0, 40.8, and 18.9 millions respectively. An average value of 27 million was assumed for 1980. Assuming an F_t value of 0.35 in 1978 and a population size at age 3 as calculated for 1977, 78, 79, and 80, catch projections were obtained in 1980. It was assumed that a TAC of 25,000 t would be taken in 1979 and an F_t value of 0.19 in 1980. The results are indicated in Tables 21-24.

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Table 1. Comparison of cod biomass estimates (metric tons on a per mille basis) obtained from survey cruises in 3N and values obtained from regressions of Canadian N-OT-5 c/hr. on the averages of these estimates.

YEAR	METHOD	METHOD	METHOD	METHOD	METHODS	C. Per Hr (3NO)	
	1	2	3	4	1-4	Can.N.OT	T.c 5
1971	109	131	79	132	113		.47
72	223	212	222	175	208		.45
73	86	92	105	69	88		.51*
74	44	51	40	39	43		.34
75	94	105	56	158	103		.44
76	64	49	67	77	64		.36
77	214	203	199	166	195		.45
78	166	157	232	184	185		.48

* omitted from regression as effort data available from 3N only.

Slope	.0005	.0006	.0004	.0009	.0007		
Intercept	.3564	.3429	.3745	.3045	.3424		
'r'	.7060	.7846	.6428	.9246	.7881		

Table 2. Cod biomass estimates (metric tons on a per mille basis) obtained from survey cruises in 30.

YEAR	STAND. CPUE	METHOD	METHOD	METHOD	METHOD	AVERAGE 1-4
		1	2	3	4	
1973		285	277	309	239	278
74						
75		141	146	134	167	147
76		150	152	84	135	130
77		236	233	305	293	267
78		188	192	168	166	178

Table 3. Average abundance estimates from Division 3N (No^s in 000's) from strata (2) surveyed in each of the years shown.

AGE	1971	1972	1973	1974	1975	1976	1977	1978
1				18	31			
2	761	426	36	164	564	38	128	56
3	3199	3071	246	668	563	268	1766	2284
4	114	4888	156	144	241	206	1630	2330
5	98	290	238	94	44	250	1577	822
6	84	104	68	53	24	42	492	287
7	58	85	19	32	24	26	146	257
8	18	48	18	13	8	6	48	46
9	8	2	16		8		20	17
10	3	18	20		2	14	7	18
11	6	8	4	8				
12		24						34
13+		97	108			34	44	
UK							286	
6-10	171	257	141	98	66	88	713	
7-11		161	77	53	42	46	221	338
S	.94	.30	.38	.43	.70	-	.47	
Z	.06	1.21	.98	.85	.36	-	.75	
F		1.01	.78	.65	.16	=	.55	

Table 4. Div. 30: Average abundance estimates (no's in 000's) from strata 7 surveyed in each of the years shown.

AGE	1973	1975	1976	1977	1978
1	49	85	76	37	304
2	644	403	402	296	142
3	478	580	294	1084	439
4	405	429	280	790	499
5	482	83	221	684	335
6	76	104	53	210	138
7	72	20	19	60	104
8	31	21	25	24	26
9	65	34	65	13	13
10	11	19	16	24	36
11	27		16	9	35
12	35	49		14	
13+	126	61	49	31	35
6-10		198	178	331	
7-11			141	130	214
S		.71	.73	.65	
Z		.34	.31	.44	
F		.14	.11	.24	

Table 5. Age composition of the 1978 catch in Division 3NO by country

AGE	CAN.	SPAIN*	PORT*	OTHER*	TOTAL
2	1				1
3	157	354		217	728
4	916	1383	1	977	3277
5	857	1599	2	1043	3501
6	269	435	32	299	1035
7	111	210	27	136	484
8	37	73	50	47	207
9	18	35	2	23	78
10	20	11	6	13	50
11	3		6	1	10
12	2	5	6	3	16
13	1		2		3
14	2			1	3
15			2		2
16					
17	1				1
18					
19	1				1
20	2			1	3
NK		142	3	60	205
#	2398	4247	139	2821	9605
Wt.	4409	5710	590	4291	15000
Av.Wt.	1.84	1.34	4.23	1.52	1.56

* Spain and Portugal are adjusted using Foreign Sampling data. Other includes all countries for which no sampling data was available.

Table 6. 3NO cod - Calculation of F from a regression of ln of Average catch per hour at age against age.

AGE	1976	1977	1978	c/hr. 1976	c/hr. 1977	c/hr. 1978	Average
4	7755	1381	3277	115	43	105	87.7
5	3999	1424	3501	59	45	112	72.0
6	1141	1134	1935	17	36	33	28.7
7	142	578	484	2	18	15	11.7
8	152	196	207	2	6	7	5.0
9	104	235	78	2	7	2	3.7
10	35	73	50	1	2	2	1.7
Total catch (all countries)				24,283	14,312	15,000	
Can(N)-OT-5 - c/hr.				.36	.45	.48	Slope - .70 Intercept 7.4512 'r' .99
Total Effort				67,453	31,804	31,250	F = .50

Table 7. 3NO cod . Estimate of F from a regression of ln of average catch per hour at age against age, using a 'standard' effort.

AGE	c/hr			c/hr			Average
	1976	1977	1978	1976	1977	1978	
4	7755	1381	3277	218	30	37	95
5	3999	1424	3501	112	31	40	61
6	1141	1134	1035	32	25	12	23
7	142	578	484	4	13	5	7
8	152	196	207	4	4	2	3
9	104	235	78	3	5	1	3
10	35	73	50	1	2	1	1
Effort (hrs.)				35,567	46,167	88,235	
Catch (tons)				24,283	14,312	15,000	
CPUE (Stand.)				.67	.31	.17	

Slope -.79
Intercept 7.7649
'r' .98
F = .59

Table 8. 3NO cod - Calculation of F from a regression of ln of average per mille catch composition at age against age.

AGE	1976			1977			1978			Average
	(per mille)			(per mille)			(per mille)			
2	56	2	1	3						
3	3719	444	728	216	80	76			124	
4	7755	1381	3277	450	247	341			346	
5	3999	1424	3501	232	255	364			284	
6	1141	1134	1035	66	203	108			126	
7	142	578	484	8	104	50			54	
8	152	196	207	9	35	22			22	
9	104	235	78	6	42	8			19	
10	35	73	50	2	13	5			7	
11	44	43	10	3	8	1			4	
12	24	30	16	1	5	2			3	
13	23	21	3	1	4				2	
14	2	8	3	1	1				1	
15	20		2							
16	1	2								
17	1		1							
18		2								
19			1							
20			3							
>20		8								
NK	19		205	1	1	21			8	
#	17,237	5,581	9,605	999	998	998			1000	

Ages 4-10 - Slope - .67

Intercept 8.76
'r' .99

F = .47

Table 9. 3NO Cod - Estimate of F from a regression of ln of catch composition at age in 1978 against age.

<u>AGE</u>	<u>CATCH COMPOSITION</u>	<u>LN CATCH</u>
4	3277	8.09
5	3501	8.16
6	1035	6.94
7	484	6.18
8	207	5.33
9	78	4.36
10	50	3.91
11	10	2.30
12	16	2.77
13	3	1.10
14	3	1.10
15	2	.69

Slope	- .74
Intercept	11.30
'r'	.99
F =	.54

Table 10. 3NO Cod - Paloheimo Z's

Age	Catch Composition (No's in 000's)				
	1974	1975	1976	1977	1978
2	822		56	2	1
3	6425	11	3719	444	728
4	9501	6871	7755	1381	3277
5	10,907	1983	3999	1424	3501
6	10,872	1184	1141	1134	1035
7	2247	1863	142	578	484
8	2147	802	152	196	207
9	1015	732	104	235	78
10	676	466	35	73	50
11	428	494	44	43	10
12	257	231	24	30	16
13	355	167	23	21	3
14	26	96	2	8	3
15	81	84	20		2
16	7	96	1	2	
17	49	174	1		1
18	192	96		2	
19	132	70			1
20	39	66			3
>20	152	29		8	
NK			19		205
Total Effort (Can N-0T5)	216,664	100,395	67,453	31,804	31,250
6-10	16,957	5047	1574	2216	
7-11		4357	477	1125	829
S	.55	.14	1.52	.38	
Z	.59	1.96	-	.97	
F	.39	1.76	-	.77	

Table 11. Div. 3NO cod 1973-78 - VPA at terminal F = 0.50

NATURAL MORTALITY=		0.20						
PARTIAL RECRUITMENT MULTIPLIER		0.2600	0.9000	1.0200	1.1700	1.0000	1.0000	1.0000 (to age 14)
ASSUMED FISHING MORTALITY FOR LAST AGES		0.3100	0.8800	1.5700	0.4000	0.8000	0.5000	
ESTIMATED POPULATION		1973	1974	1975	1976	1977	1978	
AGE	YEAR							
3		32494.	28248.	17481.	20277.	12587.	6575.	
4		48535.	17503.	17314.	14302.	13237.	9904.	
5		35695.	14764.	5734.	7958.	4693.	9588.	
6		11439.	15564.	2219.	2900.	2897.	2554.	
7		6580.	3946.	2905.	745.	1342.	1346.	
8		3398.	3604.	1198.	693.	482.	576.	
9		2631.	1902.	1008.	255.	430.	217.	
10		1309.	1514.	639.	163.	115.	139.	
11		786.	852.	628.	102.	102.	28.	
12		802.	519.	310.	67.	43.	44.	
13		166.	552.	193.	45.	33.	8.	
14		66.	48.	130.	7.	16.	8.	
KNOWN CATCHES		1973	1974	1975	1976	1977	1978	
AGE	YFAP							
3		10058.	6425.	11.	3719.	444.	728.	
4		27600.	9501.	6871.	7755.	1381.	3277.	
5		15098.	10907.	1983.	3999.	1424.	3501.	
6		5989.	10872.	1184.	1141.	1134.	1035.	
7		1971.	2247.	1863.	142.	578.	484.	
8		972.	2147.	802.	152.	196.	207.	
9		707.	1015.	732.	104.	235.	78.	
10		243.	676.	466.	35.	73.	50.	
11		137.	428.	494.	44.	43.	10.	
12		116.	257.	231.	24.	30.	16.	
13		97.	355.	167.	23.	21.	3.	
14		16.	26.	96.	2.	8.	3.	
ESTIMATE FISHING MORTALITY		1973	1974	1975	1976	1977	1978	
AGE	YEAR							
3		0.4187	0.2895	0.0007	0.2265	0.0398	0.0	
4		0.9901	0.9160	0.5773	0.9144	0.1225	0.0	
5		0.6301	1.6953	0.4816	0.8104	0.4085	0.0	
6		0.8642	1.4785	0.8911	0.5706	0.5666	0.0	
7		0.4020	0.9923	1.2337	0.2365	0.6463	0.0	
8		0.3800	1.0739	1.3471	0.2778	0.5975	0.0	
9		0.3524	0.8908	1.6215	0.5993	0.9279	0.0	
10		0.2297	0.6799	1.6393	0.2707	1.2164	0.0	
11		0.2140	0.8107	2.0334	0.6515	0.6283	0.0	
12		0.1742	0.7916	1.7355	0.5009	1.4478	0.0	
13		1.0355	1.2420	3.1666	0.8396	1.1871	0.0	
14		0.3100	0.8800	1.5700	0.4000	0.8000	0.5000	
POPULATION WTS AND NOS		1973	1974	1975	1976	1977	1978	
WT								
		242972.	174846.	87135.	59853.	49801.	46890.	
NO								
		143901.	89017.	49758.	47514.	35976.	30986.	
POPULATION WTS AND NOS AGE 6 TO 14		1973	1974	1975	1976	1977	1978	
WT								
		113287.	113245.	47482.	17901.	19566.	16896.	
NO								
		27177.	28502.	9230.	4976.	5459.	4920.	

Table 12. Values used in yield per recruit curve

<u>AGE</u>	<u>Average Wts.</u>	<u>Partial Recruitment</u>
3	.72	.26
4	1.05	.90
5	1.55	1.02
6	2.25	1.17
7	3.74	1.00
8	4.61	1.00
9	6.19	1.00
10	7.23	1.00
11	9.48	1.00
12	12.87	1.00
13	15.38	1.00
14	17.85	1.00
15	18.00	1.00
16	19.00	1.00
17	23.85	1.00
18	21.00	1.00
19	15.38	1.00
20	22.26	1.00

Table 13. 3ND COD PROJECTION OF CATCHES

NATURAL MORTALITY# 0.2000		YEAR 1978		YEAR 1979		RESIDUAL POP. NOS.	
AGE	POP. NU. X10-3K	CATCH NO. X10-3K	FISHING MORT.	MEAN WT. KG.	POP. WT. XMETRIC TONSK	CATCH WT. XMETRIC TONSK	RESIDUAL POP. NOS.
3	6595.	728.	0.130	0.720	4748.4	524.2	4741.3
4	9904.	3277.	0.450	1.050	10399.2	3440.9	5170.4
5	9588.	3501.	0.510	1.550	14861.4	5426.5	4713.9
6	2554.	1035.	0.585	2.250	5746.5	2328.7	1164.9
7	1346.	484.	0.501	3.740	5034.0	1810.2	667.7
8	576.	207.	0.500	4.610	2655.4	954.3	286.0
9	217.	78.	0.500	6.190	1343.2	482.4	107.8
10	139.	50.	0.501	7.230	1005.0	361.3	69.0
11	28.	10.	0.496	9.480	285.4	94.8	14.0
12	4.	16.	0.508	12.870	566.3	205.9	21.7
13	8.	3.	0.528	15.380	123.0	46.1	3.9
14	8.	3.	0.528	17.850	142.8	53.6	3.9
TOTAL	31007.	9392.			46890.6	15729.4	16964.3

NATURAL MORTALITY# 0.2000		YEAR 1979		YEAR 1979		RESIDUAL POP. NOS.	
AGE	POP. NU. X10-3K	CATCH NO. X10-3K	FISHING MORT.	MEAN WT. KG.	POP. WT. XMETRIC TONSK	CATCH WT. XMETRIC TONSK	RESIDUAL POP. NOS.
3	25000.	5559.	0.280	0.720	18000.0	4002.8	15469.6
4	4741.	2728.	0.960	1.050	4978.4	2664.1	1456.9
5	5170.	3199.	1.110	1.550	8012.1	4958.3	1355.1
6	4714.	3136.	1.270	2.250	10606.3	7056.4	1083.8
7	1165.	713.	1.090	3.740	4356.9	2668.0	320.7
8	588.	409.	1.090	4.610	3078.3	1885.0	183.8
9	286.	175.	1.090	6.190	1770.6	1084.2	78.7
10	108.	66.	1.090	7.230	779.1	477.1	29.7
11	69.	42.	1.090	9.480	653.7	400.3	19.0
12	14.	9.	1.090	12.870	179.7	110.0	3.8
13	22.	13.	1.090	15.380	333.4	204.1	6.0
14	4.	2.	1.090	17.850	69.0	42.2	1.1
TOTAL	41960.	16052.			52819.2	25752.6	20048.1

Table 14. 3ND C00 PROJECTION OF CATCHES

AGE	NATURAL MORTALITY# 0.2000		YEAR 1980		MEAN WT. KG.	POP. WT. %METRIC TONSK	CATCH WT. %METRIC TONSK	RESIDUAL POP. NOS.
	POP. NO. %X10-3K	CATCH NO. %X10-3K	FISHING MORT.	POP. WT. %METRIC TONSK				
3	25000.	1106.	0.050	18000.0	0.720	796.3	19470.0	
4	15470.	2198.	0.170	16243.1	1.050	2308.1	10685.4	
5	1457.	229.	0.190	2258.2	1.550	355.3	986.4	
6	1395.	251.	0.220	3138.9	2.250	563.9	916.6	
7	1084.	171.	0.190	4053.6	3.740	637.8	733.8	
8	321.	50.	0.190	1478.3	4.610	232.6	217.1	
9	184.	29.	0.190	1137.8	6.190	179.0	124.4	
10	79.	12.	0.190	569.3	7.230	89.6	53.3	
11	30.	5.	0.190	281.2	9.480	44.2	20.1	
12	19.	3.	0.190	244.3	12.870	38.4	12.9	
13	4.	1.	0.190	59.1	15.380	9.3	2.6	
14	6.	1.	0.190	106.5	17.850	16.8	4.0	
TOTAL	45047.	4055.		47570.2		5271.2	33226.7	

AGE	NATURAL MORTALITY# 0.2000		YEAR 1981		MEAN WT. KG.	POP. WT. %METRIC TONSK	CATCH WT. %METRIC TONSK	RESIDUAL POP. NOS.
	POP. NO. %X10-3K	CATCH NO. %X10-3K	FISHING MORT.	POP. WT. %METRIC TONSK				
3	25000.	1106.	0.050	18000.0	0.720	796.3	19470.0	
4	15470.	2198.	0.170	20443.5	1.050	2904.9	13448.6	
5	10685.	1681.	0.190	16562.3	1.550	2605.8	7234.6	
6	986.	177.	0.220	2219.4	2.250	398.7	648.1	
7	917.	144.	0.190	3428.2	3.740	539.4	620.6	
8	734.	115.	0.190	3822.9	4.610	532.2	496.8	
9	217.	34.	0.190	1343.9	6.190	211.4	147.0	
10	124.	20.	0.190	899.8	7.230	141.6	84.3	
11	53.	8.	0.190	505.4	9.480	179.5	36.1	
12	20.	3.	0.190	258.5	12.870	40.7	13.6	
13	13.	2.	0.190	197.7	15.380	31.1	8.7	
14	3.	0.	0.190	46.4	17.850	7.3	1.6	
TOTAL	58223.	6058.		67287.9		8288.9	42210.2	

Table 15. VAP for Div. 3NO cod, 1973-78, $F_t = 0.20$, $M = 0.20$

		PARTIAL RECRUITMENT MULTIPLIER						
		0.2600	0.9000	1.0200	1.1700	1.0000	1.0000	1.0000
		ASSUMED FISHING MORTALITY FOR LAST AGES						
		0.3100	0.8800	1.5700	0.4000	0.8000	0.2000	
		ESTIMATED POPULATION						
AGE	YEAR	1973	1974	1975	1976	1977	1978	
3		34343.	31787.	22762.	37096.	27219.	15838.	
4		49232.	19017.	20211.	18626.	27000.	21883.	
5		36142.	15334.	6973.	10331.	8233.	20861.	
6		11528.	15929.	2686.	3915.	4840.	5452.	
7		6723.	4019.	3204.	1127.	2173.	2936.	
8		3425.	3721.	1258.	938.	795.	1256.	
9		2658.	1924.	1104.	304.	630.	473.	
10		1309.	1536.	657.	242.	155.	303.	
11		786.	852.	646.	116.	166.	61.	
12		802.	519.	310.	82.	55.	97.	
13		166.	552.	193.	45.	45.	18.	
14		66.	48.	130.	7.	16.	18.	
		KNOWN CATCHES						
AGE	YEAR	1973	1974	1975	1976	1977	1978	
3		10058.	6425.	11.	3719.	444.	728.	
4		27600.	9501.	6871.	7755.	1381.	3277.	
5		15098.	10907.	1983.	3999.	1424.	3501.	
6		5989.	10872.	1184.	1141.	1134.	1035.	
7		1971.	2247.	1863.	142.	578.	484.	
8		972.	2147.	802.	152.	196.	207.	
9		707.	1015.	732.	104.	235.	78.	
10		243.	676.	466.	35.	73.	50.	
11		137.	428.	494.	44.	43.	10.	
12		116.	257.	231.	24.	30.	16.	
13		97.	355.	167.	23.	21.	3.	
14		16.	26.	96.	2.	8.	3.	
		ESTIMATE FISHING MORTALITY						
AGE	YEAR	1973	1974	1975	1976	1977	1978	
3		0.3911	0.2528	0.0005	0.1174	0.0182	0.0	
4		0.9665	0.8033	0.4711	0.6164	0.0582	0.0	
5		0.6193	1.5422	0.3773	0.5583	0.2121	0.0	
6		0.8537	1.4037	0.6680	0.3888	0.2997	0.0	
7		0.3915	0.9619	1.0288	0.1499	0.3482	0.0	
8		0.3764	1.0151	1.2200	0.1974	0.3183	0.0	
9		0.3481	0.8746	1.3197	0.4750	0.5312	0.0	
10		0.2297	0.6661	1.5318	0.1745	0.7366	0.0	
11		0.2140	0.8107	1.8640	0.5417	0.3371	0.0	
12		0.1742	0.7916	1.7355	0.3906	0.9129	0.0	
13		1.0355	1.2420	3.1666	0.8396	0.7149	0.0	
14		0.3100	0.8800	1.5700	0.4000	0.8000	0.2000	
		POPULATION WTS AND NOS						
		1973	1974	1975	1976	1977	1978	
WT		246752.	181797.	99240.	86222.	91682.	103306.	
NO		147179.	95239.	60134.	72827.	71332.	69197.	
		POPULATION WTS AND NOS AGE 6 TO 14						
		1973	1974	1975	1976	1977	1978	
WT		114312.	115175.	50821.	23943.	30967.	36591.	
NO		27462.	29101.	10188.	6775.	8874.	10615.	

Table 16. VPA for Div. 3NO cod, 1973-78, $F_t = 0.25$, $M = 0.20$.

PARTIAL RECRUITMENT MULTIPLIER							
	0.2600	0.9000	1.0200	1.1700	1.0000	1.0000	1.0000
ASSUMED FISHING MORTALITY FOR LAST AGES							
	0.3100	0.8800	1.5700	0.4000	0.8000	0.2500	
ESTIMATED POPULATION							
AGE	YEAR	1973	1974	1975	1976	1977	1978
3		33725.	30603.	20993.	31468.	22327.	12749.
4		48999.	18510.	19242.	17178.	22399.	17878.
5		35992.	15143.	6558.	9537.	7047.	17089.
6		11498.	15807.	2529.	3575.	4190.	4481.
7		6676.	3995.	3104.	1000.	1895.	2404.
8		3416.	3682.	1238.	856.	690.	1028.
9		2649.	1917.	1072.	288.	563.	387.
10		1309.	1529.	651.	215.	141.	248.
11		786.	852.	640.	111.	145.	50.
12		802.	519.	310.	77.	51.	79.
13		166.	552.	193.	45.	41.	15.
14		66.	48.	130.	7.	16.	15.
KNOWN CATCHES							
AGE	YEAR	1973	1974	1975	1976	1977	1978
3		10058.	6425.	11.	3719.	444.	728.
4		27600.	9501.	6871.	7755.	1381.	3277.
5		15098.	10907.	1983.	3999.	1424.	3501.
6		5989.	10872.	1184.	1141.	1134.	1035.
7		1971.	2247.	1853.	142.	578.	484.
8		972.	2147.	802.	152.	196.	207.
9		707.	1015.	732.	104.	235.	78.
10		243.	676.	466.	35.	73.	50.
11		137.	428.	494.	44.	43.	10.
12		116.	257.	231.	24.	30.	16.
13		97.	355.	167.	23.	21.	3.
14		16.	26.	96.	2.	8.	3.
ESTIMATE FISHING MORTALITY							
AGE	YEAR	1973	1974	1975	1976	1977	1978
3		0.3999	0.2640	0.0006	0.1400	0.0222	0.0
4		0.9742	0.8376	0.5019	0.6910	0.0706	0.0
5		0.6229	1.5896	0.4067	0.6225	0.2527	0.0
6		0.8572	1.4277	0.7284	0.4350	0.3554	0.0
7		0.3950	0.9719	1.0885	0.1708	0.4112	0.0
8		0.3776	1.0340	1.2594	0.2185	0.3769	0.0
9		0.3495	0.8799	1.4052	0.5103	0.6185	0.0
10		0.2297	0.6707	1.5658	0.1980	0.8458	0.0
11		0.2140	0.8107	1.9165	0.5739	0.3985	0.0
12		0.1742	0.7916	1.7355	0.4216	1.0373	0.0
13		1.0355	1.2420	3.1666	0.8396	0.8220	0.0
14		0.3100	0.8800	1.5700	0.4000	0.8000	0.2500
POPULATION WTS AND NOS							
		1973	1974	1975	1976	1977	1978
WT		245487.	179471.	95188.	77397.	77669.	84438.
NO		146082.	93157.	56661.	64356.	59504.	56425.
POPULATION WTS AND NOS AGE 6 TO 14							
		1973	1974	1975	1976	1977	1978
WT		113969.	114529.	49704.	21921.	27153.	29999.
NO		27367.	28901.	9867.	6173.	7732.	8708.

Table 17. VAP for Div. 3NO cod, 1973-78, $F_t = 0.30$, $M = 0.20$.

PARTIAL RECRUITMENT MULTIPLIER							
	0.2600	0.9000	1.0200	1.1700	1.0000	1.0000	1.0000
ASSUMED FISHING MORTALITY FOR LAST AGES							
	0.3100	0.8800	1.5700	0.4000	0.8000	0.3000	
ESTIMATED POPULATION							
AGE	YEAR	1973	1974	1975	1976	1977	1978
3		33313.	29815.	19817.	27723.	19071.	10691.
4		48844.	18174.	18597.	16214.	19333.	15212.
5		35893.	15016.	6282.	9009.	6258.	14579.
6		11478.	15725.	2425.	3349.	3757.	3835.
7		6644.	3979.	3037.	914.	1710.	2050.
8		3410.	3656.	1224.	801.	620.	877.
9		2643.	1912.	1051.	277.	518.	330.
10		1309.	1524.	647.	198.	132.	212.
11		786.	852.	636.	108.	130.	42.
12		802.	519.	310.	74.	49.	68.
13		166.	552.	193.	45.	39.	13.
14		66.	48.	130.	7.	16.	13.
KNOWN CATCHES							
AGE	YEAR	1973	1974	1975	1976	1977	1978
3		10058.	6425.	11.	3719.	444.	728.
4		27600.	9501.	6871.	7755.	1381.	3277.
5		15098.	10907.	1983.	3999.	1424.	3501.
6		5989.	10872.	1184.	1141.	1134.	1035.
7		1971.	2247.	1863.	142.	578.	484.
8		972.	2147.	802.	152.	196.	207.
9		707.	1015.	732.	104.	235.	78.
10		243.	676.	466.	35.	73.	50.
11		137.	428.	494.	44.	43.	10.
12		116.	257.	231.	24.	30.	16.
13		97.	355.	167.	23.	21.	3.
14		16.	26.	96.	2.	8.	3.
ESTIMATE FISHING MORTALITY							
AGE	YEAR	1973	1974	1975	1976	1977	1978
3		0.4060	0.2720	0.0006	0.1605	0.0261	0.0
4		0.9795	0.8622	0.5248	0.7520	0.0822	0.0
5		0.6253	1.6232	0.4290	0.6745	0.2896	0.0
6		0.8595	1.4443	0.7755	0.4724	0.4058	0.0
7		0.3973	0.9786	1.1327	0.1883	0.4678	0.0
8		0.3784	1.0470	1.2873	0.2353	0.4297	0.0
9		0.3505	0.8835	1.4697	0.5369	0.6951	0.0
10		0.2297	0.6737	1.5895	0.2176	0.9398	0.0
11		0.2140	0.8107	1.9537	0.5977	0.4537	0.0
12		0.1742	0.7916	1.7355	0.4451	1.1430	0.0
13		1.0355	1.2420	3.1666	0.8396	0.9144	0.0
14		0.3100	0.8800	1.5700	0.4000	0.8000	0.3000
POPULATION WTS AND NOS							
		1973	1974	1975	1976	1977	1978
WT		244646.	177924.	92493.	71526.	68345.	71880.
NO		145353.	91772.	54350.	58719.	51633.	47921.
POPULATION WTS AND NOS AGE 6 TO 14							
		1973	1974	1975	1976	1977	1978
WT		113741.	114099.	48960.	20576.	24615.	25613.
NO		27303.	28767.	9654.	5773.	6972.	7440.

Table 18. VPA for Div. 3NO cod, 1973-78, $F_t = 0.35$, $M = 0.20$.

PARTIAL RECRUITMENT MULTIPLIER							
	0.2600	0.9000	1.0200	1.1700	1.0000	1.0000	1.0000
ASSUMED FISHING MORTALITY FOR LAST AGES							
	0.3100	0.8800	1.5700	0.4000	0.8000	0.3500	
ESTIMATED POPULATION							
AGE	YEAR	1973	1974	1975	1976	1977	1978
3		33020.	29254.	18979.	25055.	16749.	9220.
4		48733.	17933.	18137.	15528.	17148.	13311.
5		35822.	14926.	6086.	8632.	5697.	12790.
6		11464.	15667.	2351.	3188.	3449.	3375.
7		6621.	3967.	2990.	854.	1578.	1798.
8		3405.	3637.	1215.	762.	570.	769.
9		2639.	1909.	1035.	269.	487.	290.
10		1309.	1521.	644.	185.	126.	186.
11		786.	852.	633.	106.	120.	37.
12		802.	519.	310.	71.	47.	59.
13		166.	552.	193.	45.	37.	11.
14		66.	48.	130.	7.	16.	11.
KNOWN CATCHES							
AGE	YEAR	1973	1974	1975	1976	1977	1978
3		10058.	6425.	11.	3719.	444.	728.
4		27600.	9501.	6871.	7755.	1381.	3277.
5		15098.	10907.	1983.	3999.	1424.	3501.
6		5989.	10872.	1184.	1141.	1134.	1035.
7		1971.	2247.	1863.	142.	578.	484.
8		972.	2147.	802.	152.	196.	207.
9		707.	1015.	732.	104.	235.	78.
10		243.	676.	466.	35.	73.	50.
11		137.	428.	494.	44.	43.	10.
12		116.	257.	231.	24.	30.	16.
13		97.	355.	167.	23.	21.	3.
14		16.	26.	96.	2.	8.	3.
ESTIMATE FISHING MORTALITY							
AGE	YEAR	1973	1974	1975	1976	1977	1978
3		0.4104	0.2780	0.0006	0.1792	0.0297	0.0
4		0.9833	0.8807	0.5424	0.8028	0.0932	0.0
5		0.6270	1.6481	0.4465	0.7174	0.3233	0.0
6		0.8612	1.4563	0.8131	0.5034	0.4515	0.0
7		0.3990	0.9835	1.1667	0.2031	0.5189	0.0
8		0.3790	1.0565	1.3080	0.2489	0.4775	0.0
9		0.3512	0.8861	1.5201	0.5577	0.7631	0.0
10		0.2297	0.6759	1.6069	0.2340	1.0218	0.0
11		0.2140	0.8107	1.9813	0.6159	0.5036	0.0
12		0.1742	0.7916	1.7355	0.4636	1.2343	0.0
13		1.0355	1.2420	3.1666	0.8396	0.9952	0.0
14		0.3100	0.8800	1.5700	0.4000	0.8000	0.3500
POPULATION WTS AND NOS							
		1973	1974	1975	1976	1977	1978
WT		244046.	176821.	90572.	67342.	61700.	62928.
NO		144833.	90785.	52704.	54703.	46023.	41858.
POPULATION WTS AND NOS AGE 6 TO 14							
		1973	1974	1975	1976	1977	1978
WT		113578.	113793.	48431.	19618.	22806.	22488.
NO		27258.	28672.	9502.	5487.	6430.	6537.

Table 19. 3NO Cod-regressions of total $F(F_{4+})$ on effort for different terminal $F(F_T)$ values.

YEAR	EFFORT (hrs) Can (N) T.C. 5	F_{4+} at F_T			
		.20	.25	.30	.35
		1973	157,000	.73	.74
1974	216,664	1.11	1.14	1.16	1.17
1975	100,395	.58	.62	.65	.67
1976	67,453	.54	.60	.65	.69
1977	31,804	.14	.17	.19	.22
1978	31,250	.20	.25	.30	.35
r^2		.92	.89	.86	.83
a		.092	.14	.18	.218
b		.0046	.0045	.0044	.0042
Predicted F_{4+} (1978)		.235	.280	.313	.348
-					
Z_c (1977-78) 6-10		.47	.53	.58	.63

Table 20. Regressions of a USSR abundance index at age 2 in 3N on VPA abundance at age 3 using different values for F_T .

YEAR CLASS	USSR INDEX AGE 2 (3N)	VPA ABUNDANCE AGE 3 at F_T			
		.20	.25	.30	.35
		1970	35	34.3	33.7
1971	51	31.8	30.6	29.8	29.3
1972	12	22.8	21.0	19.8	19.0
1973	42	37.1	31.5	27.7	25.1 *
1974	89	47.3	43.9	41.6	40.0
1975	92	48.2	44.7	42.4	40.8
1976	4	22.4	20.8	19.6	18.9
b		.293	.272	.258	.249
a		21.3	19.7	18.6	17.8
r		.79	.81	.75	.69
r^2		.62	.65	.57	.48

* Values below the line are predicted from regressions

Table 21. Data used in 3NO cod projections

NATURAL MORTALITY = 0.200

AGE	MEAN WT.	SELECTION	POPULATION NUMBERS
3	0.720	0.057	40800.000
4	1.050	0.337	32291.000
5	1.550	1.020	12790.000
6	2.250	1.170	3375.000
7	3.740	1.000	1798.000
8	4.610	1.000	769.000
9	6.190	1.000	290.000
10	7.230	1.000	186.000
11	9.480	1.000	37.000
12	12.870	1.000	59.000
13	15.380	1.000	11.000
14	17.850	1.000	11.000

Table 22.

AGE	RESULTS FOR YEAR			1978		RESIDUAL NUMBERS	RESIDUAL WEIGHTS
	POPULATION NUMBERS	POPULATION WEIGHTS	FISHING MORTALITY	CATCH NUMBERS	CATCH WEIGHTS		
3	40800.0	29376.0	0.0200	731.0	526.3	32744.1	23575.7
4	32291.0	33905.5	0.1185	3276.9	3440.7	23483.4	24657.6
5	12790.0	19824.5	0.3570	3501.0	5426.5	7327.7	11357.9
6	3375.0	7593.7	0.4097	1035.2	2329.3	1834.4	4127.3
7	1798.0	6724.5	0.3500	484.0	1810.2	1037.4	3879.9
8	769.0	3545.1	0.3499	207.0	954.3	443.7	2045.4
9	290.0	1795.1	0.3496	78.0	482.8	167.4	1036.1
10	186.0	1344.8	0.3494	50.0	361.5	107.4	776.3
11	37.0	350.8	0.3516	10.0	94.8	21.3	202.0
12	59.0	759.3	0.3531	16.0	205.9	33.9	436.8
13	11.0	169.2	0.3554	3.0	46.1	6.3	97.1
14	11.0	196.3	0.3554	3.0	53.5	6.3	112.7
TOTAL	92417.	105585.		9395.	15732.	67213.	72305.

Table 23.

AGE	RESULTS FOR YEAR			1979		RESIDUAL NUMBERS	RESIDUAL WEIGHTS
	POPULATION NUMBERS	POPULATION WEIGHTS	FISHING MORTALITY	CATCH NUMBERS	CATCH WEIGHTS		
3	18900.0	13608.0	0.0213	361.6	260.4	15147.4	10906.2
4	32744.1	34381.3	0.1270	3548.0	3725.4	23610.3	24790.8
5	23483.4	36399.2	0.3844	6836.0	10595.8	13090.6	20290.5
6	7327.7	16487.3	0.4409	2385.4	5367.2	3860.3	8685.6
7	1834.4	6860.6	0.3769	525.3	1964.6	1030.3	3853.3
8	1037.4	4782.4	0.3769	297.1	1369.5	582.7	2686.1
9	443.7	2746.5	0.3769	127.1	786.5	249.2	1542.6
10	167.4	1210.2	0.3769	47.9	346.5	94.0	679.7
11	107.4	1017.9	0.3769	30.7	291.5	60.3	571.7
12	21.3	274.3	0.3769	6.1	78.5	12.0	154.1
13	33.9	521.9	0.3769	9.7	149.5	19.1	293.2
14	12.6	225.3	0.3769	3.6	64.5	7.1	126.6
TOTAL	86113.	118515.		14179.	25000.	57763.	74580.

Table 24.

AGE	RESULTS FOR YEAR			1980		RESIDUAL NUMBERS	RESIDUAL WEIGHTS
	POPULATION NUMBERS	POPULATION WEIGHTS	FISHING MORTALITY	CATCH NUMBERS	CATCH WEIGHTS		
3	27000.0	13608.0	0.0108	183.3	131.9	15308.5	11022.1
4	15147.4	15904.8	0.0640	852.7	895.3	11632.3	12213.9
5	23610.3	36596.0	0.1938	3782.2	5862.4	15924.9	24683.6
6	13090.6	29454.0	0.2223	2373.7	5340.8	8581.4	19308.2
7	3860.3	14437.4	0.1900	607.3	2271.5	2613.6	9774.9
8	1030.3	4749.7	0.1900	162.1	747.3	697.6	3215.8
9	582.7	3606.7	0.1900	91.7	567.4	394.5	2441.9
10	249.2	1801.8	0.1900	39.2	283.5	168.7	1219.9
11	94.0	891.2	0.1900	14.8	140.2	63.7	603.4
12	60.3	776.2	0.1900	9.5	122.1	40.8	525.5
13	12.0	184.1	0.1900	1.9	29.0	8.1	124.6
14	26.2	466.8	0.1900	4.1	73.4	17.7	316.0
TOTAL	76663.	122477.		8122.	16520.	55452.	85450.

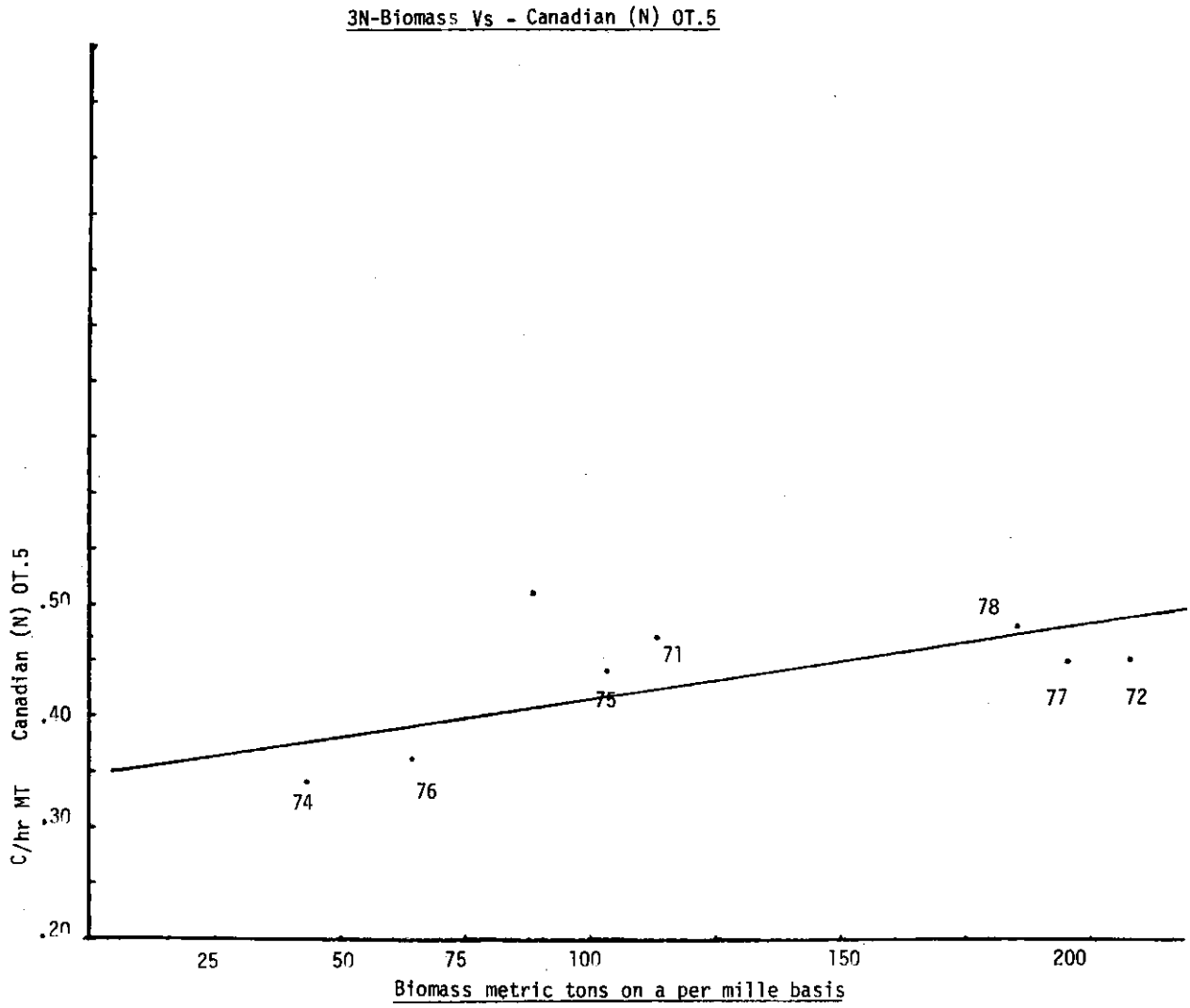


Fig. 1. Biomass estimate from surveys Vs - Canadian (N) (OT-5) catch per unit effort.

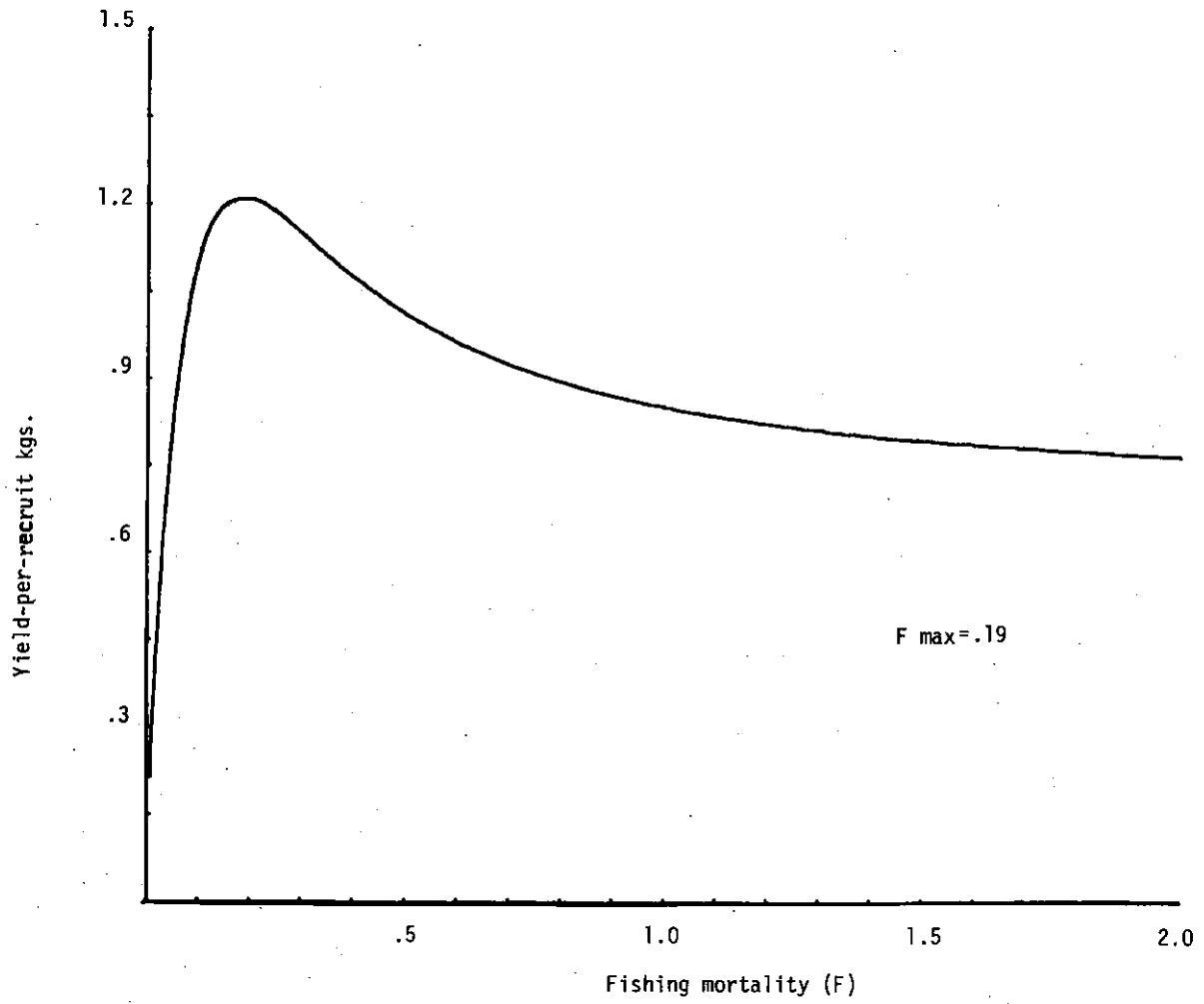


Fig. 2. Yield-per-recruit curve for 3NO cod - 1978.

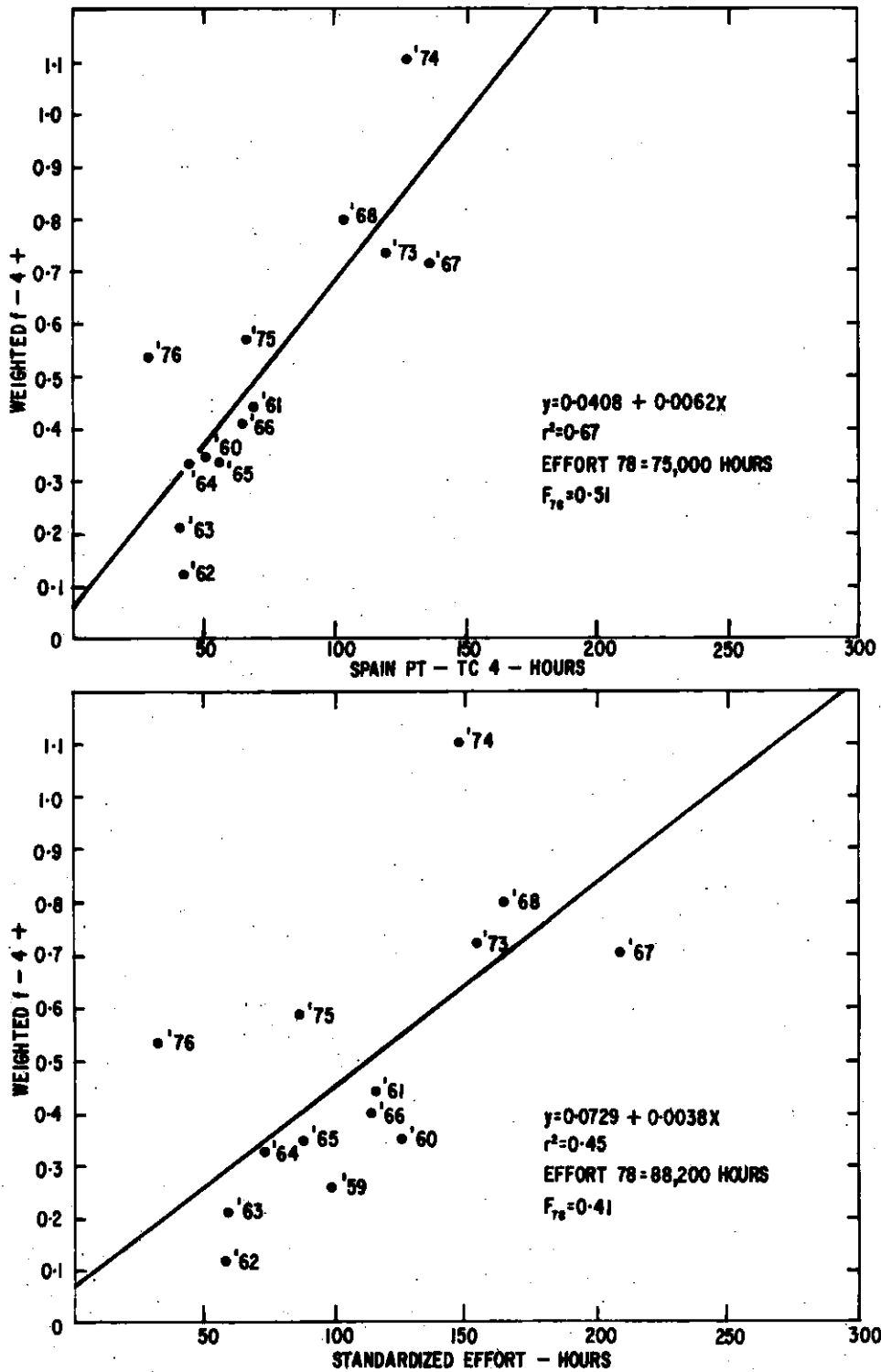


Fig. 3. Relationship of weighted F (4+) to effort for Spain pair trawl (t.c. 4) and a standardized effort.

