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Canadian Atlantic Fisheries Scientific Advisory Committee

CAFSAC Research Document 89/44

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Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 89/44

Subdivision 4Vn Cod (May-December): Update of Stock Status for 1988

by

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Abstract

The nominal catch of cod in Subdivision 4Vn during 1988 (May to December) was 9018 t, exceeding the quota by some 1500 t. As in 1987, major gear categories operated under trip limits throughout the year. The catch in 1988 was 1230 t less than that landed in 1987, with the decline proportionate among all gear sectors. Whereas the CPUE index declined from 1987 to 1988, the research vessel abundance index was about three times higher than that for 1987. In the former case, only 2% of the catch is reported with effort and therefore the trend may not be indicative of conditions experienced by the whole fleet. The increase in the 1988 survey estimate was largely attributable to two large sets which were believed to have sampled dense aggregations of cod associated with favourable hydrographic conditions. With the current accumulation of five years of catch at age data, a sequential population analysis was attempted using the survey results for calibration. However, none of the parameter estimates were significantly different from zero and the attempt proved unsuccessful. Total mortality estimates from longliner and otter trawl catch at age indicated fully recruited fishing mortalities ranged from 0.25-0.37. In addition, a yield per recruit analysis suggested that fishing mortality has been in excess of F_{max} for 4 of the last 5 years. The estimates of fishing mortality implied $F_{0.1}$ catches of between 7076–9912 t.

Résumé

Les prises nominales de morue dans la sous-division 4Vn en 1988 (de mai à décembre) se sont établies à 9 018 t, dépassant de quelque 1 500 t le contingent. Comme en 1987, des limites par voyage s'appliquaient durant toute l'année aux différentes catégories d'engin. Les prises de 1988 sont inférieures de 1 280 t à celles de 1987, la baisse étant répartie proportionnellement parmi tous les secteurs d'engin. Alors que les PUE ont diminué de 1987 à 1988, l'indice d'abondance établi par les navires de recherche était environ trois fois plus éléve que celui de 1987. Dans le cas des PUE, étant donné que l'on ne déclare l'effort que pour deux pour cent des prises, la tendance n'est peut être pas représentative de la situation existant dans l'ensemble de la flottille. L'augmentation obtenue dans les estimations établies d'après les relevés de 1988 est imputable en bonne partie à deux grands mouillages d'engins qui auraient échantillonnés d'importantes concentrations de morue associées à des conditions hydrographiques favorables. Avec les données sur les prises selon l'âge accumulées depuis cinq ans, on a tenté de réaliser une analyse séquentielle de population, en se servant des résultats des relevés pour l'étalonnage. Toutfois, comme aucune des estimations de paramètres ne s'écartait beaucoup de zéro, la tentative s'est révélée infructueuse. Les estimations de mortalité établies d'après les prises selon l'âge réalisées par les palangriers et les bateaux pêchant au chalut à panneaux révélaient que la mortalité de plein recrutement à la pêche était de l'ordre de 0,25 à 0,37. De plus, selon une analyse du rendement par recrutement, la mortalité due à la pêche a été supérieure à F_{max} durant quatre des cinq dernières années. Les estimations de mortalité due a la pêche étaient fondées sur des prises $F_{0,l}$ s'établissant entre 7 076 et 9 912 t.

Introduction

In the last three years, the cod fishery in NAFO Subdivision 4Vn (May-December) has operated under an allocation scheme which has partitioned the TAC over gear sectors and time periods. Under this scheme, the management system has implemented trip limit and bycatch restrictions even before the allocation periods had begun. The 1988 fishing year was no exception with the major gear categories operating under trip limits and/or bycatch restrictions for the whole year. Despite these measures, the total catch of cod from this stock for 1988 exceeded the quota by 1518 t.

This report summarizes the information available on this cod stock for the 1988 fishing year. The multiplicative model analysis of each of the longline and otter trawl catch rates is updated from that reported in Smith (1987) with the addition of data from 1987 and 1988. Five years of catch-at-age estimates are now available for the major gear categories in the commercial fishery and an analysis of these data with the ADAPT formulation of the sequential population model (Gavaris, 1988) was attempted. Finally, the first yield-perrecruit analysis was completed for this fishery and is reported here.

Nominal Catch

The nominal landings for Canada and selected countries for the period 1970-1988 are presented along with details on annual TAC'S to 1989 in Table 1. The trends in total landings and TAC'S over time are given in Figure 1. Final statistics from NAFO for 1986 were not available in time for the preparation of this document and therefore the statistics on landings for that year remain preliminary. The differences between the final statistics for 1986 and those presented here are expected to be small. The foreign landing entry in Table 1 under the Others column refers to 135 kg. reported by Japan as bycatch from its redfish fishery. The decline in landings from 1987 to 1988 may be attributed to the decrease in TAC over the two years; however landings for 1988 still exceeded the TAC by 1518 t.

The 1988 allocation schedule and a list of the management measures implemented during the year are detailed in the Appendix. The major gear categories operated under trip limits throughout 1988. Otter trawl landings declined in 1988, a continuing trend since 1985. Over the same period longline landings tended to rise, although the 1988 catch was down slightly from 1987 (Table 2; Figure 2). Landings by seines have been stable for the most part and the handline landings have decreased. The breakdown of landings by tonnage class for 1987 and 1988 is given in Table 3. In general, landings have decreased over all gear components and size classes and no one group changed dramatically. This is in contrast to the situation for 1986 and 1987 reported in Smith (1988). Tonnage class 1 longliners landed approximately 30% more in 1987 over the previous year while the landings from tonnage class 2 longliners and tonnage class 2 and 3 otter trawlers were down by close to 50%. At the time this pattern was interpreted as indicating that the trip limits set in 1987 were more restrictive on vessels greater than tonnage class 1 than those set in 1986. However, the trip limit schedules and allocation amounts were more similar in 1987 and 1988 than they were for 1986 and 1987 and it appears that, consequently, no pattern was evident in the landings by tonnage class.

With the exception of longliners and handlines, the bulk of the landings in 1988 occurred between May and July (Table 4). Again, this is due to the trip limit system being imposed on the mobile gear during this period. The mobile gear sector was restricted to 10% bycatch of cod by June 2 for 45'-64' vessels and by July 16 for < 45' vessels.

Research Surveys

The estimates of stratified mean total numbers and numbers by age as well as the stratified mean weight per tow for July research surveys, 1970–1988 are given in Table 5. In 1988 both the mean number and mean weight per tow were more than three times higher than the 1987 estimates. With respect to previous years' estimates, this appears to indicate an apparent increase in abundance (Table 5; Fig. 3). However, this increase is mainly attributable to two sets in strata 41 and 42 in which 675 and 419 fish were caught, respectively. The means for the same strata excluding these catches were 123.2 and 45.7 fish, respectively. With so few sets taken in 4Vn, the possibility that one or two sets may dominate the estimate of the mean is unavoidable. However, there are suggestions in the data that fluctuations in the index may not just be due to statistical aberrations. Table 6 presents the means by strata for all of the data in 1988 as well as for previous years. Hydrographic data were examined for years exhibiting large peaks in the survey index (Fig. 3). Those sets which contributed most to the the mean values for those years are compared to the longterm averages in the table below.

Year	Stratum	Bottom	Bottom	$\mathbf{Largest}$
	Number	Temperature (°C) Salinity (ppt.)	Catch
	40	5.1	34.3	-
1970-1988	41	3.2	33.4	-
	42	1.9	31.9	-
	40	5.3	34.0	2.5
1971	41	3.7	33.4	624.2
	42	1.5	32.1	51.2
	40	2.9	33.9	236.8
1981	41	5.1	34.1	49.9
	42	4.6	32.2	435.9
	40	5.9	34.7	3.1
1985	41	3.2	33.6	203.8
	42	0.3	32.3	1460.4
40	5.4	34.3	5.2	
1988	· 41	1.2	32.8	674.8
	42	1.3	32.0	419.0

Although the data are admittedly scanty, they do suggest a possible relationship between high catches and lower bottom catches. Recent studies have indicated that the abundance of cod in the trawl survey catches appears to be related to type of water mass on the bottom at the trawl location (Smith et al., MS1989). The cold intermediate layer, which is delineated by salinities of 32-33.5 ppt. and temperatures of $< 5^{\circ}C$, has been found to be the water mass most associated with large catches of cod. With two exceptions, the large catches in

the above table appear to be associated with the intermediate water mass. Although the salinities for stratum 40 in 1981 and stratum 41 in 1985 are slightly above the upper limit for the intermediate water mass, the temperatures are atypical of the warmer bottom layer. Note that the temperature of stratum 40 in 1981 was far below the longterm mean for this stratum. Therefore it is possible that the large estimates reflect an increase in density in specific areas rather than an actual increase in abundance. The two large sets in 1988 may have encountered dense aggregations of cod which formed in association with conditions favoured by this species.

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The strongest year-classes in the 1988 survey are, in decreasing order, 1982, 1981, 1980, 1984 and 1983. The first three as a group were also the strongest in the 1987 survey. The age structure was similar in all of the sets in stratum 41 with the 1982, 1981 and 1980 yearclasses predominating. The 1983 and 1984 year-classes were the dominant year-classes in the inshore shoal water stratum (42). This observation of an apparent inshore-offshore age gradient has been made before for this survey in past assessments of this stock.

Commercial Catch at Age

Details of the data collected and used to estimate the age composition of the commercial catch are given in Table 7. Age and length information were combined to form one key for the May-August period and one for September-December. The temporal distribution of the samples reflects the corresponding seasonal distribution of the landings. Longlines were sampled throughout the year while seines were only sampled in the May-August period. Only one sample was obtained from handlines and therefore this sample was combined with the longline samples to estimate the age composition of the handline catch. The age composition for the 68 t landed by seines during September-December was estimated using otter trawl samples from that period.

Estimates of the age composition of the longline catch and the associated estimate of average weight at age are presented in Tables 8 and 9, respectively. As was the case for the 1986 and 1987 landings, the 1980, 1981 and 1982 year-classes continue to dominate the age composition of the 1988 catch. The 1984 year-class appears to be promising when compared to landings of the same age (age 4) over the last 5 years. The weight at age does not indicate any consistent trends over time.

The landings at age from 1984–1988 for each of the 4 major gear categories are given in Table 10. The age compositions for 1988 are compared in Figure 4. In 1988 the same three year-classes (1980, 1981 and 1982) dominated both the longliner catch and seine catch. However, the otter trawl landings were mainly comprised of the 1981, 1982 and 1983 year classes. As was observed for the longlines, the trawl catch of the 1984 year class was larger at age 4 than had been observed for recent year-classes at the same age. The estimates of total removals at age for the period 1984–1988 are given in Table 11.

Catch per Unit Effort

Estimates of longliner catch per unit effort (CPUE) for the period 1968-1988 are given in Table 12. The trend in CPUE shows a decline over the last three years; however the proportion of catch with effort reported has also declined.

The multiplicative model analysis of longline and otter trawl CPUE reported in Smith (1987) was updated here with the addition of data from 1987 and 1988. The present analysis was conducted in a similar manner and with the same software (i.e. GLIM) as the analysis reported in 1987. However, the current analysis differs from that in 1987 by treating the longline and otter trawl catch rates separately. Various models for ln(CPUE) were screened with GLIM to assess the effects of gear types (GEAR=side and stern for otter trawl analysis only), tonnage class (TON=2,3,4,5,6), month (MONTH=May-Dec.) and year (YEAR=1981-1988). The previous analysis had found that over the period 1981-1986 the final model for longline and otter trawl combined, after the removal of nonsignificant

effects, was $\ln(\text{CPUE})=1+\text{GEAR}+\text{TON}$ with the YEAR effect confined to a marginal difference (p=0.08) between 1981–1985 and 1986. The results of fitting the model to data for 1981–1988 are given in Table 13. There is no evidence of an annual trend in either of the catch rate series.

Estimation of Fishing Mortality

This year five years of catch at age data are available for the major gear categories in the fishery (Table 11). Accordingly, we attempted an exploratory analyses of this data to estimate fishing mortality. This section presents the results of this analysis using the ADAPT framework developed by Gavaris (1988).

There has been no historical estimate of partial recruitment (PR) for this stock and therefore the first such estimate was derived here for this analysis. The estimated partial recruitment was obtained as follows. A cohort analysis was run using an input fishing mortality of 0.3 and an PR set as,

This initial run indicated that the age of full recruitment appeared to be increasing since 1984. The initial PR estimates for 1986 and 1987 indicated that full recruitment was at age 8 while the estimates for 1984 and 1985 were closer to age 6 or 7. Recall that the otter trawl landings made up a larger proportion of the landings in the first two years of the series than they have in the last three years. A new PR was estimated as the average of the 1986 and 1987 estimates from the initial run. It was believed that conditions in these years were closer to those in 1988. The cohort analysis was run iteratively replacing the 1988 PR with the mean of 1986–1987 estimates each time until the difference between the input and resulting estimated PR was less than 0.0001. This final estimate was,

> AGE 3 4 5 6 7 8+ Pr 0.007 0.057 0.320 0.630 0.847 1.000

and the final PR estimate for all ages and years is given in the form of fishing mortalities in Table 14.

The ADAPT model was used to relate the 5+ mean numbers from the survey with 5+ population numbers from the VPA. The various conditions for the model are summarized in Table 15. Neither of the parameter estimates were significantly different from zero and the correlation between the estimates was -0.954. These results are not too surprising given that the survey index has been quite variable over the 5 year period for which the age composition estimates of the commercial fishery are available. The addition of more years data in the future may improve this situation. It may also be possible to use length and age samples collected by observers to estimate the otter trawl age composition for years prior to 1984.

In the last four assessments of this stock, total mortality estimates have been obtained from longliner CPUE (numbers) at age and research survey mean numbers at age. These estimates were taken over the period 1980-1987 and represent long term conditions. Last year (Smith, 1988) the estimates of terminal fishing mortality implied by these estimates were 0.315 and 0.307 for the longliner (7+/8+) and survey data (5+/6+), respectively. However, the results of this year's multiplicative analysis of the catch rates indicate that CPUE has probably been stable over this period. Therefore, catch has been proportional to effort. The total mortality estimates from longliner numbers have been recalculated here to reflect this fact by adjusting the estimates by longliner catch weight instead of adusting by effort. Estimates from the otter trawl catch at age from 1984-1988 were obtained in a similar manner. This approach requires that the mean weight of cod in the catch over all ages has been relatively stable over the period 1980-1988. A comparison of mean weights over the period supports this assumption. The total mortality estimates from the commercial data along with those from the survey data are given in Table 16. Assuming that natural mortality is equal to 0.2 then the longterm fully recruited fishing mortality estimates from the survey data were 0.095 for 5+/6+ and 0.323 for 6+/7+. The higher abundance estimate for the survey in 1988 has obviously affected the fishing mortality estimate. The commercial data indicates fully recruited fishing mortalities of between 0.25 and 0.37 for 7+/8+. The estimates from the commercial data are very similar to those obtained last year where effort was used to scale the estimates.

Yield per Recruit Analysis

A yield-per-recruit analysis of this stock was done using the partial recruitment estimate arrived at in the previous section for input into ADAPT and with weights at age averaged over the period 1984–1988. It should be noted here that the results of the yield-per-recruit analysis are sensitive to our assumptions concerning PR. The APL function YIELD given in Rivard (1982) was used for this analysis. This function uses the Thompson and Bell method of determining the yield for a single recruit. Assuming a natural mortality of 0.2, the $F_{0.1}$ and F_{max} were estimated to be 0.1867 and 0.3497, respectively. The average weight of cod in the catch for 1984–1988 was compared with the expected average weights for these two levels of fishing mortality (Figure 5). This comparison of average weights shows that for four of the last five years fishing mortality has been in excess of F_{max} . The 1988 average weight of the catch corresponds to a fishing mortality of approximately 0.4 in this analysis.

Stock Size Estimate

The fully recruited fishing mortalities estimated to be between 0.25-0.37 imply $F_{0.1}$ catches of between 7076-9912 t. These estimates were obtained using the catch equations discussed in Smith (1988) and the average catch for 1982-88 of 12,106 t. The 1989 TAC of 7500 t is well within this range. The information available for this stock do not support a projection to 1990.

Acknowledgements

We would like to thank Dr. S. Campana for reviewing a previous draft of this report.

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Year		Canada	France	Spain	Portugal	Others	Total	TAC
1970		8701	34	1141	_	12	9888	-
1971		8469	1	2161	-	-	10631	-
1972		6729	745	1171	459	-	9104	-
1973		5245	_	241	189	73	5748	-
1974		4836	_	852	84	212	5984	10000
1975		3363		89	360	186	3998	10000
1976		5746	211	_	_	_	5957	10000
1977		7786	135	-	_	· _	7921	3500
1978		5496	53	_	-	-	5549	3500
1979		6301	73			-	6374	3400
1980		9976	214	-	-	-	10190	5000
1001		12176	172	_	_	-	12648	*
1002		12101	222	_	_	_	12333	**
1002		0102	232	_	_		9363	14000
T303		9192	170	_	_	1	10444	14000
1984		10443	-	_	-	1	10444	10000
1985		12491	-	-		. 3	12494	12000
1986	a	11755	_		-	1	11756	12000
1987	а	10248	-		_	<1	10248	9000
1988	a	9018		-	-	<1	9018	7500
1989	-							7500
2303								

Table 1. Nominal cod catch (t) by country in Subdivision 4Vn (May- Dec.)

* initially set at 7500 t, increased in September to 10,000 t. ** initially set at 10500 t, increase November 1 to 14,000 t.

Preliminary statistics a

Year	Otter Trawls	Seines	Longlines	Handlines	Misc.	Total
1970	4859	83	3229	495	1222	9888
1971	5308	109	3728	696	790	10631
1972	4418	121	3185	286	1094	9104
1973	2099	143	1982	404	1120	5748
1974	2842	138	1469	568	967	5984
1975	1851	100	875	360	812	3998
1976	4375	83	620	310	569	5957
1977	4613	554	1805	595	354	7921
1978	1600	326	3035	466	122	5549
1979	624	278	4483	640	349	6374
1980	1150	561	6440	1820	219	10190
1981	1488	557	9801	741	61	12648
1982	2785	724	7287	1360	177	12333
1983	2448	863	5101	. 924	26	9362
1984	3344	1112	4831	1112	45 `	10444
1985	5081	1162	4823	1408	20	12494
1986	* 3185	1277	5872	1191	231	11756
1987	* 1867	1185	6272	842	82	10248
1988	* 1323	1091	5888	623	93	9018

Table 2. Nominal catch (t) of cod in Subdivision 4Vn (May-December) by gear type for all countries, 1970-1988.

* Preliminary statistics.

_			·			
Tonnage <u>Class (GT)</u>	Otter Trawls	Seines	Longlines	Handlines	Other	Total
<u>1987</u>						
0-24.9 25-49.9 50-149.9 150-499.9 500-999.9 1000+	35 (2) 660 (35) 586 (31) 312 (17) 252 (14) 22 (1)	372 (31 669 (57 144 (12 - - -) 4719 (75) 1452 (23) 101 (2 - - -) 839 (100) 3 (0)) - - - -) 4 (5) 19 (23) 59 (72) - - -	5969 2803 890 312 252 22
<u>Total</u>	1867	1185	6272	842	82	10248
<u>1988</u>						
0-24.9 25-49.9 50-149.9 150-499.9 500-999.9 1000+ <u>Total</u>	45 (3) 516 (39) 353 (27) 155 (12) 241 (18) 13 (1) 1323	481 (44 551 (51 59 (5 - - - 1091) 4272 (73) 1397 (24) 40 (0 179 (3 - - 5888) 602 (97) 21 (3) -) - 623) 26 (28)) 49 (53) 17 (18) - 1 (1) 93	5426 2534 469 334 241 14 9018

Table 3. Nominal catch of cod by Canadian vessels in 4Vn (May-Dec.) by tonnage class and gear. Percentage of gear total catch by tonnage class is in parentheses. Table 4. Nominal catch (Canada) for the cod fishery in 4Vn (May-December) by month and year.

a) 1987										
Gear	<u>Nay</u>	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals	
Longlines	823 [´]	598	535	938	752	1705	818	103	6272	
Handlines	15	122	239	174	128	146	17	1	842	
Otter Travis	1064	152	187	34	91	56	54	229	1867	
Seines	553	269	65	37	61	91	109	0	1185	
Shrimp Travl	2	9	42	3	7	12	0	0	75	
Other	0	4	1	1	1	0	0	0	7	
Total	2457		1069	1187	1040	2010	998	333	10248	-
b) 1988		 Tuno			 Gant				Intals	
<u>Vear</u>	<u>nay</u>									
Longlines	866	486	676	792	981	11/4	223	220	2888	
Handlines	7	24	214	218	92	46	20	2	623	
Otter Travis	690	128	40	33	177	63	55	137	1323	
Seines	521	284	183 -	35	30	19	13	6	1091	
Shriop Travl	2	6	4	-	-	5	1	-	18	
Other	47	3	2	21	-	2	-	-	75	
Total	2133	931	1119	1099	1280	1309	782	365	9018	-

								AGE								
<u>Year</u>	1	2	3	4	5	6	7	8	9	<u> 10 </u>	11	12	13+	UK	N <u>Q.</u> tow	<u>Kg.</u> tov
1970	-	6.35	1.77	4.78	10.90	10.46	4.50	2.59	0.84	-	0.29	0.14	0.13	0.211	42.96	57.47
1971	-	1.17	42.40	10.09	26.51	16.16	10.65	3.59	1.97	0.54	-	~	0.56	0.40!	114.05	128.20
1972	-	0.52	0.28	2.35	0.30	1.61	1.47	0.39	0.27	0.25	0.19	-	0.37	0.371	8.39	22.12
1973	-	-	2.62	4.48	18.59	0.73	3.06	2.91	0.45	0.22	· _	-	-	0.221	35.28	52.58
1974	-	-	0.61	1.36	2.79	3.21	0.40	0.50	0.26	0.22	0.11	-	-	-1	9.47	14.44
1975	-	0.61	6.42	8.58	4.65	0.81	1.00	0.58	0.21	0.33	-	0.11	~	0.161	23.47	22.12
1976	-	6.49	2.25	1.48	1.93	1.55	0.73	1.79	1.65	1.41	0.24	0.23	0.47	-1	20.21	43.41
1977	-	0.25	6.26	4.01	2.74	1.90	0.72	0.21	0.24	0.14	0.21	0.24	0.15	0.091	17.16	24.58
1978	-	0.66	9.13	19.31	5.54	4.38	1.53	1.17	0.44	0.43	-	-	0.11	0.121	42.84	67.55
1979	-	1.30	0.79	5.15	2.51	0.59	1.72	0.56	0.29	0.15	-	0.17	0.45	-1	13.66	27.58
1980	-	1.88	10.52	3.97	23.58	16.40	5.15	1.16	0.45	0.37	0.37	-	-	-1	63.84	85.55
1981	0.33	4.36	16.91	36.49	12.02	25.45	11.50	1.26	0.93	0.86	0.24	0.16	0.31	0.171	110.98	161.81
1982	-	2.53	1.74	5.77	10.22	7.61	9.25	3.41	1.32	0.45	0.10	0.23	-	0.101	42.73	74.82
1983	-	4.37	22.11	7.90	10.64	10.04	1.70	3.41	1.52	0.66	0.25	-	0.43	0.27:	63.30	78.60
1984	2.83	7.25	10.02	10.48	13.51	8.75	3.58	1.81	1.58	0.85	0.32	0.41	0.46	0.28:	62.14	102.30
1985	-	0.48	3.75	19.10	125.95	52.13	22.38	7.26	1.44	0.77	0.67	-	0.37	3.63	237.94	295.97
1986	-	1.33	6.36	11.13	8.11	17.55	6.38	4.92	2.17	1.02	0.55	0.10	0.22	0.091	59.93	83.83
1987	-	0.21	3.70	4.14	5,13	8.89	6.63	2.80	1.18	0.62	0.97	0.31	-	0.081	34.66	49.21
1988	0.61	0.55	2.49	17.05	13.18	31.89	26.45	18.93	6.24	1.70	0.50	0.24	0.32	0.231	120.39	171.24

Table 5. 4Vn cod (May-Dec.) Research vessel abundance indices (mean number per tow) by age group.

Stratu Percen Depth	m no. t of area: range:	40 27.5% >100 fm.	41 29.8% 51-100 fm.	42 42.7% ≤50 fm
Year	Vessel			
1970	ATC	0.49	107.81	25.02
1971	ATC	1.25	320.84	41.99
1972	ATC	5.07	8.81	10.16
1973	ATC	1.01	59.39	40.66
1974	ATC	8.12	14.50	6.83
1975	ATC	0.00	71.88	4.86
1976	ATC	0.00	16.58	35.73
1977	ATC	0.36	23.35	23.66
1978	ATC	2.53	62.40	55.16
1979	ATC	2.72	15.62	19.34
1980	ATC LH	0.34 0.29	135.79 127.99	54.44 69.37
1981	ATC LH	79.19 123.88	37.39 80.37	182.64 60.86
1982	LH	6.74	75.70	42.93
1983	AN LH	7.63 7.62	113.18 149.24	64.30 44.03
1984	AN	2.31	99.29	74.76
1985	AN	0.77	76.55	502.88
1986	AN	1.65	153.55	32.26
1987	AN	2.06	52.03	43.55
1988	AN	1.22	261.09	99.06

Table 6. A comparison of the mean numbers of cod caught per tow for each stratum in the 4Vn summer survey (Numbers corrected for distance towed).

Gear	Time Period	<pre># of samples Length (age)</pre>	No. Measured	No. Aged	Catch (t)
Longlines	May-Aug	9 (20)	3658	1155	2820
	Sept-Dec	8 (11)	2443	520	3068
Handlines *	May-Aug	0 (0)	0	0	463
	Sept-Dec	0 (0)	0	0	, 160
Otter Trawls	May-Aug	4 (20)	1315	1155	861
	Sept-Dec	4 (11)	1101	520	462
Seines	May-Aug	6 (20)	1515	1155	1023
* *	Sept-Dec	0 (0)	0	0	68

Table 7. Data used to generate 1988 catch at age estimates for 4Vn (M-D) cod. Length-weight parameters: a=0.01185, b=2.93856.

* Used Longline samples. ** Used Otter Trawl Sept-Dec samples.

Table B. 4Vn Cod(May-Dec): catch at age by longlines(thousands)

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	-	-	_	-	-	_	-	_	_	_	_	-	_	_	_	-	-	_
-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-
3	10	-	7	15	44	-	-	35	-	-	85	32	8	5	12	3	6	12
62	43	676	133	179	177	-	-	277	17	. 8	221	227	69	116	48	102	49	153
22	236	39	437	181	127	5	-	265	208	105	310	662	412	306	317	434	472	275
14	492	604	87	184	73	10	-	197	480	532	409	477	436	438	335	838	525	525
81	600	444	193	54	36	25	-	120	305	747	672	805	294	400	469	530	671′	540
08	63	209	230	66	17	27	-	76	185	386	529	507	492	228	309	323	365	570
56	152	2	51	82	13	17	-	49	91	219	267	209	163	250	176	181	213	266
40	48	21	17	26	11	15	-	54	17	127	151	78	137	152	153	117	155	111
82	14	50	9	-	4	10	-	20	39	32	57	50	35	69	61	59	74	61
21	7	2	5	4	-	10	-	18	8	8	52	22	33	23	28	43	50	42
17	28	1	8	1	-	-	-	13	4	8	53	8	11	8	16	16	27	13
11	1	-	1	1	1	-	-	3	4	-	5	3	5	4	4	8	17	5
1	7	1	-	1	-	-	-	8	-	-	8	2	5	4	5	5	7	5
-	5	1	2	1	-	10	-	4	-	-	18	15	11	6	7	21	19	8
62180548211		$\begin{array}{cccccccccccccccccccccccccccccccccccc$																

Table 9. 4Vn Cod(May-Dec): mean weight at age for longline catch(kg.)

AGES	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2	-	-	-	-	-	0.28	-	-	-	-	-	0.21	-	-	-	-	-	-	-	
3	0,60	0.48	÷	0.40	0.49	0.53	-	-	0.56	-	-	0.50	0.58	0.65	0.56	0.51	0.53	0.58	0.52	
4	0.79	0.77	0.82	0.72	0.81	0.84	-	-	0.99	0.93	0.73	0.90	0.91	0.84	0.80	0.79	0.90	0.81	0.82	
5	1.09	1.04	0.91	1.17	1.28	1.29	1.82	-	1.40	1.63	1.22	1.35	1.33	1.22	1.27	1.14	1.21	1.14	1.12	
6	1.67	1.45	1.72	1.75	1.72	1.79	2.46	-	2.14	2.54	2.03	2.15	1.79	1.63	1.61	1.45	1.55	1.32	1.53	
7	2.14	2.01	1.66	1.78	2.65	2.29	3.08	-	3.27	3.78	2.49	2.94	2.09	2.12	2.04	2.00	2.01	1.76	1.80	
8	3.11	4.33	2.10	2.14	2.40	2.00	4.18	-	4.14	3.92	3.14	4.28	3.01	2.31	2.55	2.38	2.51	2.44	2.21	
9	4.38	3.60	9.29	2.79	2.50	3.18	4.23	-	4.97	4.99	4.55	5.21	4.09	3.50	3.19	2.77	3.15	3.40	3.19	
10	4.39	5.24	6.91	5.33	3.14	3.50	6.19	-	5.27	6.95	6.21	6.23	5.87	3.95	3.70	3.15	4.15	4.00	5.08	
11	5.15	6.29	3.46	5.98	7.72	4.41	6.07	-	6.27	7.78	6.99	7.75	6.22	6.41	5.37	4.22	5.50	6.23	6.69	
12	8.07	8.55	9.29	5.68	4.15	7.72	7.50	-	6.45	9.78	7.65	9.29	7.39	8.53	8.29	7.10	6.06	7.44	7.48	
13	8.79	4.84	15.23	7.24	11.06	11.05	-	-	7.98	10.72	8.36	8.80	8.91	9.75	9.87	8.21	6.79	8.04	9.87	
14	9.49	13.45	-	10.15	10.26	8.79	-	-	8.93	6.88	-	8.53	8.60	10.22	10.99	10.75	9.44	7.84	12.11	
15	12.02	12.03	11.06	13.03	11.37	-	-	-	9.16	-	-	9.45	11.94	11.34	10.93	12.84	11.00	10.82	11.72	
16	-	10.71	15.23	7.01	6.08	8.48	9.39	-	14.09	-	-	11.59	10.80	12.24	10.81	13.92	9.61	14.31	12.55	

			ongli	nes			Har	ndlin	1es 			Otto	er ti	ravls	5		Se	eines	i	
	84 	85 	86	87 	88	84 	85 	86	87	88	84 	85 	86 	87 	88 	84 	85 	86	87 	88
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	5	12	3	6	12	3	0	1	14	1	6	3	0	1	20	0	1	0	0	3
4	116	48	102	49	153	22	0	- 14	32	11	243	66	64	13	168	11	21	42	30	29
5	305	317	434	472	275	83	0	31	102	22	645	783	442	122	204	107	205	179	150	60
6	438	335	838	525	525	115	0	75	101	47	795	818	967	222	277	236	184	346	267	152
7	400	469	530	671	540	112	0	103	107	56	295	819	359	374	216	116	172	134	328	172
8	228	309	323	365	570	41	0	109	64	56	144	377	184	175	153	37	140	79	95	142
9	250	176	181	213	266	52	0	56	43	28	31	141	82	84	34	37	33	42	41	42
10	152	153	117	155	111	28	0	25	22	14	27	104	30	52	7	15	23	19	21	16
11	69	61	59	74	61	12	0	12	6	9	6	26	9	23	6	4	6	9	8	12
12	23	28	43	50	42	4	0	7	2	5	1	4	3	10	2	2	1	3	2	3
13	8	16	16	27	13	2	0	t	2	2	0	1	2	5	1	1	0	2	0	2
14	4	4	8	17	5	1	0	0	0	1	0	0	0	2	0	0	0	0	1	0
15	4	5	5	7	5	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
16	6	7	21	19	8	1	0	5	0	1	1	0	0	0	0	1	0	0	0	0

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Table 10. 4Vn cod(May-Dec): catch at age by longlines, handlines, otter travls and seiners for 1984-1988 (thousands).

		Vo	ar		
Age	1984	1985	1986	1987	1988
1	х О	0	0	0	0
2	0	0	0	0	0
3	14	18	4	21	35
4	394	152	222	125	364
5	1146	1473	1086	853	567
6	1591	1510	2226	1124	1011
7	927	1648	1126	1492	994
8	452	933	695	705	930
9	372	395	361	384	375
10	223	316	191	252	150
11	91	105	89	112	89
12	30	37	56	65	53
13	11	19	21	34	18
14	5	5	8	20	6
15	6	6	5	7	6
16	9	8	26	19	10

Table 11. 4Vn cod (May-December): catch at age for total landings for 1984-1988 (thousands).

Year	Longliner Catch (t)	Proportion of catch with effort reported	CPUE (t/1000 hks)
1968	2455	0.066	0.452
1969	3300	0.097	- 0.646
1970	3229	0.130	0.625
1971	3728	0.071	0.507
1972	3185	0.138	0.440
1973	1982	0.192	0.338
1974	1469	0.197	0.325
1975	875	0.022	0.232
1976	620	0.011*	0.084
1977	1805	0.027	0.499
1978	3035	0.141	0.422
1979	4483	0.169	0.545
1980	6440	0.111	0.504
1981	9801	0.028	0.666**
1982	7287	0.077	0.408
1983	5101	0.105	0.319
1984	4831	0 111	0.435
1095	4823	0 099	0.357
1986	- 5872	0.068	0.519
1007	5072	0.000	0.370
1988	5888	0.020	0.258

Table 12. Longliner catch of cod and associated catch-per-unit-effort for 1968-1988, 4Vn(May-Dec).

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* based on one log record ** calculated for records from May to September only.

Table 13. Analyses of deviance for otter trawl and longliner catch rates.

a) Otter Trawls							
Model	Difference <u>in Deviance</u>	<u>D.F.</u>	P-Level				
$\begin{array}{c}1\\+\mathrm{gear}\\+\mathrm{ton}\\+\mathrm{ton}\\+\mathrm{year}\end{array}$	$0.025 \\ 0.928 \\ 2.257 \\ 3.115$	1 3 7 7	$0.766 \\ 0.355 \\ 0.337 \\ 0.125$				

b) Longlines

;

Model	Difference <u>in Deviance</u>	<u>D.F.</u>	P-Level	
1 + ton + month + year	0.808 0.676 0.282	2 7 7	0.094 0.826 0.282	

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Table 14. Fishing mortality table resulting from estimation of PR.

AGE	1984	1985	1986	1987	1988
3	.001	.001	.000	.001	.002
4	.025	.014	.022	.016	.017
5	.134	.121	.128	.113	.096
6	.275	.262	.271	.190	.189
7	.278	.511	.318	.295	.254
8	.276	.500	.421	.338	.300
9	.386	.414	.366	.436	.300
10	.523	.670	.361	.473	.300
11	.441	.502	.398	.373	.300
12	.203	.322	.553	.572	.300
13	.088	.191	.306	.793	.300
14	.060	.053	.115	.538	.300
15	.152	.094	.068	.139	.300
16	.196	.308	.725	.393	.300
8+	.330	.472	.387	.393	.300

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Table 15: ADAPT Summary for 4Vn Cod.

Parameters:

- Year-class estimates: $N_{5+,1988}$
- Calibration constants for mid-year RV numbers: k_{5+}

Input

- Catch: $C_{i,t}$, (i = 3, ..., 16; t = 1984, ..., 1988)
- Survey Numbers: $RV_{5+,t}, (t = 1984, ..., 1988)$
- Number of observations: 30.

Structure Imposed

- Error for catch assumed negligible.
- Natural mortality, M = 0.2.
- Models do not include intercept.
- No initial estimates of F for oldest ages used. Fully recruited F estimated from weighted average of ages 8-12.
- RV 5+ mean numbers calibrated on 5+ VPA population numbers.

Objective Function (2 parameters)

minimize
$$\sum_{t=1984}^{1988} (RV_{5+,t} - k_{5+}VPA_{5+,t})^2$$

Table 16. Total mortality estimates, 4Vn Cod (May-Dec.).

a) Research survey mean numbers at age.

Age Groups	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	Mean
4+/5+	028	1.006	.285	.154	-1.630	1.738	.675	-1.186	.127
5+/6+	.150	.856	.581	.472	-1.033	1.872	.649	-1.190	.295
6+/7+	.438	1.012	1.003	.677	705	1.747	.964	951	.523
7+/8+	.646	1.012	.821	.367	420	1.393	.953	840	.491
8+/9+	128	.580	.584	.517	186	1.226	1.054	540	.388
9+/10+	380	1.110	.312	.299	333	1.246	.740	233	.345
10+/11+	173	1.398	077	.091	700	1.735	.376	145	.313

b) Longliner catch (numbers) at age standardized by total longline catch weight.

Age Groups	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	Mean
4+/5+	.267	327	.053	.053	.062	093	.097	.025	.017
5+/6+	.394	145	.203	.197	.187	.067	.259	.127	.161
6+/7+	.548	-0.28	.250	.295	.252	.379	.358	.207	.282
7+/8+	.712	.410	.288	.412	.409	.660	.406	.328	.453
8+/9+	.664	.784	.448	.493	.501	.720	.385	.532	.566
9+/10+	.556	.937	.134	.354	.631	.711	.320	.767	.551
10 + /11 +	.322	.939	.220	.677	.786	.786	.393	.894	.627
11 + / 12 +	621	1.054	.074	.744	.640	.460	.302	.914	.446

c) Otter trawl catch (numbers) at age standardized by total otter trawl catch weight.

Age Groups 84/85 85/86 86/87 87/88 Mean 4 + / 5 +-.055 -.160 0.006 .079 .161 5 + / 6 +.256 .163 .252 .085 0.189 6 + / 7 +.763 .280 .471 .295 0.4527+/8+ .163 1.091 .111 .929 0.573 8+/9+ 1.178 .032 1.604 0.741 .150 -.220 2.053 9+/10+ -.282 1.369 0.730 10+/11+ .568 1.799-.439 1.980 0.977 11 + / 12 +1.006 1.357 -.728 2.246 0.970



Year





Year





Gear	Season	Closure	Allocation	Landings ²	Management Measure
Fixed Gear					
< 45'	May 1-Oct. 31 Nov. 1-Dec. 31	May 1 Nov. 1	3300 1140	5395 823	Aug.: 11,300 kg trip limit Nov.: 1,500 kg trip limit
45'-64'	May 1-June 30 July 1-Aug. 31 Sept. 1-Oct. 31 Nov. 1-Dec.31	May 1 July 1 Sept. 1 Nov. 1	50 10 100 130	30 7 49 47	6,800ú kg trip limit
65'-100'	May 1-Dec. 31	July 1	71	179	0 kg trip limit, 0% by-catch
Mobile Gear	- -				· · ·
< 45'	May 1-July 31 Aug. 1-Aug. 31 Sept. 1-Oct. 31 Nov. 1-Dec. 31	May 1 Closed Sept. 1 Nov. 1	690 450	1226 	4,500 kg trip limit
45'-64'	May 1-July 31 Aug. 1-Aug. 31 Sept. 1-Dec. 31	May 1 Closed Sept. 1	200 315	411 61	3,200 kg trip limit
< 65' (sector ove	May 1-Dec. 31 rlap)	Oct. 4	180	246	
65'-100' (shrimp fle	May 1-Dec. 31 et)	Dec. 21	71	17	
65'-100' (groundfish	May 1-Dec. 31 fleet)	Dec. 21	71	43	
All vessels > 100'	May 1-Dec. 31	July 1	71	179	

Appendix: 4Vn Cod (May-Dec.) Allocation Schedule and Management Measures.

1 = This reflects the final allocation schedule as per the 1988 Canadian Atlantic Quota Report (31/12/88) and differs from the original scheme given in the 1988 Atlantic Groundfish Management Plan.

2 = Preliminary statistics only.