Canadian Atlantic Fisheries
Scientific Advisory Committee

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CAFSAC Research Document 91/41

CSCPCA Document de recherche 91/41

Status of the Atlantic Cod Stock on Georges Bank in Unit Areas 5Zj 5Zm, 1978-90

by

J. J. Hunt, M-I. Buzeta and J. D. Neilson

Marine Fish Division
Fisheries and Oceans
St. Andrews, NB

Abstract

Landings of cod in Div. 5Zj,m by Canada increased by 6000 t in 1990 over 1989 to 14310 t, the second highest in the time series. Total landings were 20688 t. Catch by gear type in 1990 was similar to historic patterns. Catch in numbers was dominated by the 1987 (51%) and 1985 (19%) yearclasses. Catch per tow in USA spring and fall surveys has remained stable in recent years while the spring Canadian survey has been more variable with a substantial decline in 1991 from the record 1990 estimate. Commercial catch rates are inconsistent with stock abundance and are not used to estimate stock status. An ADAPT formulation using the three surveys indicates a 1990 fishing mortality of 0.42 and a stock biomass (3+) of about 70000 t at the beginning of 1991. Catch projections for 1991 and 1992 under three options indicate total catches of 22000 t in 1991 (assumed) and 15000-22000 t in 1992. The fishery is highly dependent on recruiting yearclasses. Estimates for the 1990-92 yearclasses will have considerable impact and projections beyond 1992 are not considered reliable. Partitioning of total advised catch between Canada and the USA is required if management objectives are to be achieved.

Résumé

Les débarquements canadiens de morue provenant des divisions 5Zj,m se sont établis à 14 310 t en 1990, ce qui représente une augmentation de 6 000 t par rapport à 1989. Ce chiffre est le deuxième en importance de la série chronologique. Les débarquements totaux étaient de 20 688 t. En 1990, les prises par type d'engin ont été comparables aux tendances antérieures. Les classes d'âge de 1987 (51 %) et de 1985 (19 %) dominaient dans les prises. Lors des campagnes d'évaluation de printemps et d'automne réalisées par les Américains, les prises par trait sont demeurées stables au cours des dernières années, tandis que celles des campagnes d'évaluation de printemps réalisées par les Canadiens se sont avérées plus variables et ont régressé notablement en 1991 par rapport à l'estimation record de 1990. Les taux de prises commerciales ne correspondent pas à l'abondance du stock et ne sont pas utilisées dans l'évaluation de l'état du stock. En utilisant la méthode ADAPT et les résultats des trois campagnes d'évaluation, on obtient pour 1990 une mortalité due à la pêche de 0,42 et une biomasse du stock (+3) d'environ 70 000 t au début de 1991. En prenant pour acquis que 22 000 t seront capturées en 1991, les projections de prises pour 1992 selon trois options vont de 15 000 à 22 000 t. La pêche dépend en grande partie des classe d'âge qui seront recrutées. Les estimations relatives aux classes d'âge de 1990-1992 auront des répercussions considérables; aussi les projections au-delà de 1992 ne sont-elles pas jugées fiables. Pour atteindre les objectifs de gestion visés, il est nécessaire de répartir les prises recommandées totales entre le Canada et les États-Unis.

Introduction

The present report incorporates commercial catch data and research survey results to estimate stock status of cod for the 1978-90 time period in the two unit areas 5Zj and 5Zm. Definition of this management unit is based on analysis of historic tagging results, commercial and survey catch distribution and more recent tagging studies (Hunt, 1990).

Cod are taken by both Canada and the USA in unit areas 5Zj and 5Zm and all data relating to USA catches and research vessel surveys were provided by the National Marine Fisheries Service (NMFS) at the Woods Hole, Mass., Laboratory.

Trends in Reported Landings

Catches from unit areas 5Zj and 5Zm are thought to be under- or mis-reported prior to 1978 and estimates of population status prior to this time are suspect. Catch statistics since 1977, when foreign fleets were excluded from the 200 mile economic zones of Canada and the USA, are thought to be more reliable. Spatial distribution of foreign fleet catches in Subdiv. 5Ze are unknown. There have been no reported landings by foreign fleets since 1978.

Fishery by Country and Gear

Canadian catches of cod are taken on the "Northeast Peak" of Georges Bank primarily between April and November. Landings have been dominated by otter trawlers, except in 1984 and 1989 (Table 1,Fig. 1). In 1988, otter trawlers, longliners and gillnetters accounted for 60%, 35% and 5%, respectively, of the 12700 t catch, the second highest in the twelve year series. In 1989, fixed gear (longline and gillnet) catches were 5400 t while those by otter trawl declined to 1900 t. The below average catch by otter trawlers reflects early closure of the fishery when the combined quota for 4X+5 was exceeded.

In 1990, a 6000 t increase in Canadian landings was the result of a return to historic catches by the OTB fleet and an overall catch of 14310 t, the second highest in the time series. USA landings remained stable at 6378 t. Management of the Canadian fishery in 1990 was changed from a TAC to individual and equal boat quotas of 280000 lb with by catch restrictions. Anecdotal information suggests that both poor weather and availability resulted in most vessels not reaching their allowable catch.

Catches by Canada and the USA in unit area 5Zj and 5Zm for 1978-90 are summarized in Table 2 and in Figure 2. Catches peaked at 26000 t in 1982, averaged to about 15000 t between 1983-87 and increased to 20000 t in 1988. Since 1985, Canada has taken about 65% of the total catch. The reduction in 1989 to 14000 t was a result of decreased mobile gear catch by both Canada and the USA.

Temporal distribution of combined USA and Canada catches in 5Zj and 5Zm is shown in Table 3 by month. About 20% of the catch is taken in the first quarter, 10% in the last quarter and the remaining 70% in the April-September period.

Age Composition of the Commercial Catch

Sampling Intensity

Sampling coverage of the Canadian fishery prior to 1985 averaged about one sample per 1000 t landed. In 1985, 18 samples were collected, 19 in 1986 with a substantial increase to 33 samples in 1987, 40 in 1988, 32 in 1989 and 40 in 1990. Prior to 1978, sampling levels for Canadian catches were very low and it is unlikely that reliable estimates of removals at age could be obtained.

Age Composition

For the length weight relationship, values for a and b were derived from Canadian commercial sampling data. With round weight in kilograms and length in centimeters these values were a=0.0000163 and b=2.9048 and they were used for both Canadian and USA sampling data.

Canadian samples were used to obtain statistics by age. The bias introduced by applying otter trawl length frequencies to partition longline catches may be significant in years lacking samples for this gear. The catch at age for 1978-90 was re-calculated. This was required because of revised reported landings, inclusion of additional samples and standardization of methods used. The impact of these revisions are shown in Table 9, which compares results of ADAPT with the previous and current input parameters. The changes appear to be minimal for the dominant age groups.

Catch at age in the USA fishery for 1978-90 was estimated from USA samples of 5Zj and 5Zm catches for each year (Table 4). Annual samples by market category and month (or less frequent intervals if samples were not available) were combined to provide estimates of catch at age by market category. Canadian age keys were used for 1990 USA length frequencies since ageing of USA samples was not available.

Percent catch at age for total landings of 5Zj,m cod are shown in Table 5 and Figure 3. The dominant yearclasses were the 1987

(51%) and the 1985 (19%).

Serchuk and Wigley (1988), in their review of stock status for 5Ze cod, discounted current Canadian estimates of catch at age for 1978-85 based on a perception of an ageing problem. Neilson et al (this meeting) concluded that the preferred approach is to continue using the sum of Canadian and USA derived catch at age as the best estimate of total removals by the 5Zj,m fishery.

Mean length and weight at age for Canadian samples are given in Table 6 with the plus age group set to 115 cm and 15 kg, the approximate mean for ages 10-15. There appears to be no trend in size or weight at age over the 12 year time series, although mean weight at age in 1990 appears to be above the long term average. Mean weight at age 3 in 1990 (1987 yearclass) is well above the average and will have a substantial impact on estimated population biomass.

Stock Abundance Trends

Research Surveys

Random, depth-stratified bottom trawl surveys have been conducted by NMFS in the autumn since 1963 and a spring survey was added in 1968. A summer survey was conducted from 1977 to 1981. Surveys in Subdivision 5Ze were completed by Canada in March 1986-90. No adjustment for different gears or vessels used during the time series has been made. The spring survey used the larger "Yankee 41" trawl from 1973-81 and considerable differences in catch per tow might be anticipated. Total net opening of the "41" trawl is about 1.7 times the opening of the "Yankee 36". New trawl doors have been used for both spring and autumn surveys since 1985. Preliminary analysis of a study to develop conversion factors indicates the new trawl doors are more effective. The value of the conversion factor has not been resolved. However, catches since 1985 do not appear to indicate a substantial change in catchability relative to the pre-1985 catches. Consultation with USA researchers suggests a conversion factor for cod may not be necessary.

Data for USA surveys were provided by the NMFS and it was necessary to reformat these data prior to their incorporation in the survey database for analysis using STRAP software. An initial test to ensure correct loading and conversion of data was carried out and comparison of total abundance estimates in the 5Ze area showed no significant difference between STRAP estimates and the reported USA estimates. However, some differences in age-specific estimates was observed but this was attributed to adjustment of age length keys and it was concluded that STRAP estimates could replicate USA estimates.

Hunt (1990) describes the approach used to estimate mean catch per tow specific to the 5Zj,m area for Canadian and USA surveys. The technique required selection of only sets within the 5Zj,m boundary and using strata areas also within the 5Zj,m boundary.

Results of STRAP analysis for each of the surveys are given in Table 7. The 1982 USA spring survey is influenced by one tow of 1000 fish and the resultant high catch rate has a high standard error. This tow has been excluded by USA researchers in their analysis. Examination of tows in the 1982 survey indicates above average catches in several sets and strata and therefore all tows were included in the present study. The 1990 spring USA survey was partitioned with USA ageing data. Comparison of catch at age with results used last year, based on Canadian ageing indicate similar estimates.

Total catch per tow has been variable for each of the surveys and a general increase in the last 2-3 years of each survey is evident. However, the 1991 Canadian survey shows a marked decline from the high 1990 value. Catch per tow is strongly influenced by progression of year-classes over time and in particular the 1983 and 1985 yearclasses.

The fall survey is assumed to be a post-fishery index and spring surveys are assumed to be a pre-fishery index. Therefore the fall survey is lagged by one year for comparison of indices (ie. fall 1977 age one vs spring 1978 age two). In general, all three surveys appear to track yearclass strength and provide a consistent index. The 1987 yearclass, which will be a substantial factor in the 1990-93 fishery, appears to be above average in the Canadian and USA spring surveys in 1989-91. The 1990 yearclasses also appears to be above average in the Canadian 1991 survey.

Commercial Catch Rates

Canadian C/E for the mobile gear fleet in 1989 was not considered to be a reliable index because of the premature closure of the fishery and an updated C/E series was not possible. USA C/E was not available for 1988 or 1989. Therefore commercial OTB C/E was not included in the analysis.

A longline CPUE series, using Canadian vessels of TC 2 and 3 was examined. Data were extracted from ZIFF files and only trips where cod were the main species were included and months where total catch was greater than 10 t. Reported effort prior to June 1, 1988 was expressed in numbers of lines, and after June 1, as thousands of hooks. The earlier values were converted to hooks using the formula EFFORT ('000's of hooks) = (# of lines + 10)/20.

The program STANDAR was used to construct a multiplicative model of longline catch and effort. Months included in the model were March through October inclusive, 1977 to 1990. Reference categories within category types were September and 1986, representing

periods where longline catches of cod were high.

Results of the multiplicative analyses are shown in Table 8. The model r-squared is 0.336, and the year effect appears significant. When the retransformed CPUE is plotted against 3+ and 4+ biomass from the final ADAPT formulation contained here, there appear to be concurrent trends between CPUE and 4+ biomass (Fig. 4). However, there were several discrepancies between the series which convinced us that the CPUE series, as currently developed, is not useful for inclusion in the ADAPT formulation. Note, for example the decline in CPUE from the highest to the lowest observed value between 1989 and 1990 when other indications are that biomass levels are currently very high. Pending further analysis of this C/E series, it was concluded that it would be inappropriate to include it in the ADAPT formulation.

Estimation of Stock Size

Only research survey indices were used in the ADAPT formulation.

As noted above, catch at age and survey indices were revised for 1978-90 and the impact of these revisions was examined by rerunning ADAPT. Changes in estimated population number appeared not be substantial (Table 9).

The ADAPT formulation used in 1989 to estimate stock status, which included all three survey indices was used to estimate population parameters for 1978-91 based on estimates of the following parameters:

Year-class estimates $N_{i,1991}$ i=1,4

Calibration coefficients for each of the three surveys, where

K_i i=1,4 USA spring survey
K_i i=0,3 USA autumn survey
K_i i=1,4 Canadian spring survey

Assumed catchability for ages greater than age 4 (age 3 autumn) equal the oldest estimated for each survey. The following structure was imposed in ADAPT model:

- error in catch assumed negligible
- F on oldest age group set to weighted F for ages 3-8
- no intercept term fitted
- natural mortality set to 0.2
- logarithmic transform for indices

Input for the model consisted of:

- $RV1_{i,t}$ i=1,9; t=1978-90 USA spring survey
- $RV2_{i,t}$ i=0,8; t=1977-90 USA fall survey
- $RV3_{i,t}$ i=1,9; t=1986-91 Canadian spring survey

and the objective function required minimization of:

$$\{obs(\ln RV1_{i,t})-pred(\ln RV1_{i,t})\}^2 + \{obs(\ln RV2_{i,t})-pred(\ln RV2_{i,t})\}^2 + \{obs(\ln RV3_{i,t})-pred(\ln RV3_{i,t})\}^2$$

and a total of 21 parameters were estimated from 134 observations. Residuals for survey indices with zero catch at age (predominantly the USA fall survey) were excluded from the overall sum of residuals.

Calibration coefficients and population estimates were statistically significant from the above run except at age 1. Coefficients of variation were about 11-26% for USA survey catchability and the Canadian survey had higher CV's (19-42%), probably due to the short time series. Residuals for both USA survey indices were balanced in most cases but some year effect was evident for the 1982 spring, and 1983, 1986 and 1987 fall surveys. Comparison of results obtained with and without the 1982 USA spring survey indicate little difference in either the precison or magnitude of estimated parameters and therefore this survey was included in the final formulation. The 1987 and 1990 Canadian spring survey also had a strong pattern in residuals.

The resultant residuals for the ADAPT formulation using all three indices are given in Table 10. Parameter estimates for stock numbers at age in 1990 and the slopes relating survey indices to population numbers, with their standard error and standard error/mean, are given in Table 11.

Assessment Results

Population estimates from the above ADAPT formulation are given in Table 12 and indicate that the 1985 year-class is the largest observed with about 27 million fish at age 1. The 1980, 1983 and 1987 are also estimated to be well above the 1978-89 average abundance. The 1989 year-class appears to be average in abundance at age 1. For ages 3+ abundance has increased from a low of 8 million in 1985 to a high of 20 million in 1988 with a some decline in 1991. The 3+ biomass in 1991 is 71000 t and well above the 13 year average of 49000 t. Abundance of the 1987 and 1986 yearclasses in 1990 increased substantially over the estimates made last year with a resultant change in 3+ biomass from 69000 t to 76000 t. Population biomass, abundance, fishing mortality for ages 3+ and recruitment at age 1 are given in Figures 5-8.

Fully recruited (3+) fishing mortality in 1990 is estimated to be 0.40, an increase from 0.27 in 1989 when early closure of the Canadian OTB fishery in and reduced USA catches contributed to the reduced exploitation rate. The 1986 year-class continues to have an anomolously high F of 0.62 in 1990, a reflection of the unexpected high catch at age 3 in 1989 and age 4 in 1990.

Prognosis and Catch Projection

The following input data were used for catch projections:

Age	1991 Beginning of Year Populations Numbers (000's)	Mean Weight (kg)	Partial Recruitment
1	9886	0.696	0.004
2	7880	1.391	0.320
3	5473	2.249	1.000
4	5128	3.579	1.000
5	1020	5.012	1.000
6	3530	6.448	1.000
7	342	8.333	1.000
8	327	10.340	1.000
9	58	10.948	1.000
10+	100	15.000	1.000

As indicated earlier, the results of the assessment suggested that the 1990 year-class was above average in abundance. However, because the estimate is imprecise, the 1990 year-class was assumed to be equal to the geometric mean for the 1977-89 year-classes (9886 million).

Catch projection for 1991-92 was completed using three options - f in in 1991 and 1992 equal 1990, the 50% rule in 1992 and a catch in 1992 equal the catch in 1991. A 1991 catch of 22000 t was assumed. Results of projections with these options, which are for total catch (USA and Canada), are given below:

Option	F(3+) 1991	F(3+) 1992	Biomass 3+ ('000 t) 1991	Biomass 3+ ('000 t) 1992	Biomass 3+ ('000 t) 1993	Catch ('000 t) 1991	Catch ('000 t) 1992
1. F in 1992 and 1991 = 1990	0.40	0.40	50	46	44	22	20
2. 22000 t in 1991 50% rule in 1992	0.42	0.30	50	48	51	22	15
3. 22000 t in 1991 and in 1992	0.42	0.46	50	45	39	22	22

If fishing mortality is not allowed to exceed that in 1992, then a catch of about 20000 t in 1992 is implied. Cod in 5Zj,m are fully recruited at age 3 which means that forecasts are heavily dependent on estimates of incoming recruitment. The 1985 and 1987 year-classes will likely continue to contribute substantially to catches in 1991 but it is difficult to precisely forecast catches beyond 1992 because recruitment is variable and unpredictable. Recruitment in 1991 and later years will have a substantial impact on actual catches.

Management Considerations

Cod in the 5Zj,m management unit will continue to be exploited by both the USA and Canada and it is necessary to develop a consistent management plan. The apparent reduction in fishing mortality in recent years indicates some improvement in stock status which could be the result of reduced catches by the USA after exclusion from 5Zc. Since 1985, the USA has accounted for

an average of about 38% of the total 5Zj,m catch.

Hunt (1990) reported on a study undertaken to estimate the ratio of the 5Zj,m cod biomass relative to the 5Zc/5Zu (International) boundary as a means of determining the proportion of total biomass in 5Zj,m which would be available to the Canadian fleet. He concludes that, given the year and seasonal variation in the ratio of total 5Zj,m biomass found in the Canadian zone, it is difficult to provide a precise estimate of biomass available to the Canadian fleet. The average of the three surveys over the entire time series is 71% and 83% for the shorter time period from 1985. A ratio of about 70% would roughly reflect average conditions during the period (June-September) in which most of the Canadian fleet is active in the Georges Bank fishery. Based on projections for catch in 1991 given above, this would imply about 14000 t for the Canadian total catch and the remaining 6000t for the USA catch.

Acknowledgments

The authors wish to thank Drs. Fredric Serchuk and Ralph Mayo, of the NMFS at the Woods Hole Laboratory, for their assistance in providing data relating to the USA fishery and for comments on the analysis. Peter Perley assisted in the compliation and analyses of longliner C/E data.

Table 1. Nominal landings of cod by gear and month for Canada in unit areas 5Zjm. :(OT-otter trawl;LL-longline;GN-gillnet;MISC-miscellaneous).

YEAR	GEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
78	OT	166	762	187	26	304	1808	1095	75	219	1633	1487	0	7762
	LL	0	0	0	0	10	308	241	77	74	19	0	0	729
	MISC	0	0	55	1	0	17	102	0	0	14	98	0	287
	TOT	166	762	242	27	314	2133	1438	152	293	1666	1585	0	8778
79	OT	72	302	178	78	74	1634	649	674	648	293	28	7	4637
	LL	0	0	0	5	20	529	334	306	134	10	0	0	1338
	MISC	0	0	1	1	1	0	0	0	0	0	0	0	3
	TOT	72	302	179	84	95	2163	983	980	782	303	28	7	5978
80	OT	24	86	3	52	111	1373	1593	771	633	591	68	100	5405
	LL	0	0	0	0	208	951	596	496	337	47	0	0	2635
	MISC	0	0	1	2	1	2	1	16	0	0	0	0	23
	TOT	24	86	4	54	320	2326	2190	1283	970	638	68	100	8063
81	OT	2	205	55	7	38	529	1005	744	1013	36	229	97	3960
	LL	0	0	1	2	538	1476	1044	837	284	281	57	5	4525
	MISC	0	0	0	1	0	12	0	0	1	0	0	0	14
	TOT	2	205	56	10	576	2017	2049	1581	1298	317	286	102	8499
82	OT	90	73	0	0	11	845	4289	2109	1507	2360	934	119	12337
	LL	0	11	26	193	772	1035	1388	1082	635	308	33	4	5487
	MISC	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOT	90	84	26	193	783	1880	5677	3191	2142	2668	967	123	17824
83	OT	179	41	9	6	35	2209	1095	2115	956	171	76	11	6903
	GN	0	0	0	0	0	4	8	3	5	0	0	0	20
	LL	0	0	171	147	440	1440	698	574	1303	311	89	0	5173
	MISC	0	0	0	0	0	5	28	0	0	1	0	0	34
	TOT	179	41	180	153	475	3658	1829	2692	2264	483	165	11	12130
84	OT	5	3	13	0	37	267	92	240	60	19	0	0	736
	GN	0	0	0	0	0	34	3	0	0	0	0	0	37
	LL	0	0	167	152	112	1193	1209	1183	605	286	50	0	4957
	MISC	0	0	0	1	3	21	7	1	0	0	0	0	33
	TOT	5	3	180	153	152	1515	1311	1424	665	305	50	0	5763
85	OT	0	2	0	0	0	1336	2565	2440	693	435	5	80	7556
	GN	0	0	0	0	0	14	4	9	0	0	0	0	27
	LL	0	29	54	181	151	414	230	540	647	501	29	29	2805
	MISC	0	1	2	14	15	6	9	2	3	2	0	1	55
	TOT	0	32	56	195	166	1770	2808	2991	1343	938	34	110	10443
86	OT	14	9	0	15	6	2364	3138	477	49	11	4	22	6109
	GN	0	0	0	0	0	44	82	75	29	0	0	0	230
	LL	0	58	86	12	24	146	120	538	606	409	12	0	2011
	MISC	0	2	9	15	10	3	7	1	14	0	0	0	61
	TOT	14	69	95	42	40	2557	3347	1091	698	420	16	22	8411
87	OT	19	1	3	0	0	2485	3941	890	145	2	78	44	7608
	GN	0	0	0	0	0	109	249	308	38	0	0	0	704
	LL	0	6	112	68	8	293	591	1032	747	310	12	33	3212
	MISC	5	11	15	17	9	33	88	82	51	2	6	2	321
	TOT	24	18	130	85	17	2920	4869	2312	981	314	96	79	11845
88	OT	23	520	56	0	13	3247	3181	428	17	98	29	8	7620
	GN	0	0	0	0	0	180	224	141	50	21	0	0	616
	LL	54	86	68	205	27	1247	1685	392	426	134	10	1	4335
	MISC	2	9	12	10	16	41	95	97	53	0	20	2	357
	TOT	79	615	136	215	56	4715	5185	1058	546	253	59	11	12928
89	OT	5	140	7	0	2	1553	86	70	2	87	33	2	1987
	GN	0	0	0	0	0	131	359	440	175	9	0	0	1114
	LL	41	202	250	92	268	909	1057	1210	331	65	0	0	4425
	MISC	7	7	9	22	47	126	85	151	15	3	3	0	475
	TOT	53	349	266	114	317	2719	1587	1871	523	164	36	2	8001
90	OT	0	0	0	0	1	3187	1744	1547	928	436	9	1	7854
	GN	0	0	0	0	0	114	344	309	143	0	0	0	910
	LL	125	149	260	0	129	1156	1448	1098	581	252	4	0	5202
	MISC	6	12	19	19	10	62	77	58	63	5	11	2	344
	TOT	131	161	279	19	140	4519	3613	3012	1716	693	24	3	14310

Table 2. Summary of total catches by Canada and the USA in unit areas 5Zjm for 1978-1990.

YEAR	CANADA	USA	TOTAL
1978	8778	5502	14280
1979	5978	6408	12386
1980	8063	6418	14481
1981	8499	8094	16593
1982	17824	8565	26389
1983	12130	8572	20702
1984	5763	10551	16314
1985	10443	6641	17084
1986	8411	5696	14107
1987	11845	4792	16637
1988	12932	7645	20577
1989	8001	6182	14183
1990	14310	6378	20688

Table 3. Proportional catch by month for USA and Canada in unit areas 5Zjm ,1978-1990.

	MONTH											
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
78	0.04	0.12	0.07	0.05	0.07	0.19	0.12	0.03	0.03	0.16	0.13	0.01
79	0.03	0.07	0.09	0.06	0.06	0.23	0.12	0.14	0.08	0.06	0.04	0.02
80	0.04	0.12	0.07	0.06	0.05	0.19	0.19	0.11	0.08	0.05	0.01	0.02
81	0.03	0.14	0.05	0.02	0.06	0.18	0.19	0.13	0.10	0.04	0.03	0.02
82	0.02	0.05	0.06	0.03	0.06	0.11	0.27	0.14	0.10	0.11	0.04	0.01
83	0.03	0.09	0.05	0.03	0.05	0.23	0.14	0.16	0.13	0.04	0.03	0.02
84	0.08	0.18	0.05	0.04	0.07	0.17	0.14	0.12	0.07	0.05	0.01	0.01
85	0.03	0.08	0.10	0.05	0.05	0.11	0.19	0.20	0.09	0.07	0.01	0.02
86	0.04	0.12	0.11	0.07	0.04	0.20	0.24	0.08	0.05	0.03	0.00	0.01
87	0.04	0.02	0.04	0.06	0.06	0.20	0.30	0.15	0.06	0.02	0.02	0.03
88	0.05	0.08	0.08	0.05	0.05	0.28	0.27	0.06	0.03	0.01	0.02	0.02
89	0.06	0.08	0.06	0.06	0.09	0.28	0.13	0.14	0.04	0.03	0.02	0.03
90	0.05	0.03	0.07	0.06	0.09	0.25	0.19	0.15	0.09	0.03	0.00	0.01
MEAN	0.04	0.09	0.07	0.05	0.06	0.20	0.19	0.12	0.07	0.05	0.03	0.02

Table 4. Catch at age of cod in numbers (000's) for Canada, USA and total, in 5Zjm ,1978-1990.

		AGEGROUP									
		1	2	3	4	5	6	7	8	9	TOTAL
78	CDN	2	62	2017	667	205	78	57	12	12	3112
	USA	0	59	1571	409	102	32	26	9	0	2208
	TOT	2	121	3588	1076	307	110	83	21	12	5320
79	CDN	0	371	328	763	302	55	18	9	4	1850
	USA	10	443	71	1011	243	94	4	36	0	1912
	TOT	10	814	399	1774	545	149	22	45	4	3762
80	CDN	1	775	1121	214	420	125	32	11	14	2713
	USA	0	212	374	51	496	220	77	9	19	1458
	TOT	1	987	1495	265	916	345	109	20	33	4171
81	CDN	2	145	608	504	134	380	87	51	21	1932
	USA	17	458	835	745	21	215	82	14	15	2402
	TOT	19	603	1443	1249	155	595	169	65	36	4334
82	CDN	6	1283	1358	1105	742	164	221	97	21	4997
	USA	0	1399	328	324	324	25	124	60	16	2600
	TOT	6	2682	1686	1429	1066	189	345	157	37	7597
83	CDN	27	744	2506	1212	201	54	10	17	12	4783
	USA	13	575	910	262	265	229	21	54	27	2356
	TOT	40	1319	3416	1474	466	283	31	71	39	7139
84	CDN	0	26	118	375	340	123	72	19	18	1091
	USA	10	243	793	971	171	167	158	12	53	2578
	TOT	10	269	911	1346	511	290	230	31	71	3669
85	CDN	4	2146	904	383	497	139	45	38	9	4165
	USA	8	646	317	248	444	85	51	62	5	1866
	TOT	12	2792	1221	631	941	224	96	100	14	6031
86	CDN	19	235	1283	365	143	215	29	19	9	2317
	USA	9	91	905	148	161	185	29	20	16	1564
	TOT	28	326	2188	513	304	400	58	39	25	3881
87	CDN	14	2595	602	741	91	79	117	22	15	4276
	USA	0	1071	263	358	53	42	50	15	9	1861
	TOT	14	3666	865	1099	144	121	167	37	24	6137
88	CDN	10	232	2360	324	421	69	61	111	29	3617
	USA	0	88	1293	322	440	75	41	32	10	2301
	TOT	10	320	3653	646	861	144	102	143	39	5918
89	CDN	0	318	284	918	124	179	31	23	37	1914
	USA	0	422	368	919	69	135	25	2	4	1944
	TOT	0	740	652	1837	193	314	56	25	41	3858
90	CDN	7	339	1769	617	799	95	102	8	14	3750
	USA	0	339	1427	345	396	21	20	2	0	2550
	TOT	7	678	3196	962	1195	116	122	10	14	6300

Table 5. Percent catch at age for total 5Zj.m landings, 1978-90

Age	78	79	80	81	82	83	84	85	86	87	88	89	90
						Year							
1	0.04	0.27	0.02	0.44	0.08	0.56	0.27	0.20	0.72	0.23	0.17	0.00	0.11
2	2.27	21.64	23.66	13.91	35.30	18.48	7.33	46.29	8.40	59.74	5.41	19.18	10.76
3	67.44	10.61	35.84	33.29	22.19	47.85	24.83	20.25	56.38	14.09	61.73	16.90	50.73
4	20.23	47.16	6.35	28.82	18.81	20.65	36.69	10.46	13.22	17.91	10.92	47.62	15.27
5	5.77	14.49	21.96	3.58	14.03	6.53	13.93	15.60	7.83	2.35	14.55	5.00	18.97
6	2.07	3.96	8.27	13.73	2.49	3.96	7.90	3.71	10.31	1.97	2.43	8.14	1.84
7	1.56	0.58	2.61	3.90	4.54	0.43	6.27	1.59	1.49	2.72	1.72	1.45	1.94
8	0.39	1.20	0.48	1.50	2.07	0.99	0.84	1.66	1.00	0.60	2.42	0.65	0.16
9	0.23	0.11	0.79	0.83	0.49	0.55	1.94	0.23	0.64	0.39	0.66	1.06	0.22

Table 6. Mean size at age of cod in 5Zj,m derived from Canadian samples, 1978-89.

(a) Length

Year	1	2	3	4	5	6	7	8	9	10+
					Age group					
1978	44.3	53.9	57.9	63.6	74.6	76.0	89.9	86.0	93.6	115.0
1979	-	50.7	53.3	69.1	75.3	80.4	95.9	104.4	99.6	115.0
1980	36.7	49.3	60.1	66.7	78.0	85.7	87.6	105.6	105.2	115.0
1981	42.2	49.2	58.8	67.8	77.4	85.7	94.5	96.0	97.4	115.0
1982	36.8	49.8	57.1	69.8	78.6	84.9	95.0	95.8	107.2	115.0
1983	42.6	50.4	58.4	67.1	77.8	84.8	93.0	99.3	104.4	115.0
1984	-	50.2	60.4	70.2	76.9	83.5	92.2	99.7	101.4	115.0
1985	38.7	49.3	55.3	67.9	74.8	83.2	90.1	95.6	98.8	115.0
1986	39.6	51.7	63.5	71.0	79.7	86.9	92.8	96.2	94.5	115.0
1987	38.5	51.9	60.3	73.5	82.5	88.1	96.2	100.3	106.0	115.0
1988	40.9	48.0	60.3	70.1	79.9	84.5	95.3	100.1	102.3	115.0
1989	37.0	48.5	57.6	69.9	77.0	82.6	88.1	100.4	102.8	115.0
1990	41.6	54.3	63.1	69.0	77.6	84.0	92.0	102.0	107.4	115.0

(b) Weight

1978	0.656	1.206	2.121	2.644	3.540	5.682	6.141	9.268	8.399	15.0
1979	-	1.483	1.723	3.691	4.730	5.986	9.586	12.058	10.412	15.0
1980	0.572	1.348	2.427	3.241	5.116	6.707	7.148	12.324	12.169	15.0
1981	0.864	1.368	2.312	3.467	5.113	6.816	9.108	9.575	10.485	15.0
1982	0.592	1.410	2.128	3.814	5.335	6.656	9.158	9.574	12.941	15.0
1983	0.885	1.466	2.265	3.371	5.210	6.641	8.593	10.428	11.999	15.0
1984	-	1.438	2.477	3.841	4.977	6.310	8.541	10.486	11.034	15.0
1985	0.680	1.391	1.950	3.571	4.742	6.399	8.074	9.664	10.584	15.0
1986	0.723	1.573	2.897	3.944	5.623	7.208	8.618	9.512	9.996	15.0
1987	0.600	1.600	2.506	4.447	6.148	7.484	9.538	10.759	12.565	15.0
1988	0.790	1.270	2.489	3.862	5.662	6.641	9.309	10.765	11.636	15.0
1989	0.585	1.303	2.178	3.830	5.128	6.348	7.554	10.799	11.576	15.0
1990	0.831	1.812	2.829	3.699	5.221	6.657	8.582	11.227	10.080	15.0

Table 7. Stratified mean catch per tow in numbers for USA and Canadian research surveys in 5Zj,m, 1978-90. (USA autumn 1990 estimated using combined 1988/1989 USA age key).

Age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
USA spring															
1	-	0.17	0.44	0.02	1.38	0.64	0.44	0.13	0.08	1.13	0.01	0.58	0.27	0.18	
2	-	0.01	1.70	1.90	1.27	9.40	2.33	0.14	3.67	0.62	2.17	0.45	1.96	0.80	
3	-	3.27	0.14	1.86	1.97	20.28	4.06	0.52	1.15	2.05	0.46	5.05	0.59	4.02	
4	-	0.72	1.65	0.18	1.40	18.09	0.87	0.78	1.92	0.55	0.98	0.50	3.02	1.44	
5	-	1.03	0.64	1.93	0.06	13.78	0.68	0.31	2.75	0.78	0.01	0.84	0.58	1.57	
6	-	0.22	0.22	0.38	0.49	0.01	0.42	0.25	0.60	0.98	0.34	0.08	0.68	0.40	
7	-	0.88	0.11	0.08	0.25	4.50	0.18	0.22	0.35	0.05	0.28	0.03	0.09	0.33	
8	-	0.12	0.14	0.05	0.10	1.01	0.07	0.01	0.45	0.21	0.06	0.14	0.07	0.05	
9	-	0.05	0.01	0.04	0.01	0.57	0.01	0.14	0.13	0.27	0.11	0.01	0.11	0.01	
USA autumn															
0	0.08	0.17	0.26	0.49	0.49	0.01	0.94	0.04	2.24	0.22	0.29	0.18	0.52	0.45	
1	0.01	2.14	2.40	1.16	3.44	0.67	0.08	1.82	0.39	5.20	0.24	1.02	0.91	0.91	
2	5.12	0.21	2.38	0.62	1.78	0.83	0.27	0.09	1.80	0.11	1.53	0.33	2.13	1.00	
3	1.02	4.14	0.17	0.98	1.37	0.05	0.57	0.66	0.30	0.35	0.23	2.13	0.36	1.89	
4	0.28	0.59	2.20	0.04	0.39	0.08	0.03	1.08	0.03	0.01	0.19	0.25	0.97	0.27	
5	0.22	0.09	0.36	0.28	0.02	0.01	0.02	0.03	0.01	0.01	0.01	0.44	0.13	0.47	
6	0.27	0.09	0.13	0.03	0.04	0.01	0.02	0.04	0.03	0.02	0.01	0.01	0.05	0.05	
7	0.03	0.13	0.04	0.04	0.01	0.04	0.01	0.01	0.01	0.01	0.01	0.07	0.01	0.03	
8	0.01	0.01	0.03	0.04	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.09	0.01	0.01	
Canadian spring															
1	-	-	-	-	-	-	-	-	-	1.81	0.12	0.36	0.84	0.26	2.75
2	-	-	-	-	-	-	-	-	-	8.33	4.31	1.08	5.01	1.81	3.31
3	-	-	-	-	-	-	-	-	-	7.50	1.55	12.85	1.77	7.96	3.26
4	-	-	-	-	-	-	-	-	-	0.76	1.81	1.36	3.90	4.49	3.72
5	-	-	-	-	-	-	-	-	-	1.61	0.39	2.02	0.58	10.12	1.99
6	-	-	-	-	-	-	-	-	-	1.04	0.21	0.23	0.76	1.23	2.70
7	-	-	-	-	-	-	-	-	-	0.52	0.44	0.19	0.09	2.51	0.33
8	-	-	-	-	-	-	-	-	-	0.08	0.21	0.43	0.19	0.33	0.57
9	-	-	-	-	-	-	-	-	-	0.15	0.03	0.04	0.25	0.36	0.08

Table 8. Results of longline catch rate standardization.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.580
MULTIPLE R SQUARED..... 0.336

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	9.202E1	9.202E1	
REGRESSION	21	1.680E1	8.000E-1	3.306
TYPE 1	7	9.956E-1	1.422E-1	0.588
TYPE 2	13	1.464E1	1.126E0	4.654
TYPE 3	1	6.881E-1	6.881E-1	2.844
RESIDUALS	137	3.315E1	2.420E-1	
TOTAL	159	1.420E2		

REGRESSION COEFFICIENTS

VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
INTERCEPT	-0.869	0.172	159
1	0.171	0.168	13
2	0.034	0.179	11
3	-0.122	0.164	14
4	-0.059	0.140	24
5	-0.124	0.138	25
6	-0.067	0.144	22
7	-0.115	0.143	22
8	0.450	0.233	7
9	0.332	0.216	9
10	0.572	0.224	8
11	0.514	0.208	10
12	0.416	0.199	12
13	0.291	0.186	16
14	0.292	0.184	17
15	0.260	0.184	17
16	-0.234	0.206	11
17	0.306	0.223	8
18	-0.031	0.206	11
19	0.849	0.202	10
20	-0.467	0.192	12
21	-0.137	0.082	91

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	CATCH	EFFORT
1977	-0.6781	0.0446	0.561	0.118	500	892
1978	-0.2281	0.1019	0.854	0.267	729	853
1979	-0.3463	0.0874	0.765	0.222	1338	1750
1980	-0.1058	0.0905	0.971	0.287	2635	2714
1981	-0.1645	0.0865	0.917	0.265	4525	4932
1982	-0.2624	0.0829	0.833	0.236	5487	6584
1983	-0.3867	0.0789	0.737	0.204	5173	7015
1984	-0.3866	0.0781	0.738	0.203	4957	6718
1985	-0.4178	0.0781	0.715	0.197	2805	3922
1986	-0.9117	0.0912	0.434	0.128	2011	4638
1987	-0.6781	0.0446	0.561	0.118	3212	5729
1988	-0.7092	0.0879	0.532	0.155	4335	8152
1989	0.1708	0.0869	1.283	0.371	4425	3450
1990	-1.1446	0.0835	0.345	0.098	5202	15087

Table 9. Population numbers and fishing mortality derived with ADAPT formulation used in 1990 and revised catch at age and survey indices, 1978-89.

Numbers

	78	79	80	81	82	83	84	85	86	87	88	89	90
1	11227	9599	9366	17533	6601	4731	14594	5341	28711	4890	15905	9105	11423
2	2243	9190	7850	7667	14338	5399	3837	11939	4362	23481	3991	13013	7455
3	10683	1727	6788	5534	5732	9312	3227	2898	7249	3276	15908	2978	9984
4	3544	5500	1053	4205	3225	3167	4533	1818	1268	3955	1900	9719	1848
5	1024	1928	2898	622	2312	1347	1259	2493	917	574	2244	971	6295
6	378	561	1086	1543	369	929	681	569	1190	476	340	1058	620
7	306	210	324	577	725	131	504	295	263	612	280	148	582
8	41	175	152	167	319	282	79	205	155	163	350	137	70
9	41	15	103	106	78	119	166	37	77	92	100	157	90
3+	16017	10115	12402	12753	12760	15287	10450	8315	11119	9148	21121	15168	19489

Fishing mortality

1	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	0.06	0.10	0.15	0.09	0.23	0.31	0.08	0.30	0.09	0.19	0.09	0.06
3	0.46	0.29	0.28	0.34	0.39	0.52	0.37	0.63	0.41	0.35	0.29	0.28
4	0.41	0.44	0.33	0.40	0.67	0.72	0.40	0.48	0.59	0.37	0.47	0.23
5	0.40	0.37	0.43	0.32	0.71	0.48	0.60	0.54	0.46	0.32	0.55	0.25
6	0.39	0.35	0.43	0.56	0.83	0.41	0.64	0.57	0.46	0.33	0.63	0.40
7	0.36	0.12	0.46	0.39	0.75	0.30	0.70	0.44	0.28	0.36	0.52	0.54
8	0.82	0.33	0.16	0.56	0.78	0.33	0.57	0.78	0.33	0.29	0.60	0.23
9	0.39	0.35	0.44	0.47	0.75	0.45	0.64	0.54	0.44	0.34	0.57	0.34
3+	0.44	0.39	0.34	0.39	0.57	0.55	0.45	0.56	0.43	0.35	0.35	0.26

Ratio of population numbers estimated in 1990 to revised estimates

1	1.04	1.00	0.94	0.94	0.95	0.98	1.01	1.00	1.04	1.04	0.98	0.94	1.12
2	1.17	1.04	1.00	0.94	0.94	0.95	0.99	1.01	1.00	1.04	1.03	0.98	0.94
3	1.04	1.18	1.03	1.01	0.93	0.85	1.04	0.99	1.01	1.00	1.03	1.03	0.97
4	1.06	1.04	1.11	1.05	0.98	0.88	0.99	1.07	0.99	1.02	0.96	1.03	0.87
5	1.03	1.09	1.08	1.17	1.07	1.09	1.02	1.01	1.12	0.96	1.04	0.92	1.03
6	1.06	1.05	1.17	1.12	1.25	1.20	1.05	1.06	1.01	1.18	0.96	1.07	0.90
7	1.12	1.12	1.09	1.24	1.23	1.67	1.04	1.00	1.10	1.00	1.25	0.94	1.11
8	0.82	1.19	1.14	1.13	1.38	1.45	1.09	1.04	1.00	1.12	1.02	1.44	1.11
9	0.90	0.59	1.25	1.13	1.27	1.88	1.08	1.09	1.08	0.98	1.17	1.05	1.48

Table 10. Residuals for survey indices from ADAPT

Age	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
							Year								
(a) USA spring															
1		-0.56	0.54	-2.52	1.09	1.31	1.24	-1.08	-0.54	0.44	0.00	0.33	0.11	-0.35	
2		0.00	0.09	0.36	-0.02	1.36	0.95	-1.54	0.61	-0.14	-0.55	-0.56	-0.10	-0.45	
3		-0.01	-1.34	-0.12	0.14	2.44	0.35	-0.63	0.24	-0.08	-0.75	0.09	-0.62	0.28	
4		-1.14	-0.75	-1.31	-0.64	2.18	-0.84	-1.30	0.55	-0.40	-0.92	-0.82	-0.63	-0.02	
5		0.46	-0.65	0.05	-1.88	2.24	-0.23	-0.94	0.56	0.35	0.00	-0.50	0.04	-0.82	
6		-0.09	-0.48	-0.60	-0.69	0.00	-0.34	-0.54	0.52	0.27	0.22	-1.04	0.07	0.14	
7		1.51	-0.19	-0.95	-0.38	2.28	0.77	-0.37	0.63	-1.19	-0.31	-1.64	-0.14	-0.03	
8		1.52	0.23	-0.66	-0.06	1.61	-0.93	0.00	1.26	0.77	-0.52	-0.43	0.03	-0.05	
9		0.66	0.00	-0.49	0.00	2.45	0.00	0.29	1.72	1.74	0.66	0.00	0.16	0.00	
(b) USA fall															
0	-1.37	-0.46	-0.01	-0.00	0.99	0.00	0.84	-1.28	1.08	0.31	-0.41	-0.35	0.65	0.00	
1	0.00	0.65	0.92	0.22	0.68	0.04	-1.78	0.23	-0.27	0.65	-0.87	-0.42	0.00	-0.05	
2	1.28	-0.09	0.97	-0.17	0.85	-0.40	-0.44	-1.47	0.64	-1.34	-0.26	-0.36	0.49	0.31	
3	0.48	1.45	-0.09	0.27	0.87	-2.42	-0.34	0.75	0.27	-0.67	-0.32	0.30	-0.13	0.73	
4	0.43	0.55	1.45	-1.01	-0.05	-1.09	-2.00	0.90	-1.63	0.00	-0.71	0.47	-0.03	0.40	
5	1.19	-0.10	0.63	0.02	-1.18	0.00	-1.79	-1.20	0.00	0.00	0.00	0.91	0.29	-0.29	
6	1.60	0.88	0.82	-1.23	-1.17	0.00	-1.49	-0.26	-0.42	-1.67	0.00	0.00	-0.64	-0.19	
7	1.41	1.43	0.39	0.30	0.00	-0.22	0.00	0.00	0.00	0.00	0.00	1.30	0.00	-0.66	
8	0.00	0.00	0.50	0.75	0.00	0.00	0.02	0.00	0.00	0.00	0.00	1.23	0.00	0.00	
(c) Canadian spring															
1										0.56	-0.60	-0.50	0.89	-0.34	0.00
2										1.63	-0.70	-0.53	0.00	-0.47	0.07
3										0.42	-0.34	0.22	-0.32	0.16	-0.15
4										-0.61	-0.83	-0.35	-0.90	0.59	-0.39
5										0.55	-0.50	-0.15	-0.49	0.51	0.60
6										-0.19	-0.79	-0.51	-0.35	0.74	-0.34
7										0.63	-0.38	-0.32	-0.66	1.47	-0.11
8										-0.72	0.21	0.17	0.50	1.32	0.48
9										0.63	-1.17	-0.96	0.45	1.64	0.24

Table 11. Parameter estimates for age 1-9 population numbers at the beginning of 1991 and slopes for survey indices for cod in 5Zj,m

Age	Estimate	Std. Error	SE/mean
1	9.8859E3	2.5012E3	2.5300E-1
2	7.8804E3	3.0880E3	3.9186E-1
3	5.4732E3	1.9029E3	3.4768E-1
4	5.1284E3	2.0304E3	3.9591E-1
5	1.0199E3	4.5976E2	4.5077E-1
6	3.5298E3	1.2676E3	3.5913E-1
7	3.4206E2	1.3724E2	4.0121E-1
8	3.2717E2	1.4279E2	4.3645E-1
9	5.8356E1	3.0772E1	5.2731E-1
USA Spring survey			
1	2.6646E-5	7.0039E-6	2.6285E-1
2	1.6923E-4	4.4145E-5	2.6086E-1
3	3.0937E-4	7.7082E-5	2.4916E-1
4	6.3567E-4	7.2412E-5	1.1391E-1
USA fall survey			
0	2.8047E-5	7.3983E-6	2.6378E-1
1	1.2190E-4	3.0844E-5	2.5302E-1
2	1.3339E-4	3.2252E-5	2.4178E-1
3	1.7746E-4	2.2441E-5	1.2646E-1
Canadian survey			
1	3.8081E-5	1.6041E-5	4.2123E-1
2	3.9065E-4	1.4923E-4	3.8201E-1
3	6.9007E-4	2.5986E-4	3.7658E-1
4	1.0759E-3	2.0270E-4	1.8841E-1

Table 12. Results of ADAPT formulation using Canadian and USA spring and USA fall survey indices for cod in 5Zj,m.

Age	78	79	80	81	82	83	84	85	86	87	88	89	90	91
							Year							
(a) Numbers at age (000's)														
1	11214	9588	9350	17485	6480	4780	14436	5139	27236	5730	15624	9080	9633	9886
2	2241	9180	7841	7654	14298	5300	3877	11810	4197	22273	4678	12783	7434	7880
3	10679	1726	6779	5527	5721	9280	3146	2931	7143	3141	14919	3541	9796	5473
4	3543	5497	1052	4198	3219	3159	4506	1751	1295	3868	1789	8909	2309	5128
5	1024	1927	2895	621	2307	1343	1252	2472	863	596	2173	880	5632	1020
6	378	560	1085	1542	368	924	678	563	1172	431	358	1000	546	3530
7	306	210	324	576	724	131	500	292	258	598	244	162	534	342
8	41	175	152	167	319	280	79	202	153	159	338	107	82	327
9	41	15	103	106	78	119	165	37	75	90	97	148	65	58
3+	16012	10110	12390	12736	12735	15235	10327	8247	10958	8883	19917	14747	18965	15879
(b) Biomass at age (t)														
1	6261	6493	5346	14999	3735	4214	9775	3428	19423	3765	12238	5316	8005	8215
2	2214	13419	10567	10255	19842	7615	5507	15915	6493	34849	5834	16427	13471	14279
3	18649	2917	16242	12427	11813	20454	7647	5514	20080	7599	36090	7498	27693	15473
4	7617	19752	3410	14274	11912	10422	16954	5981	5034	16630	6703	33102	8541	18970
5	2891	8888	14792	3104	12050	6809	6140	11181	4693	3583	11904	4332	29405	5325
6	1696	3126	7285	10354	2408	6018	4220	3469	8197	3139	2305	6033	3635	23498
7	1449	1954	2318	5138	6557	1112	4156	2271	2185	5616	2228	1182	4587	2936
8	320	2088	1871	1555	2957	2889	822	1860	1433	1686	3568	1141	924	3673
9	276	155	1252	1035	998	1415	1810	371	665	1116	1085	1686	853	763
3+	32897	38881	47171	47886	48694	49120	41748	30647	42288	39369	63883	54974	75637	70637
(c) Fishing mortality at age														
1	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	
2	0.06	0.10	0.15	0.09	0.23	0.32	0.08	0.30	0.09	0.20	0.08	0.07	0.11	
3	0.46	0.30	0.28	0.34	0.39	0.52	0.39	0.62	0.41	0.36	0.32	0.23	0.45	
4	0.41	0.44	0.33	0.40	0.67	0.73	0.40	0.51	0.58	0.38	0.51	0.26	0.62	
5	0.40	0.37	0.43	0.32	0.71	0.48	0.60	0.55	0.49	0.31	0.58	0.28	0.27	
6	0.39	0.35	0.43	0.56	0.84	0.41	0.64	0.58	0.47	0.37	0.59	0.43	0.27	
7	0.36	0.12	0.47	0.39	0.75	0.30	0.71	0.45	0.29	0.37	0.62	0.48	0.29	
8	0.82	0.33	0.16	0.56	0.79	0.33	0.57	0.79	0.33	0.30	0.63	0.30	0.14	
9	0.40	0.35	0.44	0.47	0.75	0.45	0.64	0.55	0.46	0.35	0.59	0.37	0.27	
3+	0.45	0.39	0.34	0.39	0.57	0.55	0.45	0.57	0.44	0.37	0.38	0.27	0.40	

Fig 1. Canadian landings by gear type

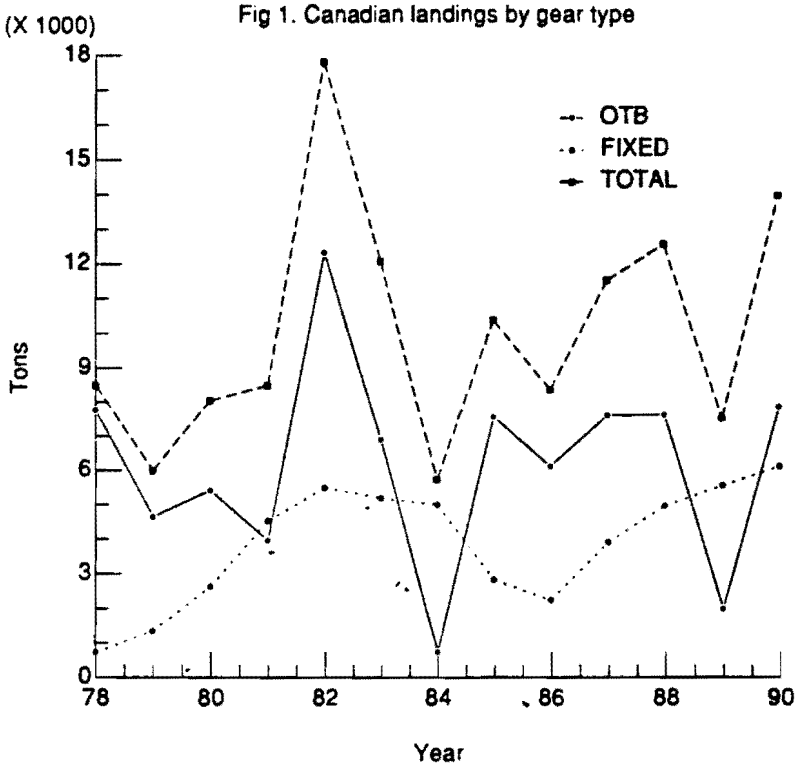

Fig 2. Canadian and USA landings of cod in 5Zj,m

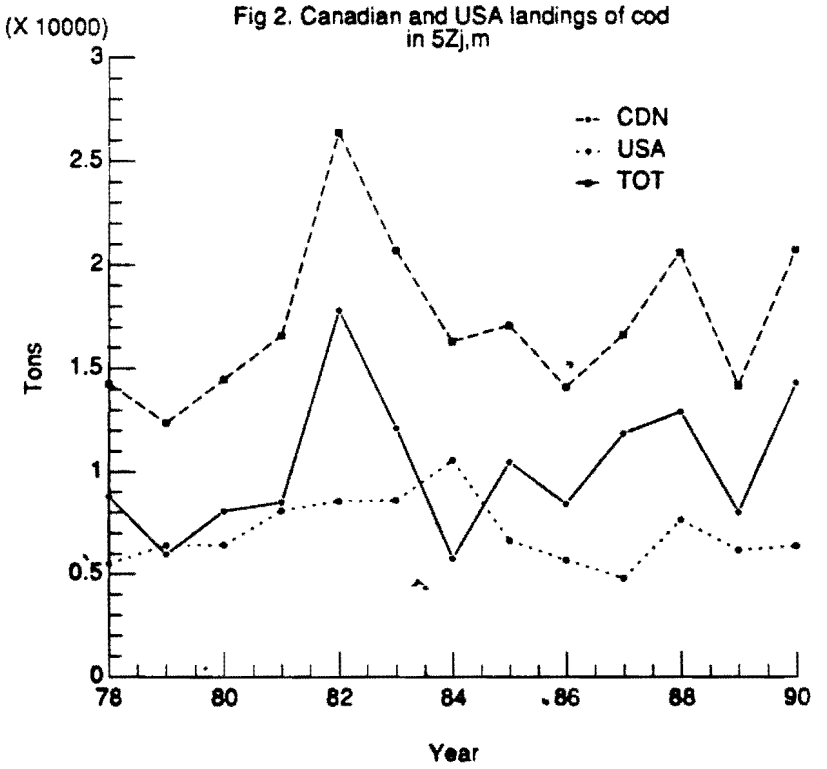

Fig 3. Percent age compostion in 1990 landings of 5Zj,m cod

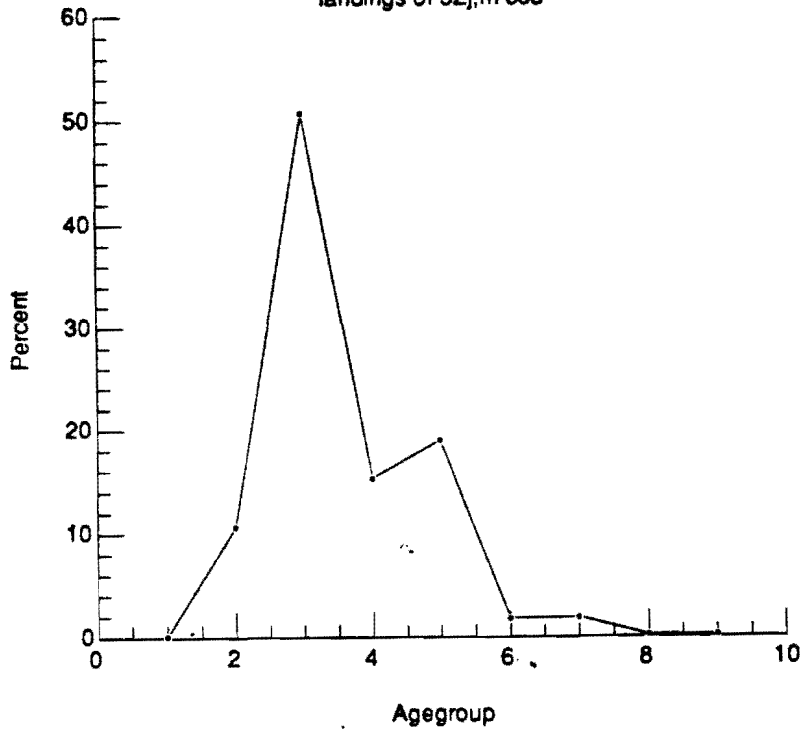

Fig 4. Population 3+ biomass (t) and Canadian longline C/E (t/1000 hooks)

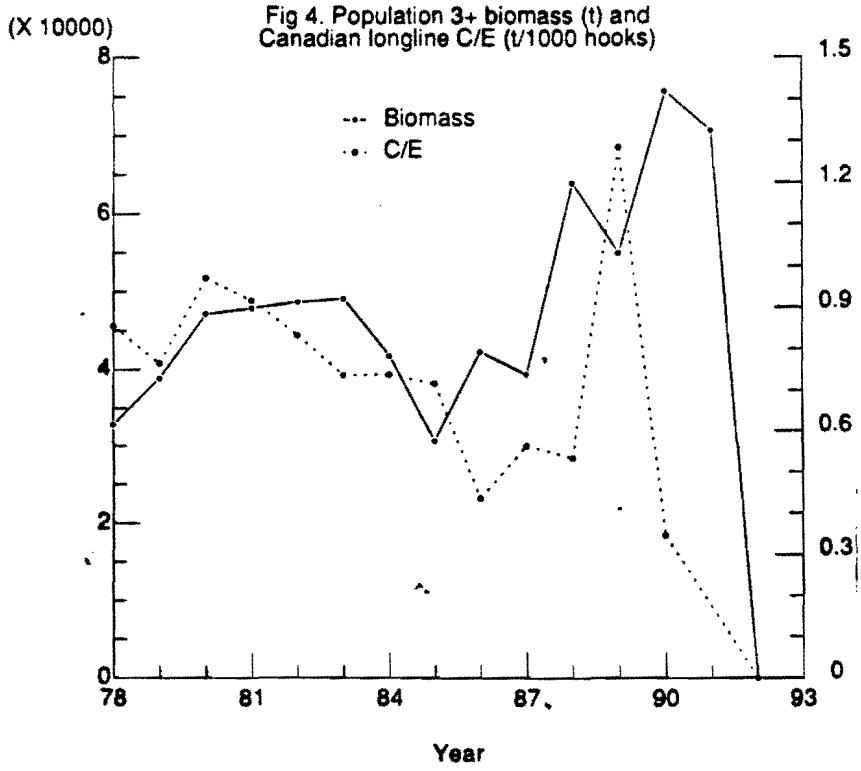

Fig 5. Fully recruited (3+) population biomass for 5Zj,m cod

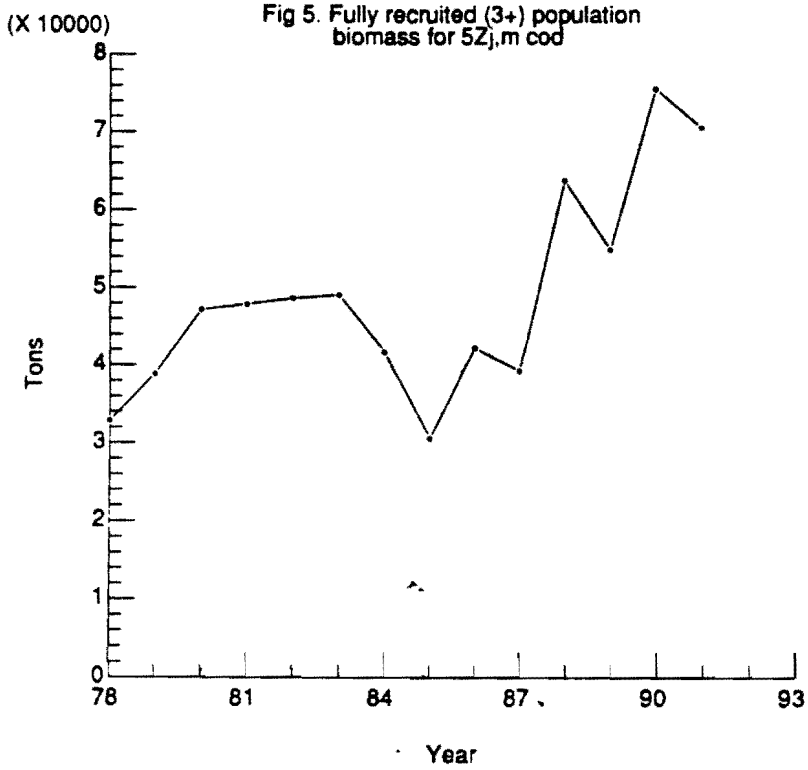

Fig 6. Populations numbers (3+) for 5Zj,m cod

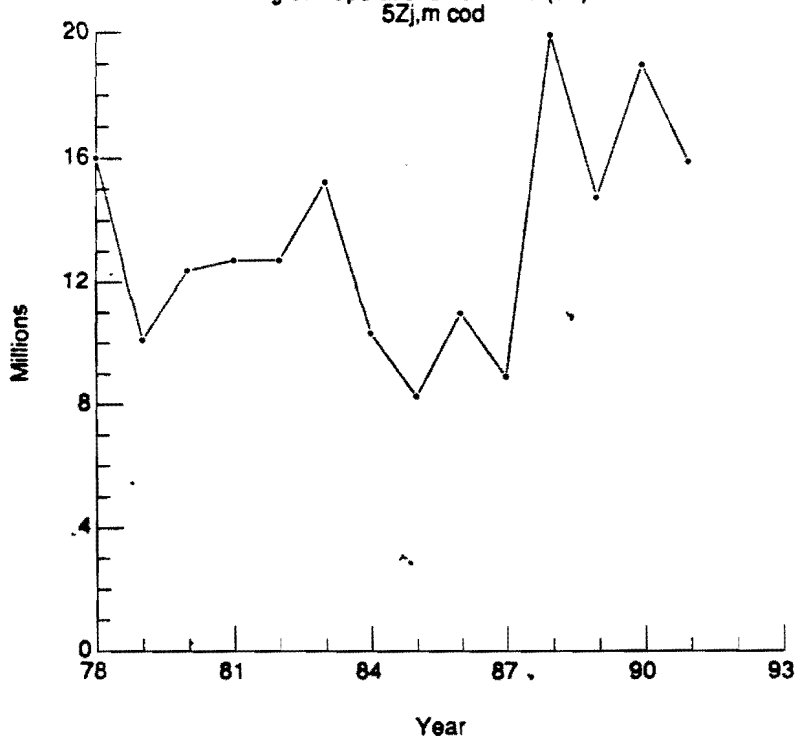

Fig 7. Fully recruited (3+) fishing mortality for 5Zj,m cod

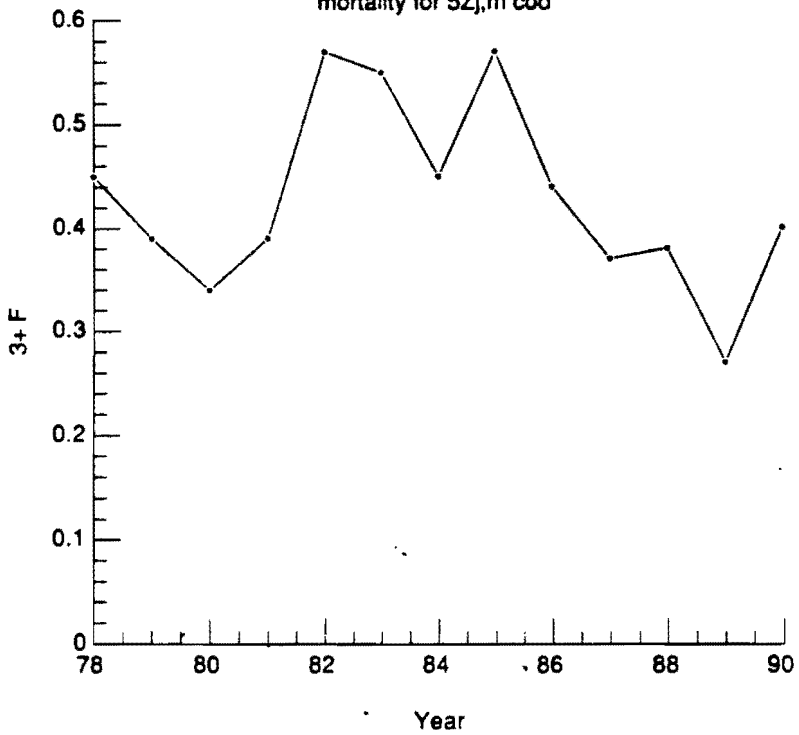

Fig 8. Recruitment at age 1 with 1991 set to geometric mean