Assessment of cod in NAFO Division 4T and Subdivision 4Vn (Jan.-Apr.) for 1984

by

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ABSTRACT

The Provisional nominal catch for 1983 was 66,881 t, the highest recorded since 1963 (70,202 t). Research vessel population estimates show a sharp increase from 1978 to 1981 with a slight decrease in 1982 with the 1983 estimates at a level comparable to 1982. The standardized commercial catch rate is down slightly from 1982 when it was the highest observed since 1968. The 1977 year class is the dominant contributer to the commercial fishery at 32% of total numbers caught.

Examination of the research survey and the commercial numbers at age yielded a partial recruitment up to and including age 7.

Best agreement between whort output and calibration was found for F_T = 0.350. If the 1984 TAC is caught (67,000 t) the 1985 $F_{0.1}$ catch would be 60606 t.

RÉSUMÉ

Les prises nominales provisoires en 1983 s'élevaient à 66 881 t, soit le taux le plus élevé depuis 1963 (70 202 t). Les chiffres estimatifs avancés par naivre de recherche sur les populations de poisson font voir un accroissement appréciable entre 1978 et 1981 et une légère diminution en 1982; le taux de 1983 se compare à celui de 1982. Le taux normalise de prises commerciales est légerement en baisse par rapport à celui de 1982 quand il avait atteint un sommet inégalé depus 1968. La classe d'âge de 1977 est le contributeur dominant à la pêche commerciale et on lui attribue 32 % des prises globales.

D'après les résultats de l'étude de recherche et les prises commerciales par âge, on constate qu'il y a recrutement partiel jusqu'à l'âge de 7 ans inclusivement.

On préconise un F_T de 0,350 entre l'ASP et la calibration. Si le TPA de 1984 (67 000 t) est atteint, les prises de 1985 suivant un taux de F0,1, seraient de l'ordre de 60 606 t.

NOMINAL CATCHES

The catches from the southern Gulf of St. Lawrence cod stock complex can be classified according to three gear groupings:

1) otter trawlers;
2) seines and pair trawlers;
3) inshore and fixed gear.

The inshore and fixed gears have generally been the major contributors to the catches from May to October while the otter trawlers have usually been the sole exploiters in the January to March-April season since 1974. The catches by the seines and pair trawlers have been increasingly more important during the second half of the year since 1976 (Maguire, et al 1983).

The 1983 4T-Vn nominal catches rose to a recent high (since 1963) to approximately 66881t (Table 1). The catches were split 79% - 21% between 4T and 4Vn respectively (Table 2). Of the 52949t caught in 4T, 42% was taken by Quebec, 57% was taken by Maritime and 1% by Newfoundland based vessels (Table 3). The Maritime 4T fishery shows a peak in May of 8312t and another peak in November of 2856t with a 40%-20%-10%-9%-21% breakdown between Danish seines, otter trawl (side), otter trawl (stern), gill net (set) and miscellaneous respectively. The Quebec 4T fishery shows a peak in June of 5360t and another peak in September of 3452t. Within this fishery 56%-42%-2% was caught by mobile, fixed and miscellaneous respectively. The Newfoundland 4T fishery showed 842t catch of which 99% was by otter trawl (stern). In 4Vn, of the 13932t caught, 45% was taken by Maritime and 9% by Newfoundland based vessels. France took 46% (Table 4). This fishery was dominated by otter trawls which account for 97% of the catch.*

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* It is assumed that the French fleet are large stern trawls (tonnage class 4).

Catch at age

Catch at age for each year was calculated back to 1971 (Table 5). A minimum criterion of 400 ages was used to generate a quarterly age length key by gear type where possible. Where this was not possible, an examination of the fishery using mean length (Table 6) for the current year concerned was conducted. This led to combining age length keys from different gear types with similar mean lenghts to attain this minimum 400 ages. The length frequency of the fishery being analyzed would then be applied to this combined age length key. Where there were no samples, the catches were applied to similar gear samples in the same year using previous year's mean lengths to determine similarity of gear. When a quarterly age length key could not be obtained, the age length key was generated on a half year, three-quarter year or a yearly basis. The variables used to calculate length weight relationships derived from the annual 4T Groundfish survey are given in Table 7. Random stations only were used.

The 1978 to 1974 year classes accounted for 89% of the 1983 commercial catches. The 1977 year class was dominant contributing 32% to the fishery followed by the 1975, 1976 and 1978 year classes at 19%, 16% and 13% respectively. The 1980 year class is very strong indicating the highest catch of three year olds since 1975.

The 1950 to 1970 catch-at-age as shown in Table 8 is taken from Maguire, et al (1983). It was not utilized in this assessment but is shown here for historical purposes only. The 1950 to 1960 catch-at-age was originally taken from Lett (1978). It was stated by Maguire at al (1983) that if this data is used "the SPA... should be interpreted with extreme caution since it is doubtful that the catch-at-age prior to 1960 gives valuable information on the age structure of the stock".

Weight at age

The average weights-at-age were estimated by:

$$\frac{\sum_i \frac{cw_i}{\bar{w}_i} \times \bar{w}_{i,j}}{\sum_i \frac{cw_i}{\bar{w}_i}}$$

cw=catch weight
w=average weight

where i indexes the keys and j indexes the ages for each individual year back to 1971 (Table 9). Table 10 shows that the bulk of the fishery occurs in May so in fact these are approximately mid-year weights at age.

STOCK SIZE INDICES

Research Vessel Survey

Table 11 shows the stratified numbers caught per tow for 1971 to 1983. Table 12 shows the population estimates at age for 1971 to 1983 from the research survey.

Population numbers at age as estimated from research vessel surveys show a sharp increase from 1978 to 1981 with a slight decrease in 1982. The 1983 estimates are comparable to 1982.

The 1980 year class which showed up as very strong in the 1981 and 1982 surveys is still indicated as being above average in the 1983 survey.

Commercial catch per unit of effort

Commercial catch rates for Canada Maritimes-Quebec and Newfoundland (except Quebec 1983) for Otter trawlers, Danish seiners, Scottish seiners and Longlines were standardized over 1967 to 1983 for the 4T-Vn cod fishery using the multiplicative model described by Gavaris (1980). The effort type chosen for the model was hours fished. Categories were grouped as shown in Table 13 where the coefficients, standard errors, and numbers of observations used for each category are also presented. As can be observed in Table 14 there has been a steady increase in catch rates from 1976-1983.

SEQUENTIAL POPULATION ANALYSIS

Assuming a natural mortality of 0.200, population estimates were made using virtual population analysis (Rivard, 1982). The fishing mortality on the oldest age for every year was determined by using an iterative process with a weighted average on ages 8 to 12 until convergence of the virtual population analysis was achieved.

A comparison of numbers at age in the commercial catch and in the research vessel surveys for 1979 to 1982 indicated full recruitment at age 8 and the following partial recruitment for younger ages:

Age	3	4	5	6	7	8	9
Pr	.008	.064	.261	.49	.8	1	1

The calibration of the SPA using 1971-1983 mean exploitable biomass with catch rates resulted in very strongly auto-correlated residuals and

therefore the calibration was rejected. Calibrations of mean 5^+ biomass against catch rate indicated a terminal F of 0.400 where the correlation coefficiant maximized and the 1983 residual minimized. Mean 4^+ research vessel numbers calibrated against mean 4^+ SPA population estimates indicated a terminal F value between 0.325 and 0.350 where the intercept was zero. The calibration of 6^+ research vessel numbers and the SPA population estimates indicated a terminal F value betwen 0.350 and 0.400 for a similar reason. Based on these results, a 1983 fully recruited fishing mortality of 0.350 was utilized. Fishing mortality, population numbers and population biomass values are shown in Tables 15 to 17 for $F_T = 0.350$.

PROJECTIONS

A regression of the 1972 to 1982 SPA three year old population estimates against the 1971 to 1981 research vessel survey estimates of two year old fish gave a correlation coefficient of .88 and predicted a recruitment of 376606 in 1982, a value close to the SPA estimate of 363013 with $F_T = .350$. However, because the 1983 value was well outside the regression an estimate of recruitment of 250 million fish at age 3 was adopted for 1983, a value equal to the highest observed. Also the regression predicted the value of 242 million for the abundance of the 1981 year class at age 3 in 1984.

Using the above estimates, the projected 1985 $F_{0.1}$ catch would be 61,744t, if the 1984 TAC is caught. However, if recruitment at age 3 is estimated to be equal to the geometric mean for the period 1971 to 1982 (100 million), then the 1985 $F_{0.1}$ catch would be 60,606t (Table 18), using the input parameters in Table 19.

REFERENCES

Gavaris, S., 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37(12); 2272-2275.

Lett, P.F. 1978. A multispecies simulation for the management of the southern Gulf of St. Lawrence cod stock. CAFSAC Res. Doc. 78/21.

Maguire, J.J., D. Lever and L. Waite. 1983. Assessment of cod in NAFO Division 4T and subdivision 4Vn (Jan.-Apr.) for 1983. CAFSAC Res. Doc. 83/51.

Rivard, D., 1982. APL programs for stock assessment (revised). Can. Tech. Rep. of Fish. Aquat. Sci. No. 1091.

Table 1. Total nominal catches of cod in Division 4T and Subdivision 4Vn(Jan.-Apr.).

Year	Nominal Catch	Year	Nominal Catch
1950	44023*	1967	41316
51	34827	68	46551
52	41956	69	47819
53	58911	1970	64465
54	63901	71	56375
1955	65227	72	65291
56	104469	73	50635
57	89131	74	48747
58	86582	1975	42471
59	70720	76	33415
1960	66013	77	22219
61	65583	78	37892
62	66664	79	55996
63	70202	1980	54634
64	60547	81	65177
1965	63027	82	58193
66	54851**	83	66891***

* . 1950 to 1966 values are from Lett (1978).
** . 1966 to 1982 values are from NAFO data files.
***. Provisional data.

Table 2. 4T-Vn cod catches during 1983 by Maritimes, Quebec, Newfoundland and France.
Values are given in t round weight.

	J	F	M	A	M	J	J	A	S	O	N	D	Total	% of 4T catch
4T														
Maritimes	1401	1508	517	3228	8312	3485	2170	1579	1692	1416	2856	1778	29952	44.78
Quebec	---	---	---	980	2823	5360	4511	1504	3452	2602	436	497	22165	33.14
Newfoundland	---	---	385	7	---	---	---	38	27	142	234	9	842	1.26
TOTAL	1401	1508	902	4215	11135	8845	6681	3121	5171	4160	3526	2284	52949	79.17
4Vn														
Maritimes	2913	1936	495	990									6334	9.47
Newfoundland	700	354	100	84									1238	1.85
France	1975	4365	20	---									6360	9.51
TOTAL	5588	6655	615	1074									13932	20.83
GRAND TOTAL	6989	8163	1517	5289	11135	8845	6681	3121	5171	4160	3526	2284	66881	100.00

Table 3. 4T cod catches during 1983 by Maritimes, Newfoundland and Quebec.
Values are given in t round weights.

MARITIMES

GEAR TYPE	J	F	M	A	M	J	J	A	S	O	N	D	Total	% of 4T catch
Otter trawl(side)	898	442	27	221	2707	579	243	119	92	205	467	356	6356	12.00
Otter trawl(stern)	490	1066	490	257	392	251	260	137	193	156	162	206	4060	7.67
Danish seine	13	---	---	2496	4377	1496	469	367	456	419	1369	848	12310	23.24
Scottish seine	---	---	---	140	244	223	85	23	17	40	73	---	845	1.60
Gill net(set)	---	---	---	---	140	428	739	632	528	207	56	11	2741	5.18
Gill net(drift)	---	---	---	---	---	15	14	5	1	---	---	---	35	0.07
Longline	---	---	---	9	111	33	15	59	123	183	701	367	1601	3.02
Handline	---	---	---	---	23	261	312	204	258	184	28	---	1270	2.40
Stern trawl	---	---	---	105	76	---	---	---	---	13	---	---	194	0.37
Pair seine	---	---	---	---	239	136	17	22	5	2	---	---	421	0.79
Fix	---	---	---	---	1	35	5	---	1	---	---	---	42	0.08
Scallop	---	---	---	---	1	---	---	---	---	---	---	---	1	0.00
57	---	---	---	---	---	2	---	---	---	---	---	---	2	0.00
61	---	---	---	---	---	---	1	---	---	---	---	---	1	0.00
Miscellaneous	---	---	---	---	1	19	9	11	18	7	---	---	65	0.12
Unknown	---	---	---	---	---	7	1	---	---	---	---	---	8	0.02
TOTAL	1401	1508	517	3228	8312	3485	2170	1579	1692	1416	2856	1788	29952	56.56

NEWFOUNDLAND

Otter trawl(stern)	---	---	385	7	---	---	---	37	27	142	225	---	823	1.55
Gill net(set)	---	---	---	---	---	---	---	1	---	---	---	---	1	0.00
Longline	---	---	---	---	---	---	---	---	---	---	9	9	18	0.03
TOTAL	---	---	385	7	---	---	---	38	27	142	234	9	842	1.59

QUEBEC

Unknown	---	---	---	---	---	---	---	---	---	---	436	---	436	0.82
Fixed	---	---	---	---	401	1670	2078	1504	1971	1227	---	488	9339	17.63
Mobile	---	---	980	---	2422	3690	2433	---	1481	1375	---	9	12390	23.40
TOTAL	---	---	980	---	2823	5360	4511	1504	3452	2602	436	497	22165	41.85

GRAND TOTAL	1401		1882		11135		6681		5171		3526		52959	100.00
		1508		3235		8845		3121		4160		2294		

Table 4. 4Vn (Jan.-Apr.) cod catches during 1983 by Maritimes, Newfoundland and France. Values are given in t round weight.

MARITIMES

GEAR TYPE	J	F	M	A	Total	% of 4T catch
Otter trawl(side)	1403	1186	271	57	2917	20.94
Otter trawl(stern)	1436	739	224	480	2879	20.66
Longline	58	7	---	294	359	2.58
Danish seine	16	4	---	148	168	1.21
Scottish seine	---	---	---	11	11	0.08
TOTAL	2913	1936	495	990	6334	45.46

NEWFOUNDLAND

Otter trawl(stern)	700	353	100	84	1237	8.88
Longline	---	1	---	---	1	0.01
TOTAL	700	354	100	84	1238	8.89

FRANCE

Otter trawl(stern)	1975	4365	20	---	6360	45.65
GRAND TOTAL	5588	6655	615	1074	13932	100.00

Table 5. 4T-Vn Commercial Cod Catch at Age.

Year / Age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	6	3177	1337	2731	1556	466	546	538	142	314	96	372	920
4	2040	22152	6888	4980	8781	3460	3357	9854	4959	2019	3762	1244	4538
5	7082	11824	14327	4774	6761	8930	4115	10627	15531	15000	7277	10101	6314
6	9018	6541	5242	9404	2487	6563	2865	4463	10956	14152	18841	9530	15581
7	5746	7422	3648	2986	3237	1592	1686	2589	3391	9541	12863	12737	7810
8	2276	3467	2736	1795	1293	1138	406	1065	1670	1274	6026	6690	9112
9	1225	919	1803	1702	1104	446	291	237	835	699	867	2157	3645
10	510	529	540	1035	791	265	180	241	291	320	432	326	746
11	129	354	328	266	671	135	124	104	247	124	190	110	74
12	346	114	97	194	150	140	55	72	64	24	64	58	40
13	73	49	67	85	53	45	59	44	33	16	81	6	6
14	117	14	46	26	74	14	11	5	15	8	2	3	2
15	151	46	11	6	7	10	4	13	15	11	14	2	3
16	61	36	23	15	66	9	5	6	8	26	3	2	5
TOT.	28780	56644	37093	29999	27031	23213	13704	29858	38157	43528	50518	43338	48796

Table 6. Mean length (cm), 2 standard deviations of mean length and mean age of cod in the commercial samples of the 4TVn cod stock.

	4Vn Otter Trawl Jan - Apr			4T Otter Trawl Jan - Apr			4T Otter Trawl May - Dec			4T Seines Unsp May - Dec			4T Gill Net May - Dec			4T Long Lines May - Dec			4T Handlines May - Dec			4T Pair Trawl Jun - Jul		
	Mean Length	2 S.D.	Mean Age	Mean Length	2 S.D.	Mean Age	Mean Length	2 S.D.	Mean Age	Mean Length	2 S.D.	Mean Age	Mean Length	2 S.D.	Mean Age	Mean Length	2 S.D.	Mean Age	Mean Length	2 S.D.	Mean Age	Mean Length	2 S.D.	Mean Age
1983	53.96	±.074	6.82	50.66	±.222	6.89	52.09	±.083	6.17	51.99	±.064	6.35	61.79	±.185	6.29	58.55	±.175	6.70	54.21	±.173	5.93	52.85	±.222	5.93
1982	50.74	±.099	6.54	-	-	-	51.26	±.130	6.51	50.97	±.043	6.60	49.91	±.131	5.72	52.83	±.142	6.51	52.83	±.142	6.51			
1981	49.03	±.083	6.31	52.18	±.322	6.96	52.53	±.124	6.35	49.56	±.058	6.22	59.09	±.515	7.02	62.92	±.253	7.39	50.13	±.126	5.92			
1980	50.25	±.1	6.02	51.67	±.291	6.17	50.26	±.191	5.92	48.80	±.134	5.64	60.12	±.697	6.69	-	-	-	47.68	±.484	5.64			
1979	51.11	±.118	5.64	-	-	-	51.02	±.105	5.40	51.01	±.119	5.59	61.06	±.580	6.80	-	-	-	54.68	±.218	5.90			
1978	51.96	±.129	5.51	-	-	-	45.72	±.164	4.89	46.79	±.109	4.81	52.37	±.505	5.38	53.15	±.371	5.54	52.75	±.359	5.55			
1977	51.93	±.218	5.67	-	-	-	51.77	±.155	5.33	48.60	±.104	4.83	68.20	±.301	7.71	48.24	±.432	4.92	51.99	±.198	5.10			
1976	50.39	±.095	5.68	52.35	±.297	5.84	49.31	±.182	5.13	49.06	±.111	4.95	67.27	±.358	7.53	50.52	±.529	5.27	52.48	±.241	5.33			
1975	47.29	±.178	5.27	-	-	-	51.31	±.146	5.37	46.33	±.285	4.47	71.77	±.337	8.84	-	-	-	62.47	±.691	6.78			
1974	54.50	±.166	6.50	49.13	±.311	5.88	49.99	±.262	5.21	46.12	±.384	4.33	72.77	±.385	8.76	-	-	-	-	-	-			
1973	48.25	±.207	5.81	48.61	±.327	5.75	48.83	±.222	5.13	48.11	±.345	5.03	80.04	±.298	8.95	68.35	±.565	8.51	-	-	-			
1972	52.43	±.317	5.73	42.72	±.193	4.89	45.35	±.209	5.05	49.37	±.209	5.35	85.74	±.626	9.47	-	-	-	-	-	-			
1971	53.91	±.211	6.36	-	-	-	52.76	±.291	5.91	49.70	±.163	5.41	79.23	±.891	8.78	63.47	±.987	6.16	-	-	-			
1970	51.81	±.390	5.94	46.94	±.476	5.48	51.76	±.250	5.46	49.88	±.185	4.94	-	-	-	-	-	-	-	-	-			
1969	49.98	±.255	5.77	45.91	±.374	5.02	52.54	±.174	5.35	51.83	±.242	4.97	83.00	±1.556	8.52	-	-	-	-	-	-			
1968	53.09	±.415	6.16	-	-	-	43.41	±.110	4.37	-	-	-	-	-	-	-	-	-	-	-	-			
1967	51.85	+.381	6.16	-	-	-	49.36	+.144	4.79	-	-	-	-	-	-	-	-	-	-	-	-			

Table 7. A, B, log A and number of fish sampled of length/weight relationships derivred from 4T Fall Groundfish Surveys.

	Random Stations				Fixed Stations				Random and Fixed Stations			
Year	a	b	log a	# of fish	a	b	log a	# of fish	a	b	log a	# of fish
1983	.004364844	3.166966	-2.360031	1758	.00892367	2.982329	-2.049456	205	.004609982	3.152896	-2.336300	1968
1982	.009150628	3.003925	-2.038548	1461	.014061989	2.897984	-1.851953	307	.00991098	2.984174	-2.003883	1768
1981	.008767	3.005085	-2.057126	1828	.007184	3.040869	-2.14363	319	.008514	3.010291	-2.069843	2147
1980	.007656	3.044187	-2.115980	1627	.005881	3.095755	-2.230528	373	.007519	3.045749	-2.123813	2000
1979	.002387	3.332688	-2.622167	1903	.002332	3.333190	-2.632266	302	.00238689	3.332688	-2.622167	1903
1978	.003956	3.219355	-2.402759	1463	.002899	3.296050	-2.537805	354	—	—	—	—
1977	.007358	3.061350	-2.133261	1531	.006570	3.083951	-2.182421	431	—	—	—	—
1976	.007017	3.079470	-2.153852	1212	.005561	3.142265	-2.254854	287	—	—	—	—
1975	.010814	2.980825	-1.966008	1066	.011966	2.966304	-1.922042	274	—	—	—	—
1974	.007118116	3.074415	-2.147635	1105	.006421	3.100387	-2.192400	246	—	—	—	—
1973	.005877698	3.119851	-2.230793	1254	.006527	3.095000	-2.185285	293	—	—	—	—
1972	.007373615	3.0681	-2.132320	1442	.005446	3.135714	-2.263957	416	—	—	—	—

Table 8. 4T-Vn (Jan.-Apr.) Cod Catch for 1950 to 1970.

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
3	173	133	192	294	412	324	396	359	506	535	75	1	16	255	100	464	1498	700	310	327	26
4	728	638	1034	2120	2968	2336	2372	2372	3341	3535	3967	3304	1720	2123	970	5504	7055	7068	8140	4936	3395
5	1559	1462	1915	5596	7832	6165	6727	6109	8607	9107	8983	13921	10887	4352	6728	6148	10689	5503	8086	12530	14972
6	2703	2113	3104	5037	7049	5549	6648	6037	8606	9000	12515	9475	1889	16021	5863	9292	4505	4586	4674	3571	11925
7	2772	2127	3065	4713	6596	5191	6331	5750	8101	8571	7144	8313	7870	14742	12038	4481	3423	3040	2916	2516	4194
8	2495	1874	2643	3799	5319	4186	5223	4743	6683	7071	1736	2661	4290	6390	9261	8524	1841	1735	1276	2136	1905
9	3327	2365	3141	3593	5029	3959	5381	4887	6885	7286	795	777	1480	3180	3760	5534	2262	407	753	917	1444
10	2183	1582	2146	2680	3751	2952	3878	3522	4961	5250	1812	506	589	984	1133	1845	1890	1021	434	785	727
11	901	638	843	942	1319	1038	1424	1293	1823	1929	388	741	153	392	347	1004	867	901	899	212	569
12	478	351	483	636	890	701	902	819	1153	1221	279	385	178	137	149	423	375	383	698	283	360
13	138	106	153	235	329	259	316	287	405	428	76	188	37	102	103	150	242	171	259	292	239
14	128	94	130	173	243	191	245	222	314	332	93	174	26	37	88	52	76	82	139	55	139
15	79	58	80	106	148	117	150	136	192	203	51	33	36	50	24	124	42	23	65	21	30
3+	17664	13541	18929	29924	41885	32968	39993	36536	51577	54468	37914	40479	29171	48765	40564	43545	34765	25620	28649	28581	39925
4+	17491	13408	18737	29630	41473	32644	39597	36177	51071	53933	37839	40478	29155	48510	40464	43081	33267	24920	28339	28254	39899
5+	16763	12770	17703	27510	38505	30308	37225	33805	47730	50398	33872	37174	27435	46387	39494	37577	26212	17852	20199	23318	36504
6+	15204	11308	15788	21914	30673	24143	30498	27696	39123	41291	24889	23253	16548	42035	32766	31429	15523	12349	12113	10788	21532

Table 9. 4T-Vn Commercial Cod Average Weight at Age. 1971-1983

Year / Age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	0.756	0.352	0.456	0.602	0.481	0.640	0.533	0.400	0.506	0.563	0.503	0.713	0.701
4	0.815	0.559	0.667	0.778	0.737	0.739	0.759	0.680	0.706	0.687	0.674	0.757	0.900
5	1.114	0.914	0.919	1.078	1.142	1.067	1.250	1.028	1.005	0.918	0.848	0.971	1.153
6	1.402	1.329	1.273	1.484	1.762	1.504	1.809	1.658	1.415	1.205	1.132	1.179	1.280
7	2.145	1.515	1.682	1.958	2.363	2.168	2.437	2.257	2.215	1.471	1.381	1.448	1.452
8	3.679	2.540	2.301	2.676	2.751	2.828	3.511	2.810	3.302	2.641	1.831	1.671	1.655
9	3.834	4.788	3.575	2.892	3.220	3.213	4.238	4.348	4.067	2.893	3.149	2.112	1.879
10	5.251	5.921	5.511	4.176	3.697	3.858	4.286	4.650	7.137	3.563	4.120	3.081	2.068
11	6.009	7.181	6.007	6.065	4.455	4.739	5.069	6.489	7.025	7.949	4.454	3.852	5.468
12	4.774	8.037	7.910	7.261	6.955	5.055	5.489	6.542	6.706	5.799	5.600	3.713	7.117
13	6.822	8.823	6.148	8.292	9.193	6.233	6.735	6.245	4.701	10.305	6.029	6.890	8.186
14	7.452	10.103	6.706	6.595	6.316	10.357	8.968	5.080	8.719	5.806	7.070	9.297	11.246
15	7.912	5.591	8.927	9.119	8.392	11.498	10.803	11.560	15.417	9.758	3.492	4.190	14.412
16	17.903	11.172	6.048	11.741	6.172	14.203	9.262	10.183	17.403	9.348	6.759	11.101	13.040

Table 10. 4T-Vn Cod Catch by Month.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	MEAN MONTH
1983	6989	8163	1527	5289	11135	8845	6681	3121	5171	4160	3526	2294	5.74
1982	4286	5808	3145	2691	5356	8162	6349	5284	4331	4571	4839	3371	6.48
1981	8661	3677	3976	4541	7844	8313	6237	5995	5599	4653	5186	495	5.93
1980	5248	8373	3293	4141	5896	5870	4834	4859	3210	3832	3460	1618	5.68
1979	1276	5182	2304	2630	7895	6351	6264	4977	3056	4314	7200	4547	7.05
1978	5523	6080	943	837	5993	3656	4811	3834	2499	2560	939	217	5.31
1977	819	863	919	266	2750	2795	3596	3296	2104	2114	2594	103	7.12
1976	9343	4454	3744	2240	2664	2060	2886	1987	1751	825	468	357	4.08
1975	5376	5903	2927	2147	6419	3276	3665	2883	2423	2123	1308	2781	5.48
1974	13622	9476	2470	2799	1987	2270	3204	2532	2168	1648	2118	2606	4.43
1973	8099	6813	7470	3675	2245	3718	4505	4438	2926	2188	1556	1763	4.98
1972	8734	8026	7787	6211	7783	7133	5044	4747	3319	2002	1623	2228	4.99
1971	2694	5688	5927	6829	4544	6303	8276	5894	4538	2591	1587	1504	5.80
TOTAL	80670	78506	46432	44296	72511	68752	66352	53847	43095	37581	36404	23884	5.60

Table 11. Averages numbers of cod per tow in Fall Research Vessel Surveys from 1971 - 1983.

Strat. \ Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
15	0	13	1	5	1	0	0	0	0	0	2	1	5
16	79	62	67	12	19	7	74	78	221	88	203	281	338
17	100	3	33	20	22	129	98	80	50	807	1430	113	638
18	121	66	185	25	29	70	117	71	146	67	16	87	365
19	62	57	41	271	5	207	121	417	708	207	161	115	290
20	22	61	114	118	21	89	112	174	105	22	92	16	219
21	45	85	62	25	57	9	60	140	162	43	296	120	0
22	113	148	113	71	140	438	50	267	506	230	744	90	223
23	29	21	25	7	5	20	40	124	146	233	279	164	142
24	14	18	6	11	12	17	32	1	199	166	526	903	161
25	7	1	0	1	21	1	1	0	0	4	1	0	0
26	16	57	9	22	1	4	6	19	83	76	260	174	321
27	39	10	4	8	1	3	26	21	42	63	33	377	173
28	3	78	63	12	35	97	23	1	482	81	337	365	347
29	11	22	69	53	73	27	101	22	115	119	200	119	200
31	34	5	17	39	23	31	99	66	112	144	121	157	173
32	14	130	9	0	91	0	0	5	13	2	1	2	0
33	6	5	1	26	25	16	70	18	41	1	60	41	14
34	4	38	3	3	10	7	10	11	53	58	93	64	143
35	10	17	14	25	100	214	16	9	11	214	38	4	127
36	19	4	3	6	3	6	4	4	20	77	57	52	24
37	1	7	4	0	18	71	3	3	24	58	31	128	58
38	31	55	3	32	1	12	13	29	132	141	107	39	134
39	0	24	2	20	1	0	6	60	4	0	49	5	10

Table 12. 4TV-n Cod Fall Research Vessel Survey Population Estimates from 1971 to 1983.

Age \ Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	118	1522	146	174	1052	6117	1105	2489	336	1976	9709	5336	9609
2	1149	4393	9522	4793	23809	15934	20630	6732	43878	9328	41508	68459	37234
3	12508	8887	18795	19768	6814	63330	30614	34014	44532	64773	38524	51237	137302
4	15131	25099	8727	14661	19095	16008	25812	27033	94435	48643	114900	37737	53328
5	14335	9493	13775	5637	7450	10604	10103	17009	57619	84680	95211	76862	19325
6	11228	8458	6554	6621	3231	4589	5358	6104	23494	41569	92909	37864	33723
7	6979	6109	4613	2866	2573	1333	3056	3388	6135	14994	39094	28749	19272
8	1727	3097	3528	2028	1873	878	1315	1329	2517	2494	21063	13641	15344
9	354	638	2235	2343	1345	495	969	396	1258	1210	2841	1966	3869
10	381	529	611	748	652	390	621	720	336	506	1162	627	1055
11	218	295	145	400	690	423	503	574	371	122	513	244	477
12	127	191	461	192	364	108	404	211	615	24	209	88	129
13	633	208	439	700	261	191	614	412	0	73	502	210	56
1+	64888	68919	69551	60931	69209	120400	101104	100411	275526	270392	458145	323020	330723
2+	64770	67397	69405	60757	68157	114283	99999	97922	275190	268416	448436	317684	321114
3+	63621	63004	59883	55964	44348	98349	79369	91190	231312	259088	406928	249225	283880
4+	51113	54117	41088	36196	37534	35019	48755	57176	186780	194315	368404	197988	146578
5+	35982	29018	32361	21535	18439	19011	22943	30143	92345	145672	253504	160251	93250
6+	21647	19525	18586	15898	10989	8407	12840	13134	34726	60992	158293	83389	73925
7+	10419	11067	12032	9277	7758	3818	7482	7030	11232	19423	65384	45525	40202

Table 13. Country - Gear - Tonnage Categories 4T-Vn Cod.

Unweighted regression

Multiple r: .723

Category	Coefficient	Std. error	No. obs.
Intercept	-1.189	.088	1223
M-Q; OTB1 TC2	Ref.		13
M-Q; OTB1 TC3; SDN TC2	.463	.045	331
M-Q-N; OTB1 TC4; OTB2 TC4	1.125	.051	332
M-Q; OTB2 TC3	.655	.056	129
M-Q-N; OTB1 TC5; OTB2 TC5	1.404	.060	154
M-Q; SD TC3	.890	.061	94
M-Q; SSC TC3; LL TC2	.996	.053	170

Table 14. 1983 4T-Vn cod predicted catch rate.

STANDARDS USED VARIABLE NUMBERS: 0 0 0

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1967	41316	0.368	0.332	0.029	124439
1968	46551	0.405	0.458	0.040	101698
1969	47819	0.493	0.435	0.035	110044
1970	64465	0.370	0.370	0.030	174396
1971	56375	0.473	0.322	0.025	174964
1972	65291	0.484	0.369	0.029	176892
1973	50635	0.365	0.301	0.025	168223
1974	48747	0.320	0.253	0.021	192676
1975	42471	0.366	0.247	0.022	171947
1976	33415	0.528	0.260	0.022	128519
1977	22219	0.413	0.356	0.032	62417
1978	37892	0.519	0.421	0.035	89926
1979	55996	0.597	0.549	0.043	102016
1980	54634	0.555	0.566	0.045	96608
1981	65177	0.520	0.591	0.046	110367
1982	58193	0.538	0.621	0.049	93712
1983	66891	0.320	0.751	0.062	89069

Table 15. FISHING MORTALITIES - 4TVn cod with F_T = .350.

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	0.000	0.111	0.033	0.058	0.043	0.005	0.004	0.003	0.001	0.002	0.001	0.001	0.003
4	0.060	0.422	0.362	0.163	0.268	0.127	0.044	0.085	0.035	0.025	0.023	0.014	0.022
5	0.296	0.575	0.521	0.454	0.345	0.484	0.224	0.193	0.186	0.142	0.116	0.081	0.091
6	0.396	0.489	0.533	0.779	0.455	0.674	0.288	0.403	0.310	0.258	0.267	0.218	0.172
7	0.415	0.665	0.547	0.661	0.686	0.605	0.370	0.457	0.614	0.488	0.394	0.291	0.279
8	0.565	0.476	0.540	0.568	0.683	0.560	0.309	0.424	0.607	0.494	0.661	0.367	0.350
9	0.541	0.470	0.477	0.770	0.848	0.541	0.275	0.298	0.700	0.557	0.751	0.529	0.350
10	0.423	0.477	0.547	0.552	1.067	0.507	0.449	0.384	0.728	0.645	0.822	0.722	0.350
11	0.309	0.589	0.604	0.568	0.866	0.517	0.485	0.510	0.872	0.814	1.056	0.509	0.350
12	0.633	0.493	0.307	0.888	0.748	0.441	0.423	0.583	0.691	0.183	1.528	1.196	0.350
13	0.585	0.167	0.598	0.482	0.646	0.530	0.345	0.717	0.586	0.365	1.652	0.544	0.350
14	0.603	0.207	0.228	0.477	1.050	0.365	0.241	0.044	0.576	0.271	0.070	0.217	0.350
15	0.835	0.507	0.250	0.043	0.236	0.384	0.168	0.498	0.179	1.173	1.066	0.093	0.350
16	0.532	0.482	0.516	0.634	0.824	0.537	0.336	0.405	0.661	0.532	0.691	0.409	0.350

Table 16. POPULATION NUMBERS - 4TVn cod with F_T = .350.

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	86059	33293	44770	51594	39861	104560	163952	192744	112340	219468	120644	276388	363014
4	38336	70454	24394	35471	39850	31271	85193	133739	157319	91848	179401	98689	225952
5	30365	29546	37812	13908	24685	24959	22545	66720	100607	124325	73375	143484	79676
6	30259	18495	13610	18378	7231	14315	12589	14755	45057	68384	88271	53514	108363
7	18541	16681	9281	6542	6904	3755	5972	7732	8076	27043	43259	55326	35236
8	5766	10025	7025	4398	2766	2846	1679	3376	4009	3579	13592	23874	33847
9	3204	2684	5100	3351	2041	1143	1331	1009	1809	1789	1789	5744	13539
10	1620	1527	1373	2591	1270	716	545	828	613	735	839	691	2771
11	533	869	776	651	1222	358	353	285	462	242	316	302	275
12	806	320	394	347	302	421	175	178	140	158	88	90	149
13	180	350	160	238	117	117	222	94	81	57	108	16	22
14	282	82	243	72	120	50	56	128	37	37	33	17	7
15	290	127	55	158	37	34	29	36	101	17	23	25	11
16	162	103	62	35	124	24	19	20	18	69	4	7	19
3+	216403	184556	145057	137734	126529	184569	294660	421644	430669	537753	521743	658165	862880
4+	130344	151262	100287	86140	86669	80009	130708	228900	318329	318285	401098	381777	499866
5+	92007	80808	75893	50669	46819	48738	45515	95161	161010	226437	221697	283088	273915
6+	61642	51262	38082	36761	22134	23779	22970	28441	60403	102112	148321	139604	194239
7+	31384	32767	24471	18383	14902	9464	10380	13686	15346	33728	60051	86090	85876
8+	12843	16087	15190	11841	7998	5708	4408	5954	7270	6684	16792	30764	50640

Table 17. POPULATION BIOMASS - 4TVn cod with F_T = .350

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	58984	10078	18203	27361	17037	60512	79121	69727	51476	111993	55004	178496	230236
4	27495	29322	12439	23154	23456	19721	57332	79200	98972	56550	108332	67215	182241
5	26673	18799	24749	11001	21736	19293	22967	56741	83850	96670	53344	121508	79687
6	31958	17764	12283	17392	9349	14350	18027	18374	49931	66102	79812	51570	115826
7	29708	16911	10999	8589	10818	5591	11091	12793	12238	28756	45044	63308	40649
8	14827	18507	11419	8216	5052	5636	4620	7057	9084	6817	16686	30445	43100
9	8676	9365	13247	6202	4072	2594	4491	3457	4850	3629	3635	8615	19565
10	6329	6568	5333	7607	2662	1980	1717	2916	2853	1769	2165	1391	4408
11	2510	4313	3203	2756	3347	1211	1296	1322	1989	1212	801	833	1156
12	2611	1857	2448	1537	1357	1570	714	807	621	761	235	180	813
13	852	2588	678	1428	725	518	1150	383	265	452	296	76	140
14	1447	682	1325	345	433	397	409	579	227	172	202	129	64
15	1431	507	393	1281	249	300	258	302	1291	92	46	90	124
16	2051	835	270	278	480	238	138	151	211	456	20	54	186
3+	215552	138096	116989	117147	100773	133911	203331	253809	317858	375431	365622	523910	718195
4+	156568	128018	98786	89786	83736	73399	124210	184082	266382	263438	310618	345414	487959
5+	129073	98696	86347	66632	60280	53678	66878	104882	167410	206888	202286	278199	305718
6+	102400	79897	61598	55631	38544	34385	43911	48141	83560	110218	148942	156691	226031
7+	70442	62133	49315	38239	29195	20035	25884	29767	33629	44116	69130	105121	110205
8+	40734	45222	38316	29650	18377	14444	14793	16974	21391	15360	24086	41813	69556

Table 18. 4TVn cod projections to 1985 catching the 1984 67000t TAC.

AGE	POPULATION NUMBERS 1984	1985	MEAN POPULATION BIOMASS 1984	1985	CATCH BIOMASS 1984	1985	FISHING MORTALITY 1984	1985
3	100000	100000	57643	57659	127	92	.002	.002
4	203852	81693	142280	57151	2512	732	.018	.013
5	180896	163979	156798	143486	11288	7490	.072	.052
6	59538	137817	60521	142591	8213	14031	.136	.098
7	74686	42560	87012	51005	19129	8130	.220	.159
8	21826	49080	29873	69576	8240	13915	.276	.200
9	19550	13562	37025	26603	10213	5321	.276	.200
10	7811	12148	19206	30937	5298	6188	.276	.200
11	1599	4854	5839	18362	1611	3672	.276	.200
12	159	993	692	4484	191	897	.276	.200
13	86	99	482	572	133	114	.276	.200
14	13	53	92	406	26	81	.276	.200
15	4	8	23	48	6	10	.276	.200
16	6	2	52	21	14	4	.276	.200
3+	670026	606848	597536	602902	67000	60677	.083	.076
4+	570026	506848	539893	545243	66873	60585		
5+	366174	425155	397613	488091	64361	59853		
6+	185278	261176	240816	344605	53073	52363		

Table 19. Input parameters to 4TVn cod projection.

Age	PR	1981-1983 Av. Wt. Kg.	Catch Nos. ('000)	1983 Population Nos. ('000)
3	.008	.64	920	250000
4	.064	.78	4538	225952
5	.261	.99	6314	79676
6	.49	1.20	15581	108323
7	.80	1.43	7810	35236
8	1	1.72	9112	33847
9	1	2.38	3645	13539
10	1	3.09	746	2771
11	1	4.59	74	275
12	1	5.48	40	149
13	1	7.04	6	22
14	1	9.21	2	7
15	1	7.36	3	11
16	1	10.30	5	19

Recruitment for 1984: 100 million at age 3 equal to geometric mean of 1971 to 1982 values at age 3.