Department of Fisheries and Oceans
Canadian Stock Assessment Secretariat
Research Document 97/53

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Ministère des pêches et océans
Secrétariat canadien pour l'évaluation des stocks
Document de recherche 97/53

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Population Status of Georges Bank Cod in Unit Areas 5Zj,m for 1978-96

by

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ABSTRACT

An analytical assessment of the Georges Bank cod stock in 5Zj,m was completed using updated catch-at-age for 1978-96 and research survey indices. Results of the assessment provided statistically significant parameter estimates for the 1997 beginning of year population at age. Bias and precision for the estimates were within acceptable limits. The adult biomass increased between 1995 and 1997 to about 21,000 t, primarily due to survival and growth of the 1992 yearclass. Exploitation decreased from the ~50% level in the early 1990's to less than the $F_{0.1}$ = 16% reference level in 1995 and 1996. Recruitment in recent years has been poor with the 1992 and 1995 yearclasses being better than adjacent ones but still only of moderate strength. The 1996 yearclass appears to be very weak. Projections for 1997 indicates a yield of about 4,000 t at the $F_{0.1}$ reference level and continued biomass rebuilding. Comparison of population abundance in 5Zj,m with those in the total 5Z area show similar trends in abundance, recruitment and exploitation.

RÉSUMÉ

On a effectué une évaluation analytique du stock de morue du banc Georges, situé dans 5Zjm, en faisant appel aux données récentes sur les prises selon l'âge pour 1978-1996 et à des indices de relevés de recherche pour obtenir des estimations statistiquement significatives des effectifs selon l'âge au début de 1997. Le biais et la précision des estimations se situaient dans les limites acceptables. La biomasse d'adultes a augmenté entre 1995 et 1997, pour atteindre environ 21 000 t. Cette augmentation est en grande partie due à la survie et à la croissance de la classe de 1992. L'exploitation a diminué, passant d'un pourcentage d'environ 50 % au début des années 90 à moins du niveau de référence $F_{0,1}$ = 16 % en 1995 et 1996. Le recrutement dans les dernières années a été faible; bien que les classes de 1992 et 1995 sont plus fortes que celles des années adjacentes, leur abondance demeure toutefois modérée. La classe de 1996 semble très peu abondante. Les prévisions pour 1997 indiquent un rendement d'environ 4 000 t au niveau de référence $F_{0,1}$ et un rétablissement continu de la biomasse. Une comparaison des effectifs de la population de 5Zjm à l'ensemble de 5Z montre des tendances semblables de l'abondance, du recrutement et de l'exploitation.

Introduction

This report incorporates commercial catch data and research survey results for the 1978-97 time period to estimate the stock status of cod in the two unit areas 5Zj and 5Zm (5Zj,m) (Fig. 1). Definition of this management unit was based on analysis of tagging results and commercial and survey catch distribution (Hunt, 1990). Hunt and Buzeta (1996) reported the status of the stock in 1996.

Cod are taken in 5Zj,m by both Canada and the USA 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.

The Fishery

Canadian landings of Georges Bank cod peaked at about 18,000 t in 1982 and have declined from about 14,000 t in 1990 to 1,100 t in 1995 reflecting the lower TAC (Table 1, Fig. 2). The 1996 Canadian Georges Bank cod fishery was limited to 2,000 t and remained closed until June 6, 1996. The 1996 Canadian Management Plan allocations by fleet sector and reported landings (from Quota reports) are shown below:

Fleet Sector	Allocation	Landings	Percent
Fixed <66'	1283	1219	95
Mobile <65' (ITQ)	591	535	91
Fixed 66 - 100'	18	24	133
Mobile 65 - 100'	30	29	97
Vessels >100'	78	86	110
Total all sectors	**2000**	**1893**	**95**

Between 1978-96, USA landings reached 11,000 t in 1984 , were stable at about 6,000 t until 1993 when a closed area was implemented. Landings in 1994 were 1,229 (2,000t), 665t in 1995 (1,000 t) and 773 t in 1996, where the values in brackets are the estimates used in the 1996 assessment. Almost 100 percent of USA catches in 5Zj,m are taken by otter trawl gear.

Total combined USA and Canada landings for 1996 are shown in (Table 2, Fig. 3). USA landings for 1994 and 1995 were updated to the most recent USA estimates.

Samples of landings and catches (Commercial samples and Observer program) were used to estimate catch at length and age composition for the Canadian fishery. A summary of the number of length and age samples used to estimate catch-at-age is shown in Table 3. About 26,000 length observations and 880 age determinations were available to construct the catch-at-age for 1996 (Table 4). About 20% of trips in 1996 included an Observer and landings were regulated by 100% dockside monitoring. Comparison of 1996 Observer samples with on-shore samples showed little evidence of discarding. Discarding and high grading were reported by some fishermen during pre-assessment meetings but the extent and quantity of discards are uncertain.

Comparisons of age determinations between and within age readers were completed and results indicate good agreement. While the secondary age reader's results were not used in construction of the catch-at-age, they compared favorably with ages produced by the primary age reader. Otolith exchanges between the Canadian and USA labs were made from the 1996 Spring USA survey. Canadian age comparisons were made with otoliths from the 1996 commercial fishery. Results for all comparisons are summarized in Table 5. The overall bias in 1996 is small and negative. The 1995 results showed a bias of similar magnitude but in a positive direction and therefore trends in comparison aging does not apear to be a concern.

Catch-at-age for the reported USA landings in 1994-96 was estimated from USA sampling, rather than prorating the Canadian catch as was done in the last assessment. Ages for USA landings in 5Zj,m were limited and therefore these were supplemented with Canadian age samples (Table 3).

Total removals-at-age, average weight-at-age and average beginning-of-year weight are given in Tables 6 and 7. Overall, the 1992 year-class accounted for about 48% of the catch in numbers. Catch at length and the contribution by agegroups for 1996 is shown in Figures 4 and 5. Mean weights-at-age 3 and the average (1978-96) are shown in Figure 6. Weight-at-age appears to have been variable over the 1978-96 time period and without evidence of trend.

Indices of Abundance

Research Surveys

Hunt et al (1991) describe the approach used to estimate mean catch per tow specific to the 5Zj,m area for Canadian and USA surveys. Only sets within the 5Zj,m area were used with strata area adjusted to conform to the 5Zj,m boundary. Vessel and gear conversion factors, reported by Serchuk *et al* 1994 were used to adjust results of the USA surveys conducted by the *Delaware II* to *Albatross IV* equivalents and to account for a change in trawl doors in 1985. The impact of the vessel conversion factors was reported by Hunt and Buzeta (1996). Some preliminary work to evaluate conversion factors for trawl doors has been completed. Results indicate that reported factors may overestimate the impact of different trawl doors on survey catches but further work is required to more fully assess door conversion effects.

Catch in numbers and weight for the 1997 Canadian survey declined from those observed in 1996. Highest catch rates were in the Canadian zone with relatively small catches west of the International Maritime Boundary. The 1997 distribution pattern was similar to that seen in recent years.

The Canadian survey was initiated in 1986 while the USA surveys started prior to 1978. Results of analysis for each of the surveys are given in Table 8 and Figure 7.

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).

The Canadian surveys show a decline between 1990 and 1995 with a substantial increase in 1996 followed by a decline in 1997. The 1994 USA fall survey catch per

tow has a slight increase from 1993 and remained stable in 1995 and 1996 but a very low level. The 1994 USA spring was the lowest observed but increased in 1995 to the recent average level and remained stable in 1996. The three surveys for ages 3+ in number per tow, adjusted by the estimated catchability (Q's) from recent ADAPT formulations, excluding the USA spring 1982 survey, are shown in Figure 7. In general, all three surveys appear to track year-class strength and provide a consistent index.

Estimates of recruitment at age one from the surveys are shown in Figure 8 as population numbers derived from catch per tow adjusted by catchability factors. Both the 1995 USA fall and 1996 Canadian spring survey indicate an increase in recruitment for the 1995 year-class over the 1993-95 year-classes. However, estimates for the 1995 year-class are less than 25% of the large 1990 and 1985 year-classes and similar to the average 1987 year-class. Recruitment of the 1996 year-class appears to be very low at age 0 in the fall survey and at age 1 in the 1997 Canadian spring survey.

Longline Research Survey

A survey of the Georges Bank area was completed by five longliners in 1995 using a box design with one set in each selected box. Gear was standardized between vessels (number of hooks, hook size, bait, etc) to minimize between vessel variance and boxes were assigned to vessels to achieve a mix of high and low expected catch rates. Catch rates in 1995 were similar to those observed in the commercial fishery.

The survey was repeated in 1996 with a modification to the box design which included the 50 and 100 fm depth contour as a box boundary. Direct comparison with the 1995 results was not possible because of spatial coverage and sampling intensity in 1996 and further interpretation of this index will require additional years of data before trends or changes in stock abundance can be evaluated.

Commercial Fishery Catch Rates

The mobile gear catch rate was used as an index of abundance in the 1995 evaluation of stock status. However, the reduced TAC and bycatch limitations imposed since 1995 preclude use of catch rates. Effort information for the longline fleet was not collected in 1994 and therefore catch rates for this fleet sector are not available.

A summary of landings, effort and catch per day for the mobile, longline and gillnet fleets for 1990-96 is given in Table 9. Estimated total effort (number of fishing days) is calculated from the catch per day and reported landings to account for missing effort data for some trips. For example, only 30% of longline vessels reported effort in 1990 representing 825 fishing days with an average catch of 1.91 t per day. This catch per day was divided into the total reported landings to estimate total fishing days (5202/1.91 = 2724 days). The number of active vessels and total effort in 1995 were less than 50% of the 1990-94 average for all three fleet sectors. In 1996, the addition of about 20 TC 1 longline vessels increased the effort of this gear sector while the gillnet and and mobile gear sectors remained stable.

The number of Canadian vessels, by gear sector, with cod landings for the 1990-96 time period is shown in Figure 9. Overall, the number of vessels declined between

1990 and 1995 with an increase in 1996. Most of the increase in 1996 was due to the addition of about 20 TC1 longline vessels.

ESTIMATION OF STOCK PARAMETERS

The adaptive framework (Gavaris 1988) was used to calibrate the sequential population analysis with the research survey indices of abundance. The integrated formulation used the following data:

$C_{a,y}$ = catch
a=1 to 8, y=1978 to 1996

$I_{1,a,y}$ = USA spring survey
a=1 to 8, y=1978 to 1996

$I_{2,a,y}$ = USA fall survey
a=0 to 4 y=1977 to 1996

$I_{3,a,y}$= Canadian spring survey
a=1 to 8, y=1986 to 1997

The spring survey results were compared to beginning of year population abundance. The fall survey for ages 0-4 was also compared to beginning of year population abundance in year t+1 (ie fall 1977 ages 0-4 compared to 1978 population ages 1-5). Natural mortality was assumed constant and equal to 0.2. The fishing mortality rate on age 8 was calculated as the unweighed average for ages 4 to 6 in the same year. Errors in the catch-at-age were assumed negligible relative to those for the abundance index. The errors for the log transformed abundance index were assumed independent and identically distributed.

A model formulation using *ln* population abundance at the end of the terminal year (beginning of year y = t+1) as parameters was used. Natural log population abundance was used because this parameterization displayed a more "close to linear" behaviour improving performance of the search algorithm. ADAPT was used to solve for the parameters using the techniques described by Gavaris (1993) and Hunt and Buzeta (1994).

Assessment Results

Population estimates derived from the above ADAPT formulation are given in Table 10 and parameter estimates and bias adjustment are given in Table 11. Population parameter estimates have a relative error of 63 to 30% for ages 1 to 8, similar to those seen in the 1996 ADAPT-based analytical assessment. In general, catchabilities for survey indices show a flat topped selection-at-ages 4 and older. Catchabilities were

highest for the Canadian spring survey, followed by the USA survey and the USA fall survey.

Considerable differences in the stock abundance for 1994-96 exist between the present evaluation and the 1996 results given in Hunt and Buzeta (1996). For example, adult biomass for 1994 and 1995 was 17,100t and 18,100t, respectively, in last years' assessment compared to 13,100t and 15,700t from the current analysis. Most of this apparent decrease is a result of the decline in survey indices for the last value in the series, an increased exploitation in 1996 and lower population size at the beginning of 1997. The impact of population size in 1997 influences cohort estimates for earlier years. The revised USA catch-at-age for 1994-96 also accounts for some of the differences.

There appear to be strong year effects in the residuals for survey indices. The 1982 USA spring survey has relatively large positive residuals, and negative residuals predominate in the last several years. The USA fall survey and the Canadian spring survey appear to overestimate population size (positive residuals) (Figs. 10 and 11). However, residuals by age for all three surveys appear to be reasonably well balanced and without trend within cohorts. The relatively high number of positive residuals for USA surveys prior to 1985 may be a function of trawl door conversion factors. As noted above, preliminary analysis of the impact of trawl door conversion has been completed but further work is required before alternative conversion factors can be recommended.

The decline in adult biomass between 1990 and 1994 is substantial and was the lowest observed in 1994 at 13,000 t. However, biomass shows some increase in 1995-97 to about 20,500 t but still well below the long term average of about 30,000 t (Fig. 12). Fishing mortality (Table 10) increased rapidly between 1989 and 1991 and was over three times the $F_{0.1}$ = 0.2 reference level in 1991-93. The decline starting in 1994 is consistent with reduced effort. Fishing mortalities in 1995 and 1996 are below the $F_{0.1}$ reference level. The rate of exploitation for the stock has been over 30% for most of the time series, above 40% in 1991-93, about 32% in 1994, 8% in 1995 and increased to about 13% in 1996. (Fig. 13).

The reduced exploitation in 1995 and 1996 has resulted in improved survival of the 1992 year-class and increased the relative contribution of ages 5 and older in the 1997. The higher mean weight-at-age associated with these older fish has a substantial impact on stock biomass but reflects growth rather than recruitment.

Recruitment since the 1990 year-class has been well below average and the 1994 year-class will contribute very little to the stock. Estimates for the 1995 year-class show some improvement to about the recent average recruitment, but early indications for the 1996 year-class show very poor recruitment prospects (Fig. 12 and Table 10).

Retrospective Analysis

To evaluate potential retrospective patterns in population estimates, ADAPT formulations were run using the same model as described above. Research survey indices and catch-at-age were used starting with 1992 and sucessively adding an additional years' data for subsequent runs. The derived estimates of population

numbers-at-age 2 for the 1987-94 year-classes were used to assess trends. Results are shown in Figure 14.

Typically, a retrospective pattern results in overly optimistic estimates for a year-class in the first year with a decline as additional data are added to the model. However, in this analysis the reverse appears to be evident for the 1991-94 year-classes with the terminal year having the highest estimate of abundance. Other year-classes do not show substantial evidence of trend. The impact of shortening the Canadian spring survey index time series in this type of analysis may be the main contributing factor rather than a model bias in the ADAPT formulation.

Yield Per Recruit Analysis

A yield per recruit analysis was completed using average mean weight-at-ages 1-15 and partial recruitment reflecting the recent trend in the fishery. Results are shown below:

Age	Weight (kg)	Partial Recruitment
1	0.951	0.001
2	1.623	0.200
3	2.465	0.700
4	3.453	1.000
5	4.562	1.000
6	5.757	1.000
7	7.042	1.000
8	8.366	1.000
9	9.716	1.000
10	11.077	1.000
11	12.431	1.000
12	13.768	1.000
13	15.076	1.000
14	16.347	1.000
15	17.575	1.000

NATURAL MORTALITY RATE : 0.2
$F_{0.1}$ COMPUTED AS **0.1941** AT Y/R OF 1.5443
F_{MAX} COMPUTED AS 0.3992 AT Y/R OF 1.6791

and indicate an $F_{0.1}$ fishing mortality of 0.1941 and very close to the value of 0.2 used in previous assessments. Therefore no adjustment was made from $F_{0.1} = 0.2$ for yield projections.

Prognosis

Catch projections were completed using the bias-adjusted beginning of year population abundance for 1997 derived from ADAPT. Partial recruitment was derived from the 1994-96 fishing mortality matrix, to reflect possible changes in PR associated with both gear and season. Mean (fishery) and beginning of year weights-at-age used were the 1994-96 average. Recruitment for 1997 age one was set to 0.746 million, the value from ADAPT, and to 5.2 million for 1998, the 1990-96 geometric mean. Input for the catch projection is shown below:

Age Group	Population Numbers in 1997	Mean Weight-at-age in the fishery	1991-96 Mean Partial Recruitment
1	746	1.00	0.01
2	4152	1.54	0.19
3	863	2.43	0.71
4	1250	3.54	1.00
5	1826	4.87	1.00
6	608	6.29	1.00
7	465	7.97	1.00
8	83	9.46	1.00
9+	22	10.70	1.00

The **combined** Canada and USA $F_{0.1}$ catch in 1997 is estimated to be about 4,000 t and details of the projection are given in Table 11. There is about a 20% relative error associated with the projected catch. Fishing at the $F_{0.1}$ reference level in 1997 is projected to result in an increase adult stock biomass from 21,000 t 1997 to 24,000 t in 1998. The 1992 year-class-at-age 5 is expected to account for about 36% of the catch biomass in 1997. Yield and biomass projections at a range of exploitation rates are shown in Figure 15. Only a small increase above the $F_{0.1}$ reference yield will result in zero biomass increase in 1997 and even with zero yield in 1996 the 1997 biomass would increase by about only 4,000t Given the very low spawning stock biomass in 1997 (21,000 t compared to the longterm average of 32,000 t) and low levels of recruitment since 1990, a stock rebuilding strategy should be considered.

Uncertainty associated with the yield projection indicates that even at $F_{0.1}$ there is a 45% probability that the adult biomass will decrease in 1997. A yield of about 3,000t in 1997 reduces this probability to about 20%. It is also important to note that even small increases in yield above the $F_{0.1}$ level substantially increases the chances that biomass in 1997 will decline. Results are shown in Figure 16.

Adult biomass levels and subsequent **recruitment abundance**-at-age 1 is compared in Figure 17 for the 1978-97 time period. Recruits appear to have a positive correlation with biomass and the probability of good recruitment increases at higher biomass levels. The projected 1997 adult biomass of 21,000 t is below but close to the stock size at which improved recruitment would be expected to occur. Rebuilding to increase the adult biomass above the projected 1997 level would enhance the prospects for the furture.

Comparison of Assessment Results in 5Zj,m and 5Z for Georges Bank Cod

The USA defines a management unit encompassing the entire NAFO Division 5Z (small amounts of cod caught in NAFO Subarea 6 are included). Canada conducts fisheries for cod in the Eastern area of Georges Bank and is concerned with regulatory measures which could be applied to it in order to achieve benefits. Accordingly, Canada defines unit areas 5Zj and 5Zm as a management unit.

Stock evaluation of the 5Z area was recently completed and comparison of trends in population with those in the 5Zj,m area is now possible

Recent management measures including Canadian TACs, year round USA closed areas, increases in regulated mesh size and effort control strategies have resulted in reduced F and some improvement in stock biomass. However, continuing low recruitment in both the 5Zj,m and total 5Z areas have limited recovery of the stock.

Catches in 1978-96 from 5Zj,m averaged about 44% of the total catches from 5Z (Fig. 18), ranging between 59% and 22%. Since 1994, when the USA introduced a closed area in 5Zj,m, catches from 5Zj,m have averaged 26% of the total catches from 5Z. The total biomass showed a similar pattern between the two management units (Fig. 19). The adult biomass in 5Z declined from about 100,000 t in the late 1970's to 26,000 t in 1994 but has since increased to 44,000 t in 1997. Adult biomass in the 5Zj,m area ranged between 43,000 t and 13,000 t and was 21,000 t in 1997. The 5Zj,m area accounts for 40-60% of the total 5Z adult biomass.

Recruitment patterns in the two areas have been similar (Fig 20). The 1985 and 1980 year-classes were the most abundant followed by the 1983 and 1987 cohorts. Since 1990, recruitment has been below average in both areas. The 1995 year-class appears to be more abundant than the 1991-94 while the 1996 year-class is well below average.

The fishing mortality rates showed a similar trend of increase since the late 1970s and were above 1.0 in 1993. Substantial reductions in TAC in the 5Zj,m area and reduced effort by the USA have lowered the F to below the $F_{0.1}$ level in 1996 (Fig. 21). Since 1994, the fishing mortality rates for both 5Zj,m and all of 5Z have a similar trend but are somewhat higher in the 5Z area.

Population trends between the 5Zj,m and 5Z area have remained relatively consistent over the 1978 to present time. This implies some measure of stability in the geographic distribution of the stock and the potential for effective management within the 5Zj,m area.

Acknowledgements

We thank the numerous individuals who contributed to the analysis and in particular the many fishermen who provided valuable insights on the Georges Bank fishery. In particular, Mr. Peter VanBuskurk, a Georges Bank gillnet fisherman who assisted in the 1997 research survey. Mr. Don Clark (MFD, Gulf of Maine Section) provided useful suggestions for improvements to an earlier version of the document.

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Table 1. Nominal landings(t) of cod by gear and month for Canada in unit areas 5Zj,m.(OT-ottertrawl; 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**

Table .1 Continued

YEAR	GEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
90	OT	0	0	0	0	1	3187	1744	1547	929	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**
91	OT	348	33	22	1	0	3455	1536	672	316	296	14	6	6698
	GN	0	0	0	0	17	427	696	364	163	20	0	0	1688
	LL	49	335	187	230	202	597	1028	860	699	363	113	43	4706
	MISC	8	8	7	25	15	59	71	104	51	6	9	0	363
	TOT	405	376	216	256	234	4538	3331	2000	1229	685	136	49	**13455**
92	OT	261	375	0	1	12	2835	972	287	214	541	132	9	5638
	GN	0	0	0	0	1	294	350	342	203	26	2	0	1217
	LL	114	340	475	275	237	799	676	612	509	337	101	0	4474
	MISC	9	13	19	21	24	141	75	47	0	4	8	1	383
	TOT	384	726	494	296	274	4068	2073	1287	945	909	243	10	**11712**
93	OT	826	998	77	380	0	1203	590	162	123	237	178	114	4890
	GN	0	0	0	0	0	287	367	261	212	48	0	0	1175
	LL	4	30	166	76	148	422	515	462	261	122	118	63	2387
	MISC	9	4	10	14	17	4	5	1	0	1	2	0	67
	TOT	839	1032	253	470	165	1916	1477	886	596	408	298	177	**8519**
94	OT	0	0	0	0	0	777	410	115	128	263	117	83	1893
	GN	0	0	0	0	0	133	539	243	97	19	0	0	1031
	LL	0	0	0	0	0	409	481	869	492	5	30	0	2287
	MISC	7	7	10	14	9	6	4	2	0	1	3	1	66
	TOT	7	7	10	14	9	1327	1434	1229	717	288	150	84	**5276**
95	OT	0	0	0	0	0	100	62	57	82	25	41	27	395
	GN	0	0	0	0	0	17	39	0	70	0	0	0	126
	LL	0	0	0	0	0	116	161	122	98	20	20	7	544
	MISC	1	4	4	5	4	5	8	3	1	0	0	0	35
	TOT	1	4	4	5	4	238	271	182	251	45	61	34	**1100**
96	OT	0	0	0	0	0	217	96	100	58	42	40	103	656
	GN	0	0	0	0	0	26	137	81	0	0	0	0	245
	LL	0	0	0	0	0	29	381	269	81	137	65	21	984
	MISC	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOT	0	0	0	0	0	272	614	450	139	179	105	124	**1885**

Table 2.Summary of total catches (t) by Canada and the USA in unit areas 5Zj,m for 1978-1995. USA catches for 1994, 1995 and 1996 since last year's document.

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
1991	13455	6777	20232
1992	11712	5080	16792
1993	8519	4019	12538
1994	5277	1229	6505
1995	1100	665	1765
1996	1885	773	2658

Table 3. Canadian and USA commercial landings samples for 1978-95. Canadian 1994 and 1995 lengths include IOP samples. Sampling data for USA in 1994 and 1995 are updated to the most recent available samples.

	USA			Canada		
	Samples	Lengths	Ages	Samples	Lengths	Ages
1978	29	2047	385	29	7684	1308
79	21	1833	402	13	3991	656
1980	16	1258	286	10	2784	536
81	21	1615	456	17	4147	842
82	45	4111	778	17	4756	858
83	40	3775	903	15	3822	604
84	44	3891	1130	7	1889	385
85	23	2076	597	18	7644	1062
86	27	2145	644	19	5745	888
87	23	1865	525	33	9477	1288
88	37	3229	797	43	11709	1984
89	19	1572	251	32	8716	1561
1990	28	1989	287	40	9901	2012
91	23	1894	397	45	10873	1782
92	25	2048	445	48	10878	1906
93	29	2215	440	51	12158	2146
94	13	1323	260	104	25845	1268
95	0	0	0	36	11598	548
96	3	284	74	129	26663	879

Table 4. Summary of Canadian commercial and IOP samples used to estimate catch-at-age.

GEAR	MONTH	TONS by Month	#LEN	#AGES	TONS by Quarter
OTB+Misc	Jan				
	Feb				
	Mar				0
	Apr				
	May				
	Jun	217	5693	253	217
	Jul	96	1375	31	
	Aug	100	1955	109	
	Sep	58	563	33	254
	Oct	42	1089		
	Nov	40	221		
	Dec	103	367	35	185
Total Canadian		657	11263	461	
Longline	Jan				
	Feb				
	Mar				0
	Apr				
	May				
	Jun	29	374		29
	Jul	381	3721	88	
	Aug	269	2483	51	
	Sep	81	1252		731
	Oct	137	3334	105	
	Nov	65	271	49	
	Dec	21			224
Total		984	11435	293	
Gillnet	Jan				
	Feb				
	Mar				0
	Apr				
	May				
	Jun	26	640		26
	Jul	137	1351	41	
	Aug	81	1974	84	
	Sep				219
	Oct				
	Nov				
	Dec				0
Total		245	3965	125	
Age Keys	Q1		0	0	0
	Q2		6707	253	272
	Q3		14674	437	1204
	Q4		5282	189	409
TOTAL Canada		1885	26663	879	**1885**

USA catch-at-age for 1994-96 USA landings was provided by the USA, and based on commercial landings samples prorated by market category.

Table 5. 1996 age comparisons and precision tests.
a)results of the spring (Albatross 9604) otolith exchange between Canada and USA.

	USA Ager							
1ry Can Ager	2	3	4	5	6	7	8	Total
2	3							3
3	1	13						14
4		5	14					19
5				3				3
6				1	7			8
7						1		1
8							1	1
blank	1							1
Total	5	18	14	4	7	1	1	50
%Agreement								86
CV								2.9

b) precision test for the Canadian age reader. Samples are from the 1996 Canadian commercial fishery.

	2nd Age											
1st Age	1	2	3	4	5	6	7	8	9	11	blank	Total
1		1										1
2		5	1									6
3			5	2								7
4				13	2							15
5					5	2					1	8
6						6						6
7						1	4	1	1			7
8								1				1
9	1							1	2			4
blank		1							1	1	1	4
Total	1	7	6	15	7	9	4	3	4	1	2	59
%Agreement												76
CV												6.16

c) comparison tests between the two Canadian age readers(no production aging is done by the secondary Canadian age reader). Samples are from i) Albatross 9604, and ii) Canadian 1996 commercial fishery.

i)	2ry Can Ager							
1ry Can Ager	2	3	4	5	6	7	8	Total
2	1	2						3
3		11	3					14
4		1	18					19
5				3				3
6					7	1		8
7						1		1
8							1	1
blank		1						1
Total	1	15	21	3	7	2	1	50
%Agreement								84
CV								3.03

ii)	2ry Can Ager									
1ry Can Ager	2	3	4	5	6	7	8	9	10	Total
1		1								1
2	3	3								6
3		4	3							7
4			13	1	1					15
5			1	4	3					8
6					4	2				6
7					1	4	1		1	7
8						1				1
9								2	2	4
blank	1						1	1	1	4
Total	4	8	17	5	9	7	2	3	4	59
%Agreement										62
CV										7.38

Table 6 . Commercial fishery catch-at-age for combined Canada and USA fishery

Age

Numbers

Year	1	2	3	4	5	6	7	8	total
78	2	121	3588	1076	307	110	83	21	5308
79	10	814	399	1774	545	149	22	45	3758
80	1	987	1495	265	916	345	109	20	4138
81	19	603	1443	1249	155	595	169	65	4298
82	6	2682	1686	1429	1066	189	345	157	7560
83	40	1319	3416	1474	466	283	31	71	7100
84	10	269	911	1346	511	290	230	31	3598
85	12	2792	1221	631	941	224	96	100	6017
86	28	326	2188	513	304	400	58	39	3856
87	14	3666	865	1099	144	121	167	37	6113
88	10	320	3653	646	861	144	102	143	5879
89	1	740	652	1837	193	314	56	25	3818
90	7	678	3196	962	1195	116	122	10	6286
91	11	626	783	1939	953	790	93	56	5251
92	86	2358	1251	432	908	250	233	25	5543
93	4	414	1967	809	215	332	110	93	3944
94	2	182	486	751	246	41	59	26	1799
95	0	56	235	120	89	14	4	3	522
96	1	39	231	386	75	47	11	3	792

Age

Percent

Year	1	2	3	4	5	6	7	8
78	0.0	2.3	67.6	20.3	5.8	2.1	1.6	0.4
79	0.3	21.7	10.6	47.2	14.5	4.0	0.6	1.2
80	0.0	23.9	36.1	6.4	22.1	8.3	2.6	0.5
81	0.4	14.0	33.6	29.1	3.6	13.8	3.9	1.5
82	0.1	35.5	22.3	18.9	14.1	2.5	4.6	2.1
83	0.6	18.6	48.1	20.8	6.6	4.0	0.4	1.0
84	0.3	7.5	25.3	37.4	14.2	8.1	6.4	0.9
85	0.2	46.4	20.3	10.5	15.6	3.7	1.6	1.7
86	0.7	8.5	56.7	13.3	7.9	10.4	1.5	1.0
87	0.2	60.0	14.2	18.0	2.4	2.0	2.7	0.6
88	0.2	5.4	62.1	11.0	14.6	2.4	1.7	2.4
89	0.0	19.4	17.1	48.1	5.1	8.2	1.5	0.7
90	0.1	10.8	50.8	15.3	19.0	1.8	1.9	0.2
91	0.2	11.9	14.9	36.9	18.1	15.0	1.8	1.1
92	1.6	42.5	22.6	7.8	16.4	4.5	4.2	0.5
93	0.1	10.5	49.9	20.5	5.5	8.4	2.8	2.4
94	0.1	10.1	27.1	41.9	13.7	2.3	3.3	1.4
95	0.0	10.7	45.1	23.0	17.1	2.8	0.8	0.6
96	0.1	4.9	29.2	48.7	9.5	5.9	1.4	0.3

Table 7. Beginning of year and mid-year mean weight-at-age.

Mid-year

Year	Age 1	2	3	4	5	6	7	8
78	0.71	1.31	2.46	3.47	4.34	5.79	7.37	8.49
79	0.89	1.49	2.15	4.21	4.89	7.18	9.18	10.31
80	0.84	1.46	2.47	3.67	5.65	6.68	8.39	9.09
81	0.88	1.50	2.36	3.42	5.21	7.22	8.57	9.89
82	0.77	1.40	2.66	3.83	5.35	6.51	9.36	9.90
83	0.97	1.49	2.38	3.31	4.64	6.39	7.96	10.29
84	1.05	1.64	2.45	3.62	5.08	6.58	8.91	10.10
85	0.91	1.42	2.09	3.89	5.09	6.41	8.10	10.24
86	0.93	1.48	2.45	3.66	5.60	7.19	8.92	9.96
87	0.73	1.48	2.50	4.19	5.81	7.73	8.95	10.01
88	0.79	1.52	2.36	3.51	5.40	6.65	8.78	9.99
89	0.81	1.62	2.27	3.77	5.40	6.69	8.22	10.72
90	0.83	1.56	2.46	3.52	4.89	6.33	8.46	10.65
91	1.11	1.63	2.55	3.42	4.77	5.89	7.41	10.52
92	1.15	1.54	2.46	3.84	4.70	6.16	7.51	9.85
93	0.88	1.57	2.31	3.08	4.50	5.73	7.08	8.88
94	0.91	1.46	2.41	3.83	4.80	7.09	7.86	8.93
95	0.90	1.49	2.51	3.72	5.22	6.52	11.06	10.12
96	1.03	1.54	2.36	3.34	5.24	6.36	6.92	8.46
78-96	0.90	1.50	2.40	3.65	5.08	6.58	8.37	9.81
94-96	1.00	1.54	2.43	3.54	4.87	6.29	7.97	9.46

Beginning of year

	1	2	3	4	5	6	7	8	9
78	0.49	0.96	1.80	2.92	3.88	5.01	6.53	7.91	9.11
79	0.69	1.03	1.68	3.22	4.12	5.58	7.29	8.72	9.11
80	0.63	1.14	1.92	2.81	4.88	5.71	7.76	9.14	12.20
81	0.70	1.12	1.86	2.90	4.37	6.39	7.56	9.11	9.04
82	0.55	1.11	2.00	3.01	4.28	5.83	8.22	9.21	10.73
83	0.75	1.07	1.83	2.97	4.22	5.85	7.20	9.81	10.64
84	0.91	1.26	1.91	2.93	4.10	5.52	7.55	8.97	10.78
85	0.71	1.22	1.85	3.09	4.29	5.71	7.30	9.55	11.38
86	0.74	1.16	1.86	2.76	4.67	6.05	7.56	8.98	10.97
87	0.50	1.17	1.92	3.20	4.61	6.58	8.02	9.45	11.04
88	0.55	1.05	1.87	2.96	4.76	6.21	8.23	9.45	10.61
89	0.58	1.13	1.86	2.98	4.35	6.01	7.39	9.70	10.55
90	0.59	1.12	2.00	2.83	4.30	5.85	7.52	9.36	11.84
91	0.95	1.16	1.99	2.90	4.10	5.37	6.85	9.43	12.12
92	0.98	1.31	2.00	3.13	4.01	5.42	6.65	8.54	11.73
93	0.69	1.34	1.89	2.75	4.16	5.19	6.60	8.17	11.35
94	0.71	1.13	1.95	2.97	3.85	5.65	6.71	7.95	9.66
95	0.71	1.16	1.91	2.99	4.47	5.60	8.85	8.92	10.04
96	0.70	1.21	1.91	2.91	4.16	5.48	7.39	8.35	10.35
97	0.70	1.21	1.91	2.91	4.16	5.48	7.39	8.35	10.35
78-96	0.69	1.15	1.89	2.96	4.29	5.74	7.43	8.98	10.70
94-96	0.75	1.23	1.93	2.94	4.13	5.47	7.27	8.38	10.58

Table 8. Survey indices of abundance (catch per tow) adjusted for vessel and door conversions.

Spring Can	1	2	3	4	5	6	7	8
86	1.78	8.19	7.41	0.77	1.6	1.03	0.51	0.08
87	0.12	4.31	1.55	1.81	0.39	0.21	0.44	0.21
88	0.36	1.08	12.85	1.36	2.02	0.23	0.19	0.43
89	0.84	5.22	1.84	4.11	0.62	0.8	0.1	0.2
90	0.25	1.91	8.36	4.7	10.6	1.29	2.63	0.35
91	2.83	2.43	3.4	3.93	2.06	2.87	0.36	0.6
92	0.11	4.93	2.94	0.99	1.55	1.09	0.72	0.22
93	0.07	0.85	4.15	1.5	0.89	1.82	0.66	0.64
94	0.03	1.51	1.66	3.1	1.15	0.44	0.88	0.2
95	0.08	0.45	2.99	1.82	1.25	0.45	0.11	0.16
96	0.22	0.49	4.2	10.44	3.45	2.49	1.07	0.26
97	0.07	0.9	1.37	3.19	3.04	0.52	0.12	0.08

Fall USA	1	2	3	4	5
78	0.1	0	6.31	1.26	0.35
79	0.21	2.64	0.26	5.1	0.73
80	0.32	2.96	2.93	0.21	2.71
81	0.6	1.43	0.76	1.21	0.05
82	0.6	4.24	2.19	1.69	0.48
83	0	1.05	1.29	0.08	0.12
84	1.47	0.12	0.42	0.89	0.05
85	0.06	2.84	0.14	1.03	1.68
86	2.24	0.39	1.8	0.3	0.03
87	0.22	5.2	0.11	0.35	0
88	0.29	0.24	1.53	0.23	0.19
89	0.18	1.02	0.33	2.13	0.25
90	0.41	0.72	1.68	0.28	0.77
91	0.36	0.72	0.79	1.49	0.21
92	0	0.36	0.13	0.16	0.02
93	0	0.37	1.31	0.28	0
94	0	0.14	0.19	0.28	0.03
95	0.02	0.14	0.54	0.39	0.28
96	0.4	0.05	0.22	0.54	0.12
97	0.02	0.56	0.15	0.56	0.41

Spring USA	1	2	3	4	5	6	7	8
78	0.27	0	5.1	1.12	1.61	0.34	1.37	0.19
79	0.69	2.65	0.22	2.57	1	0.34	0.17	0.22
80	0.03	2.96	2.9	0.28	3.01	0.59	0.12	0.08
81	1.7	1.57	2.43	1.73	0.07	0.6	0.31	0.12
82	0.79	11.58	24.99	22.29	16.98	0	5.55	1.24
83	0.69	3.63	6.33	1.36	1.06	0.66	0.28	0.11
84	0.2	0.22	0.81	1.22	0.48	0.39	0.34	0
85	0.08	3.67	1.15	1.92	2.75	0.6	0.35	0.45
86	1.13	0.62	2.05	0.55	0.78	0.98	0.05	0.21
87	0	2.17	0.46	0.98	0	0.34	0.28	0.06
88	0.58	0.45	5.05	0.5	0.84	0.08	0.03	0.14
89	0.21	1.55	0.47	2.39	0.46	0.54	0.07	0.06
90	0.13	0.62	3.14	1.09	1.18	0.29	0.3	0.03
91	1.31	1.12	0.92	1.63	0.83	0.69	0.08	0.03
92	0.14	1.2	0.65	0.17	0.45	0.27	0.29	0.05
93	0	0.83	2.32	0.47	0.08	0.33	0.08	0.08
94	0.1	0.37	0.29	0.36	0.09	0.02	0.06	0
95	0.09	0.52	1.64	0.88	1.63	0.35	0.47	0.06
96	0.25	0.54	1.78	2.41	0.22	0.17	0.05	0

Table 9. Summary of landings and effort data by gear sector for Georges Bank cod (value in brackets for effort is the calculated value of total landings divided by landings per day)

	Mobile	Gillnet	Longline
1990 Total	7854	910	5202
Total with effort	7285	534	1579
Boats	176	14	103
Percent with effort	92.7	58.7	30.4
Effort (fish_days)	3837(4133)	215(367)	825(2724)
Landings per day	1.90	2.48	1.91
1991 Total	6698	1688	4706
Total with effort	6395	1084	1581
Boats	188	26	118
Percent with effort	95.5	64.2	33.6
Effort (fish_days)	3769(3940)	308(480)	849(2530)
Landings per day	1.70	3.52	1.86
1992 Total	5638	1217	4474
Total with effort	5583	684	1893
Boats	138	19	130
Percent with effort	99.0	56.2	42.3
Effort (fish_days)	2051(2073)	389(691)	1076(2542)
Landings per day	2.72	1.76	1.76
1993 Total	4890	1175	2387
Total with effort	4877	943	1179
Boats	125	20	135
Percent with effort	99.7	80.3	49.4
Effort (fish_days)	2377(2385)	635(789)	1377(2776)
Landings per day	2.05	1.49	0.86
1994 Total	1893	1031	2287
Total with effort	1886	79	73
Boats	95	21	78
Percent with effort	99.6	7.7	3.2
Effort (fish_days)	1926(1932)	-	-
Landings per day	0.98	-	-
1995 Total	313	123	505
Total with effort	313	116	494
Boats	64	11	49
Percent with effort	99.9	94.3	97.8
Effort (fish_days)	506(506)	202(216)	522(532)
Landings per day	0.62	0.57	0.95
1996 Total	656	245	984
Total with effort	656	245	984
Boats	76	10	102
Percent with effort	100.0	100.0	100.0
Effort (fish_days)	1082	111	852
Landings per day	0.61	2.21	1.15

Table 10. Population estimates derived from ADAPT.

Numbers

	1	2	3	4	5	6	7	8	9	1+	3+
78	11292	2208	10307	3533	1071	247	280	60	0	28998	15498
79	9275	9243	1699	5223	1927	602	104	155	30	28258	9740
80	9084	7584	6834	1032	2686	1089	359	65	86	28819	12151
81	17149	7437	5320	4251	607	1378	582	196	36	36956	12370
82	6257	14023	5545	3060	2359	358	596	325	102	32625	12345
83	4506	5118	9068	3027	1230	979	124	182	126	24360	14736
84	13397	3653	3005	4365	1163	589	548	74	85	26879	9829
85	4496	10959	2748	1643	2366	496	224	243	33	23208	7753
86	21268	3670	6464	1159	780	1095	206	97	109	34848	9910
87	7109	17388	2711	3331	491	367	539	116	45	32097	7600
88	13583	5807	10939	1444	1742	273	192	291	62	34333	14943
89	3823	11111	4466	5681	605	658	95	66	111	26616	11682
90	5502	3129	8430	3069	3003	322	259	28	32	23774	15143
91	9769	4499	1952	4040	1650	1390	160	103	14	23577	9309
92	3524	7988	3119	898	1577	504	435	48	34	18127	6615
93	5473	2808	4424	1435	349	484	189	149	17	15328	7047
94	2734	4477	1926	1864	455	95	103	57	39	11750	4539
95	1340	2237	3501	1140	854	153	41	32	24	9322	5745
96	5073	1097	1781	2654	825	619	113	30	23	12215	6045
97	746	4152	863	1250	1826	608	465	83	22	10015	5117

Beginning of year population biomass

										1+	3+
78	5492	2125	18506	10323	4154	1237	1829	475	0	44141	36524
79	6434	9499	2851	16814	7935	3358	758	1352	273	49275	33341
80	5679	8640	13123	2897	13098	6221	2786	594	1049	54087	39768
81	11997	8314	9871	12341	2654	8800	4401	1785	326	60489	40178
82	3430	15594	11066	9201	10085	2086	4901	2992	1095	60449	41426
83	3372	5464	16554	8987	5186	5727	893	1786	1340	49309	40473
84	12157	4603	5743	12802	4770	3254	4136	664	916	49044	32285
85	3198	13391	5075	5071	10152	2832	1635	2321	376	44050	27461
86	15648	4245	12041	3202	3640	6623	1557	871	1196	49024	29130
87	3567	20396	5201	10662	2264	2415	4324	1096	497	50421	26458
88	7443	6100	20447	4274	8284	1697	1581	2751	658	53234	39691
89	2227	12526	8294	16946	2633	3956	702	640	1171	49097	34343
90	3268	3515	16820	8676	12900	1882	1949	262	379	49650	42868
91	9250	5231	3892	11723	6762	7462	1096	971	170	46557	32076
92	3458	10469	6245	2810	6325	2731	2893	410	399	35741	21813
93	3762	3771	8346	3953	1451	2513	1247	1217	193	26452	18919
94	1932	5078	3747	5542	1750	536	691	453	377	20107	13096
95	947	2598	6691	3414	3820	856	363	285	241	19216	15671
96	3553	1331	3409	7716	3431	3391	835	250	238	24154	19271
97	522	5036	1652	3634	7594	3331	3436	693	228	26125	20567
98											24945

Fishing Mortality	1	2	3	4	5	6	7	8	1+	3+	Exploitation Rate 3+
78	0	0.062	0.480	0.406	0.377	0.665	0.393	0.483	0.25	0.46	0.34
79	0.001	0.102	0.298	0.465	0.371	0.317	0.264	0.384	0.17	0.40	0.30
80	0	0.155	0.275	0.331	0.467	0.427	0.405	0.408	0.18	0.34	0.26
81	0.001	0.094	0.353	0.389	0.329	0.638	0.383	0.452	0.15	0.40	0.30
82	0.001	0.236	0.405	0.712	0.679	0.856	0.989	0.749	0.32	0.59	0.41
83	0.010	0.332	0.531	0.756	0.535	0.381	0.319	0.558	0.41	0.57	0.40
84	0.001	0.085	0.404	0.412	0.653	0.768	0.614	0.611	0.18	0.47	0.34
85	0.003	0.328	0.663	0.545	0.570	0.679	0.631	0.598	0.36	0.61	0.42
86	0.001	0.103	0.463	0.66	0.555	0.510	0.370	0.575	0.15	0.50	0.36
87	0.002	0.263	0.43	0.448	0.388	0.449	0.415	0.428	0.25	0.44	0.32
88	0.001	0.063	0.455	0.670	0.773	0.855	0.865	0.766	0.24	0.53	0.38
89	0	0.076	0.175	0.437	0.430	0.734	1.023	0.534	0.19	0.36	0.27
90	0.001	0.272	0.536	0.421	0.571	0.501	0.722	0.498	0.37	0.52	0.37
91	0.001	0.166	0.577	0.741	0.987	0.961	1	0.896	0.34	0.79	0.50
92	0.027	0.391	0.577	0.743	0.981	0.778	0.873	0.834	0.44	0.73	0.48
93	0.001	0.177	0.664	0.948	1.099	1.348	0.996	1.129	0.40	0.81	0.51
94	0.001	0.046	0.324	0.580	0.887	0.634	0.974	0.683	0.21	0.51	0.37
95	0	0.028	0.077	0.123	0.122	0.106	0.112	0.11	0.06	0.09	0.08
96	0	0.040	0.154	0.174	0.105	0.087	0.113	0.115	0.08	0.15	0.13

Table 11. Parameter estimates derived from ADAPT.

	PAR.EST.	STD.ERR.	REL.ERR.	BIAS	REL.BIAS
Terminal year class abundance at January 1, 1997					
1	933	586	0.63	186	0.20
2	4519	1796	0.40	367	0.08
3	912	295	0.32	48	0.05
4	1312	418	0.32	63	0.05
5	1909	573	0.30	83	0.04
6	637	201	0.31	29	0.05
7	494	180	0.36	29	0.06
8	89	38	0.42	7	0.07
Canada					
1	-1.001E1	2.593E-1	-2.592E-2	-3.411E-3	3.409E-4
2	-7.832E0	2.531E-1	-3.232E-2	-3.209E-3	4.098E-4
3	-6.899E0	2.510E-1	-3.638E-2	-2.899E-3	4.202E-4
4	6.719E0	2.507E-1	-3.731E-2	-2.143E-3	3.189E-4
5	-6.395E0	2.513E-1	-3.929E-2	-1.195E-3	1.869E-4
6	6.300E0	2.529E-1	-4.014E-2	1.310E-3	-2.080E-4
7	-6.113E0	2.537E-1	-4.150E-2	3.582E-3	-5.860E-4
8	-5.734E0	2.541E-1	-4.431E-2	6.219E-3	-1.085E-3
US Fall					
1	-1.024E1	2.198E-1	-2.146E-2	-1.205E-3	1.176E-4
2	-9.035E0	1.992E-1	-2.204E-2	-2.027E-3	2.243E-4
3	8.766E0	1.929E-1	-2.201E-2	-1.739E-3	1.984E-4
4	-8.352E0	1.928E-1	-2.309E-2	-1.285E-3	1.539E-4
5	-8.772E0	2.036E-1	-2.321E-2	-9.296E-4	1.060E-4
US Spring					
1	-1.007E1	2.103E-1	-2.089E-2	-1.838E-3	1.825E-4
2	-8.437E0	2.033E-1	-2.410E-2	-2.010E-3	2.382E-4
3	-7.860E0	1.972E-1	-2.508E-2	-1.782E-3	2.267E-4
4	-7.683E0	1.971E-1	-2.565E-2	-1.519E-3	1.977E-4
5	-7.406E0	2.029E-1	-2.740E-2	-8.723E-4	1.178E-4
6	-7.345E0	2.036E-1	-2.771E-2	6.230E-4	-8.482E-5
7	-6.995E0	1.977E-1	-2.826E-2	1.871E-3	-2.675E-4
8	-6.854E0	2.137E-1	-3.118E-2	1.838E-3	-2.681E-4

Table 12. Catch Projection results

Population Numbers

	1	2	3	4	5	6	7	8	9
97	746	4152	863	1250	1826	608	465	83	22
98	5200	611	3273	613	838	1224	408	311	55

Fishing Mortality

	1	2	3	4	5	6	7	8
97	0.000	0.038	0.142	0.200	0.200	0.200	0.200	0.200

PRF

	1	2	3	4	5	6	7	8
97	0.00	0.19	0.71	1.00	1.00	1.00	1.00	1.00

Beginning of Year Weights

	1	2	3	4	5	6	7	8	9
97	0.75	1.23	1.93	2.94	4.13	5.47	7.27	8.38	10.58
98	0.75	1.23	1.93	2.94	4.13	5.47	7.27	8.38	10.58

Projected Population Biomass

	1	2	3	4	5	6	7	8	9	1+	2+	3+	4+
97	558	5103	1665	3680	7547	3325	3376	692	234	26179	25621	20518	18853
98	3884	751	6313	1805	3463	6691	2962	2609	586	29065	25180	24430	18116

Projected Catch Numbers

	1	2	3	4	5	6	7	8
97	0	140	104	206	301	100	77	14
98								

Mid Year Weights 1991-96 average

	1	2	3	4	5	6	7	8
97	1.00	1.54	2.43	3.54	4.87	6.29	7.97	9.46

Projected Catch Biomass

	1	2	3	4	5	6	7	8	1+	2+	3+	4+
97	0	216	252	729	1466	631	610	129	4033	4033	3818	3565

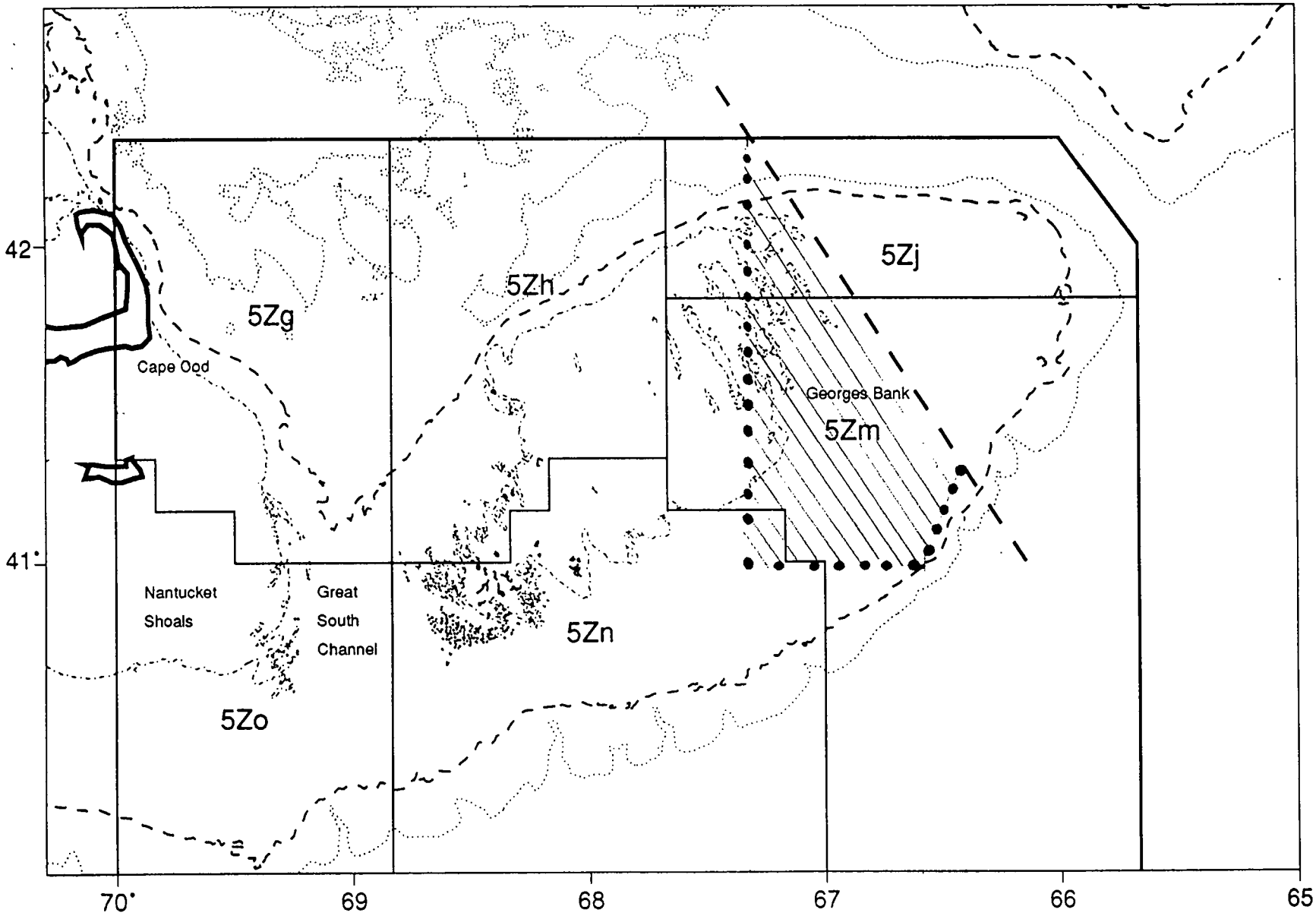


Fig. 1. Canadian fisheries statistical unit areas in NAFO Division 5Z.

Figure 2. Landings of 5Zj,m cod by gear type for Canadian fisheries.

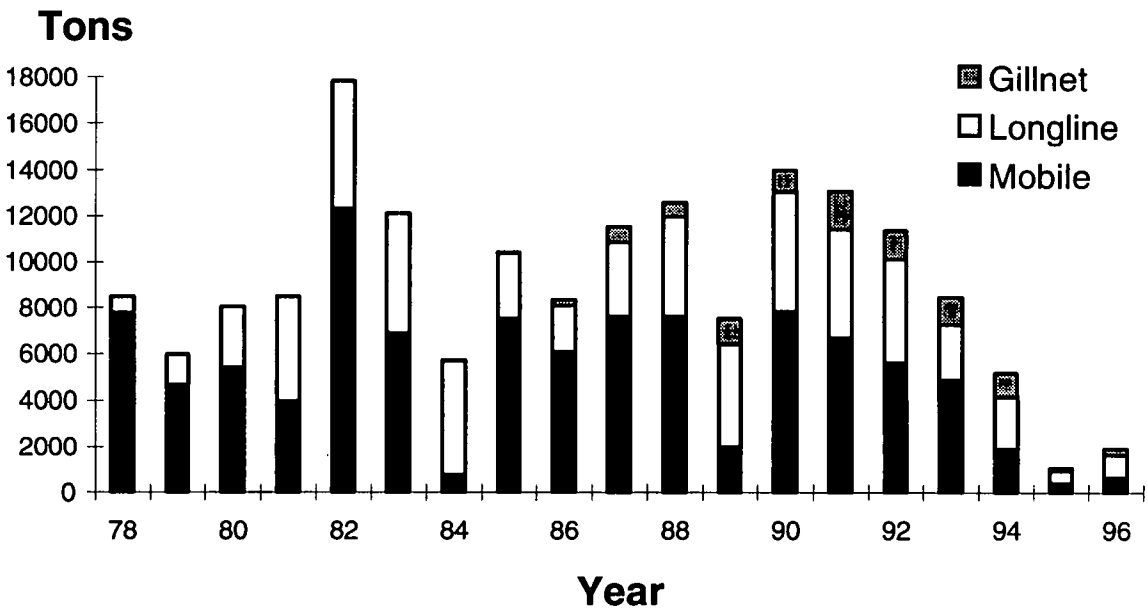


Figure 3. Landings of 5Zj,m cod by Canada and the USA

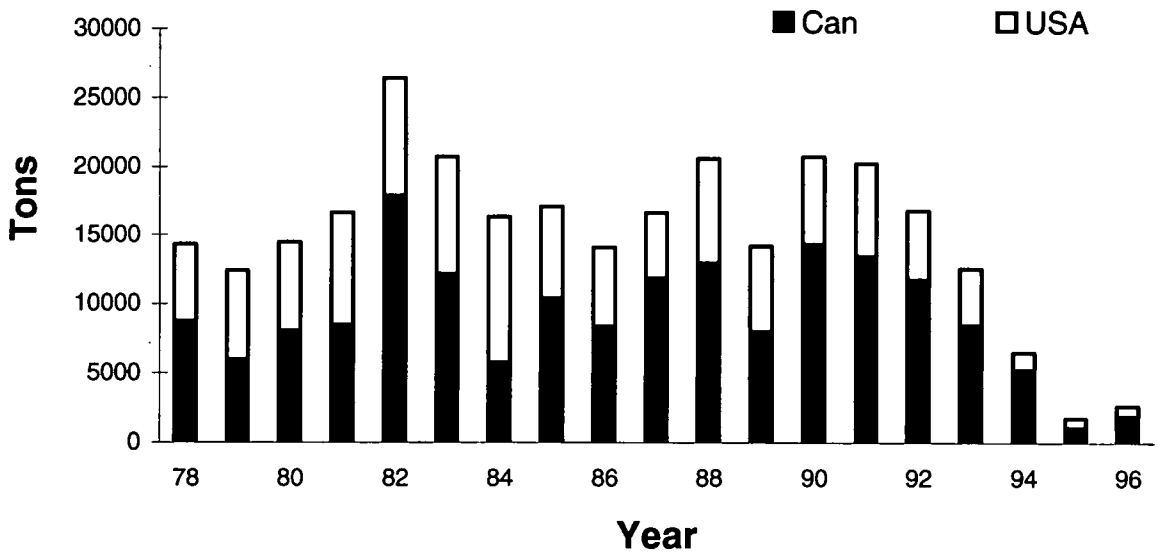


Figure 4. Percent catch at age for the 1996 Canadian and USA 5Zj,m cod fishery

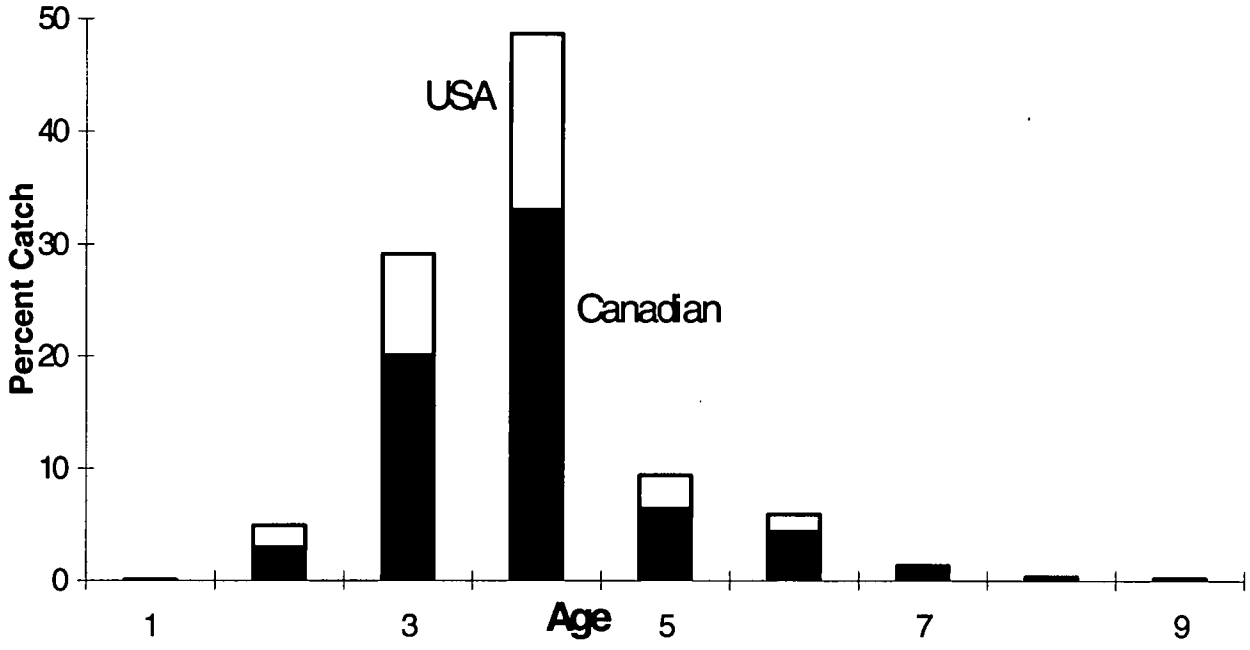


Figure 5. Length and age composition for the 1996 Canadian 5Zj,m cod fishery

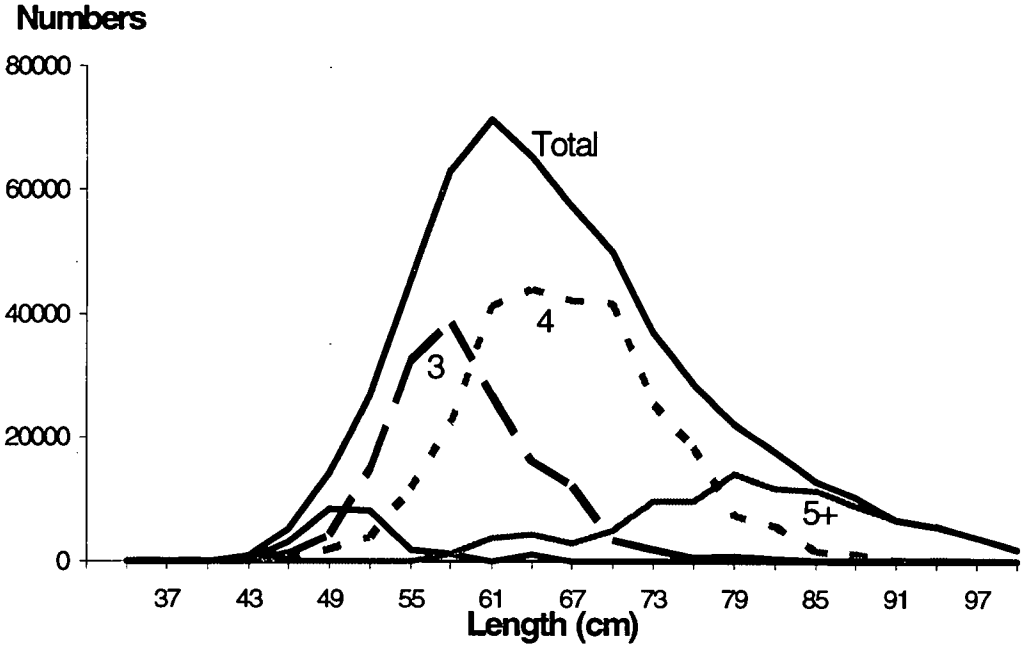


Figure 6. Mean weight (kg) of three year old cod in the Canadian fishery

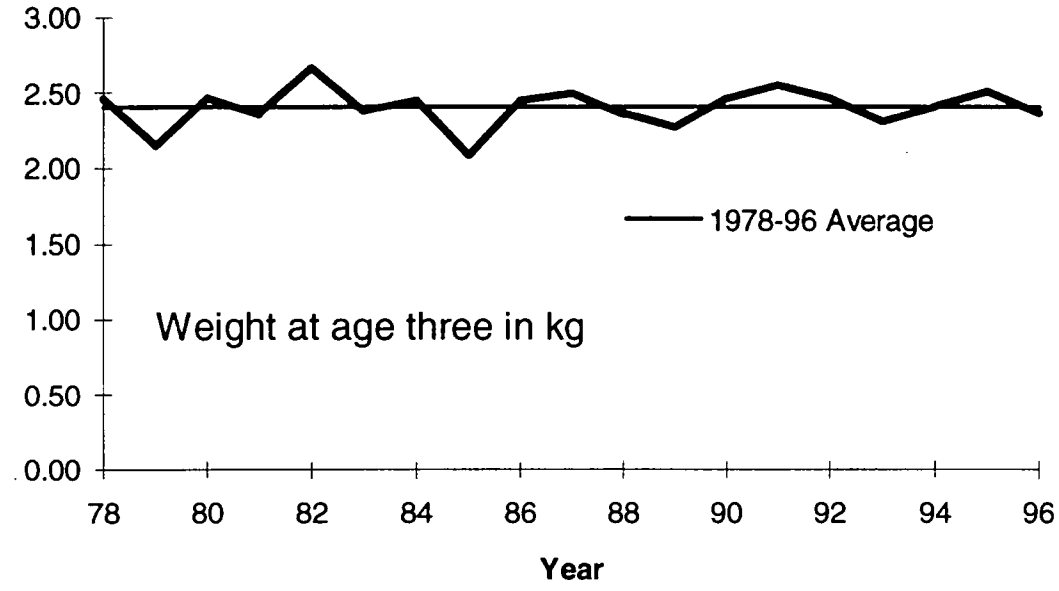


Figure 7. Stratified mean indices of abundance for 5Zj,m cod from the Canadian spring and USA spring and fall surveys in 5Zj,m

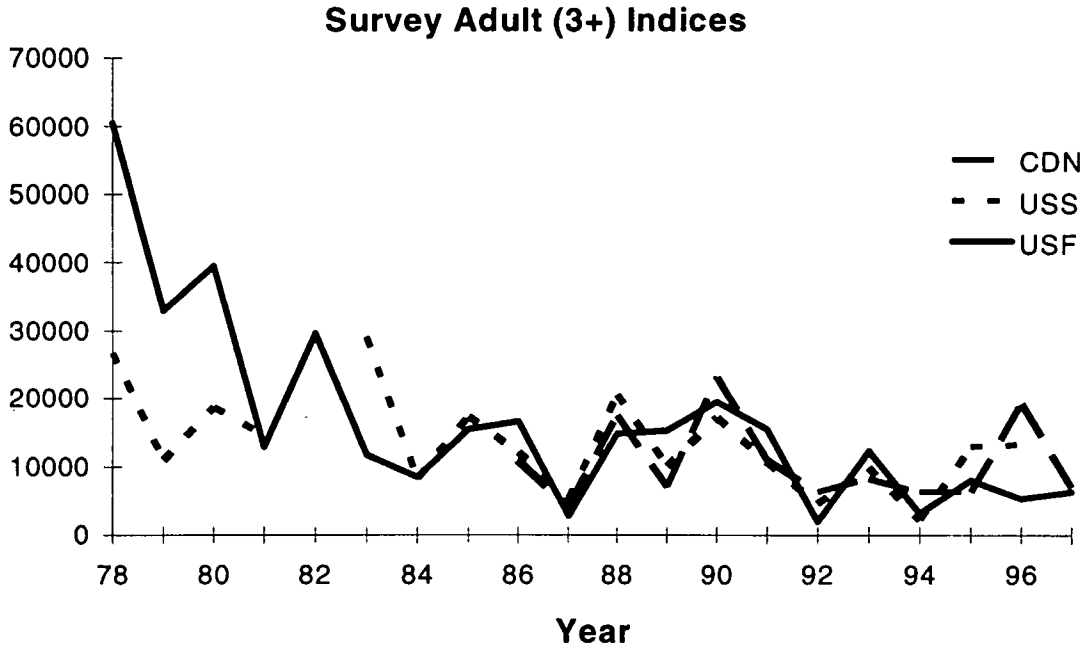


Figure 8. Stratified mean indices of abundance at age 1 for 5Zj,m cod from Canadian spring, and U.S.A. spring and fall surveys in 5Zj,m

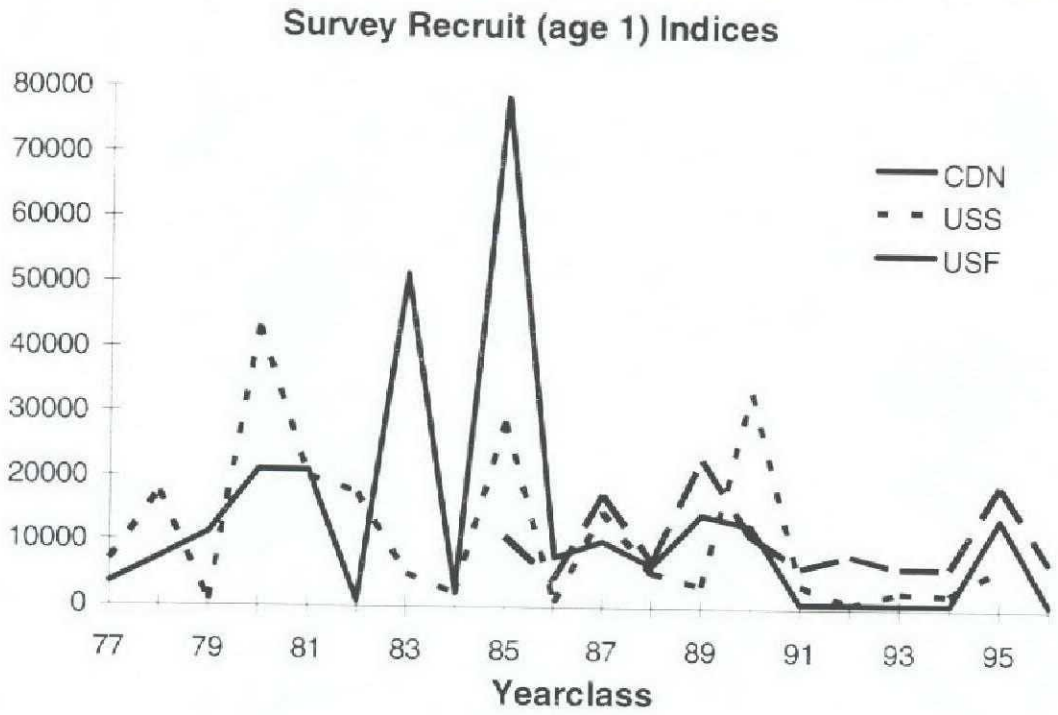


Figure 9. Number of Canadian vessels with cod landings

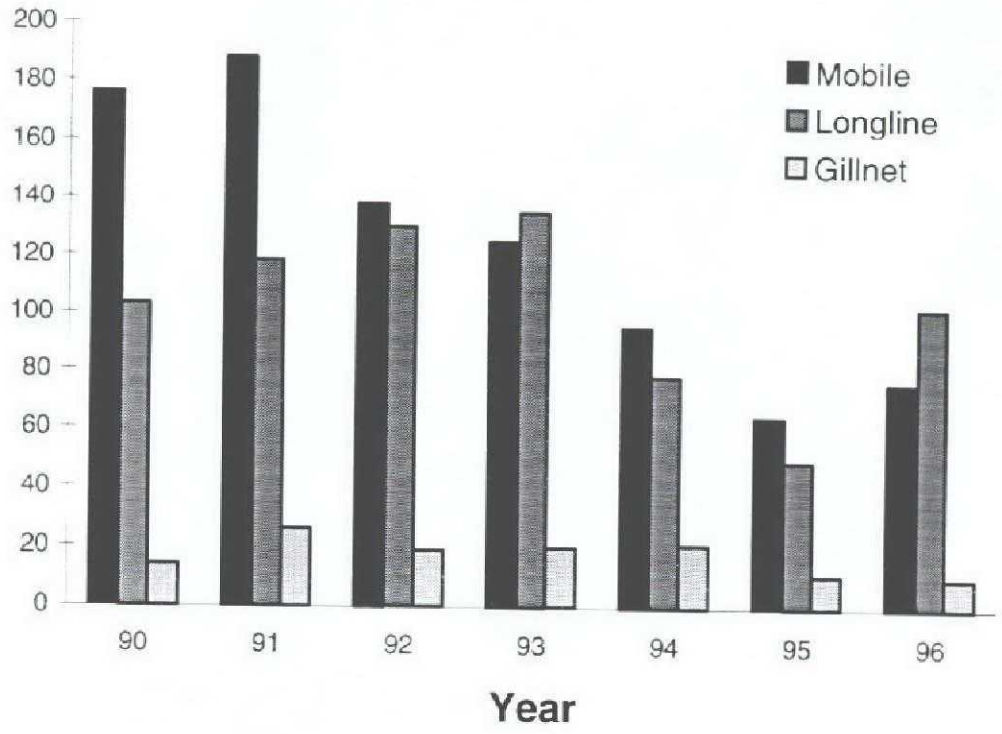
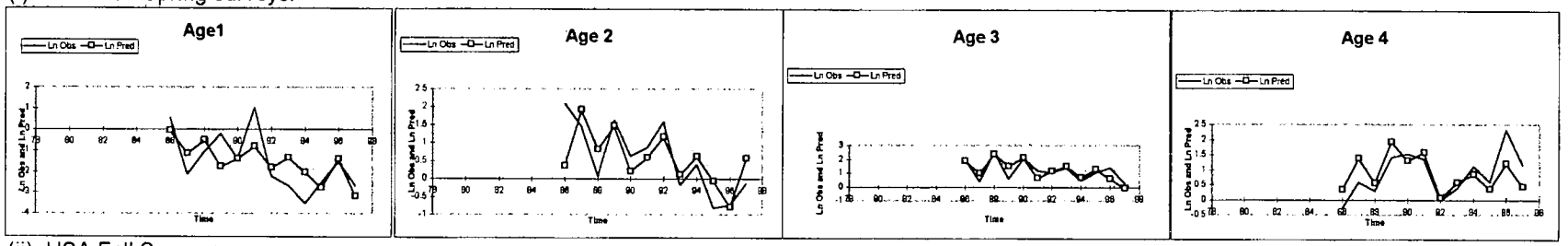
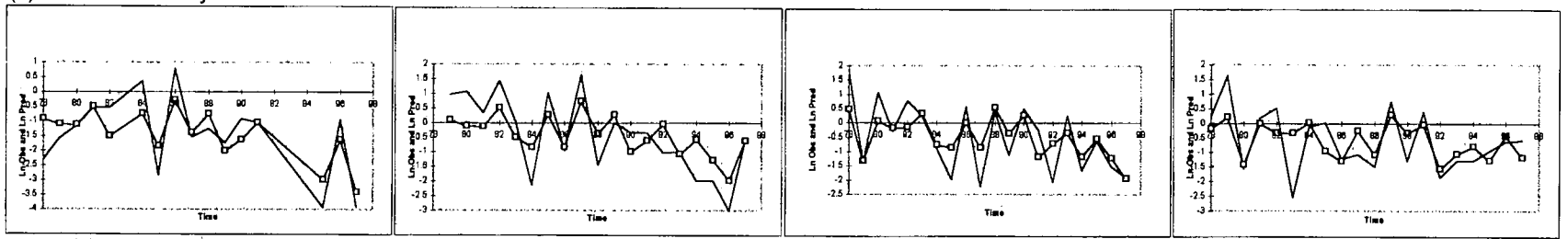


Figure 10a. Age 1 to age 4 plots of Observed and Predicted ln abundance plotted against year for the Canadian Spring (i),USA Fall (ii), and USA Spring (iii) surveys for cod in 5Zj,m.

(i). Canadian Spring surveys.



(ii). USA Fall Surveys.



(iii). USA Spring surveys.

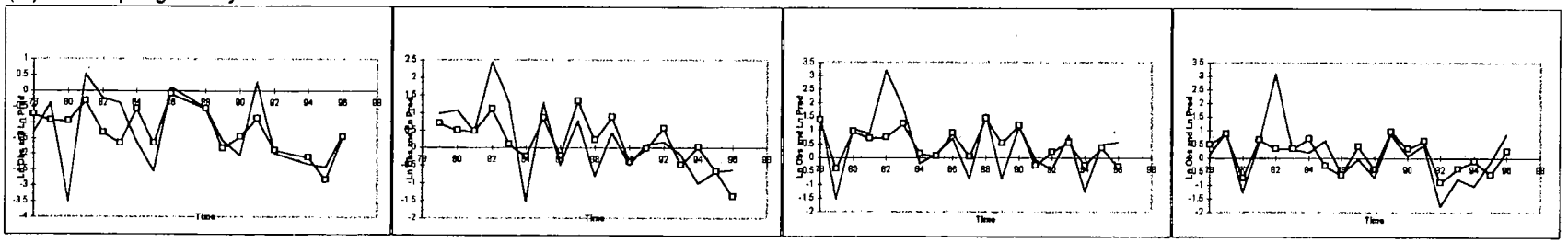
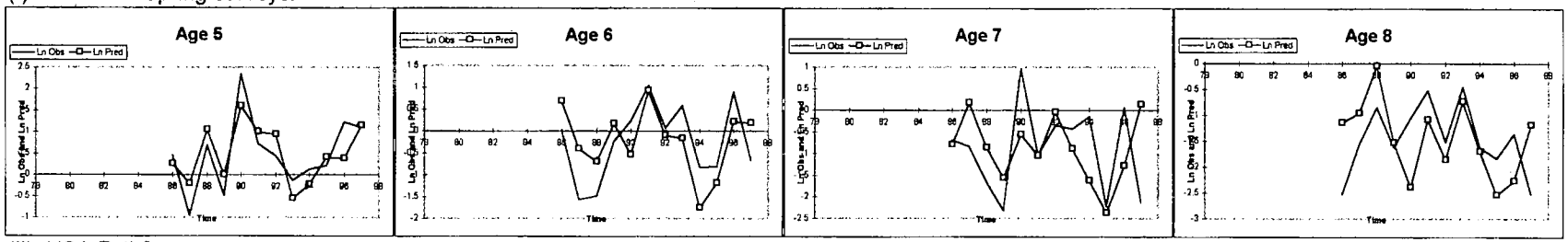
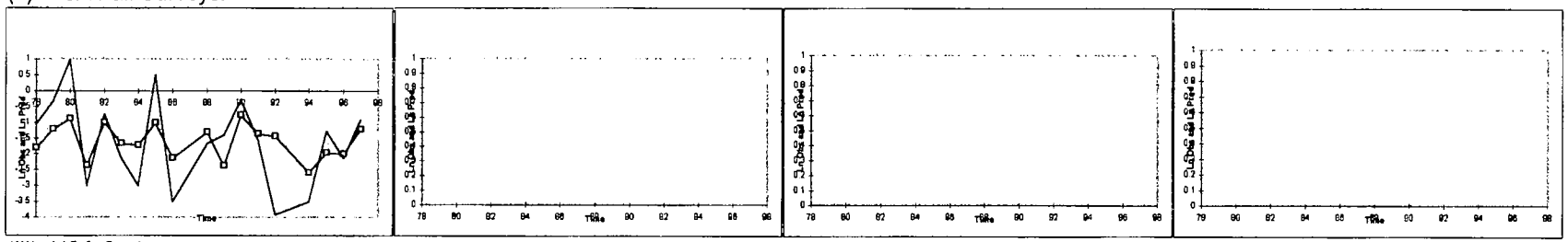


Figure 10b. Age 5 to age 8 plots of Observed and Predicted ln abundance plotted against year for the Canadian Spring (i),USA Fall (ii), and USA Spring (iii) surveys for cod in 5Zj,m.

(i). Canadian Spring surveys.



(ii). USA Fall Surveys.



(iii). USA Spring surveys.

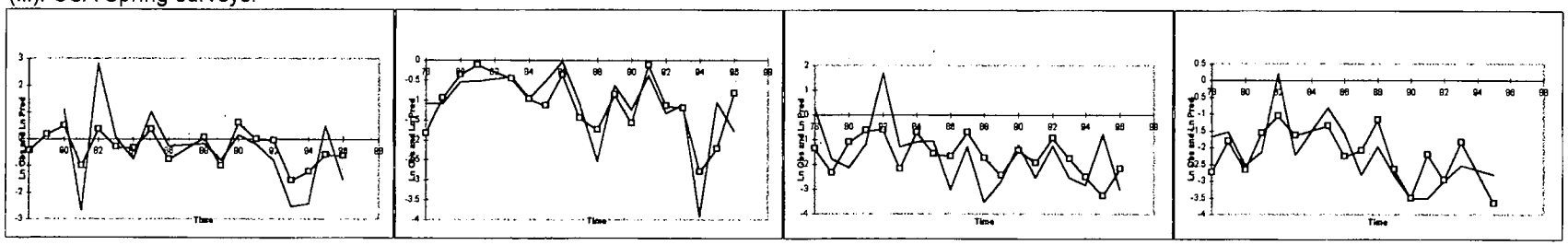
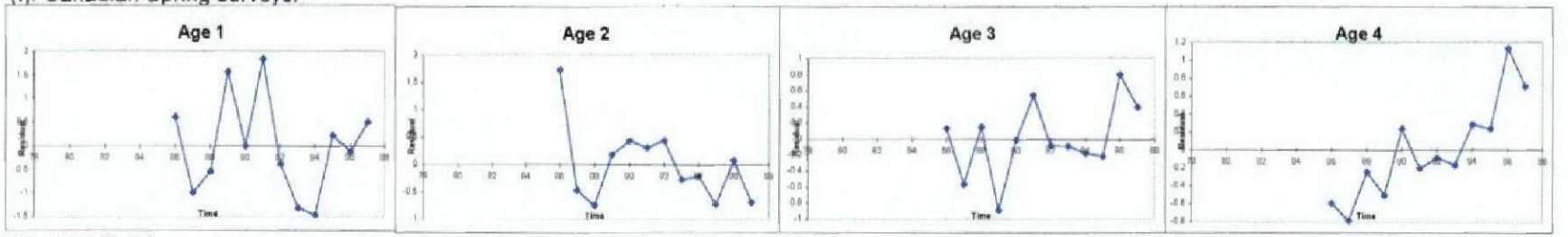
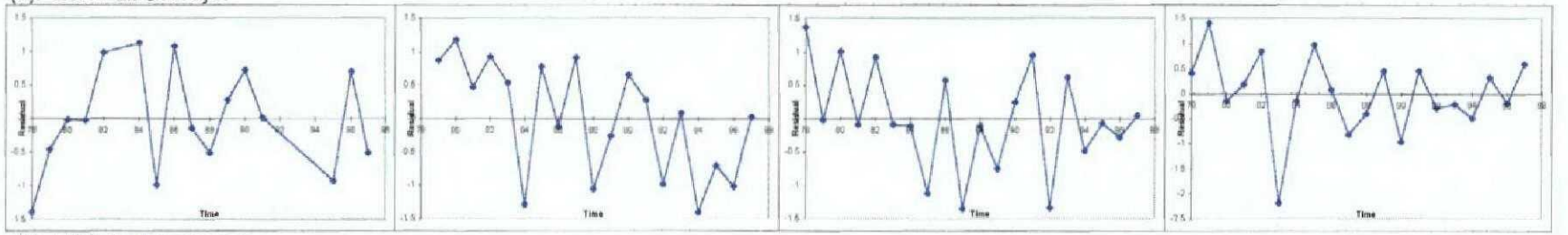


Figure 11a. Age 1 to age 4 plots of Residuals plotted against year for the Canadian Spring (i),USA Fall (ii), and USA Spring (iii) surveys for cod in 5Zj,m

(i). Canadian Spring surveys.



(ii). USA Fall Surveys.



(iii). USA Spring surveys.

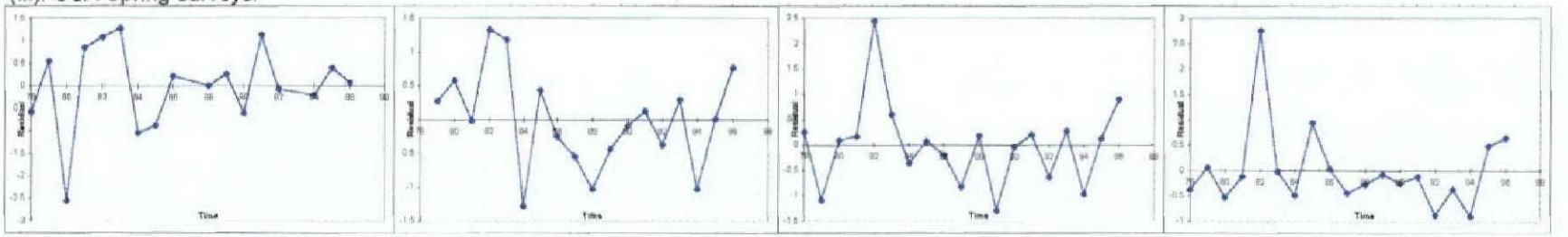
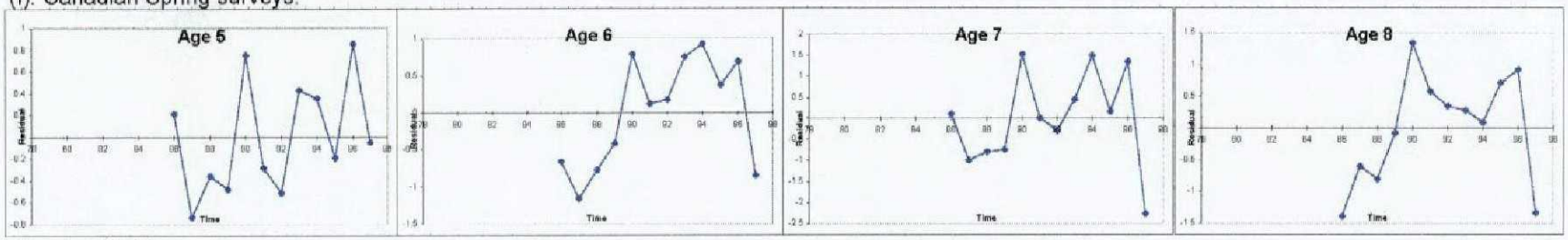
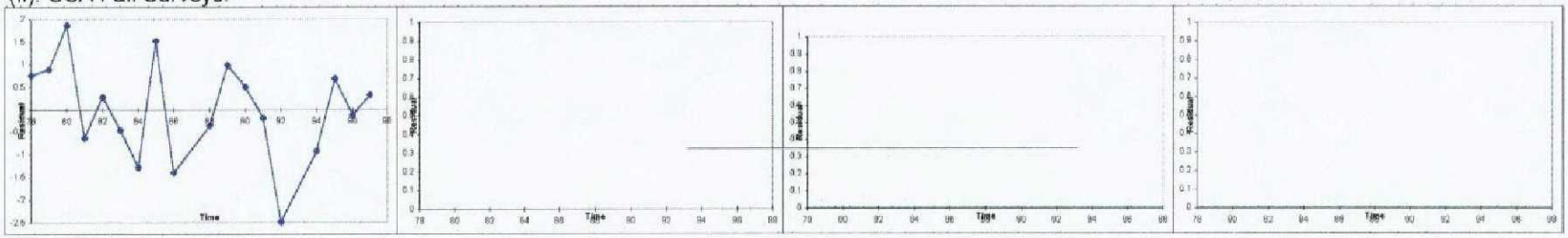


Figure 11b. Age 5 to age 8 plots of Residuals plotted against year for the Canadian Spring (i),USA Fall (ii), and USA Spring (iii) surveys for cod in 5Zj,m

(i). Canadian Spring surveys.



(ii). USA Fall Surveys.



(iii). USA Spring surveys.

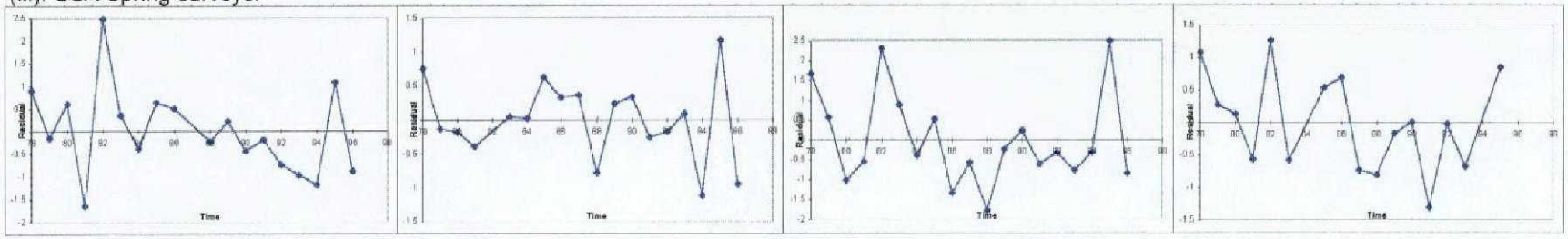


Figure 12. Adult (3+) biomass and recruits at age 1 from ADAPT for 5Zj,m cod

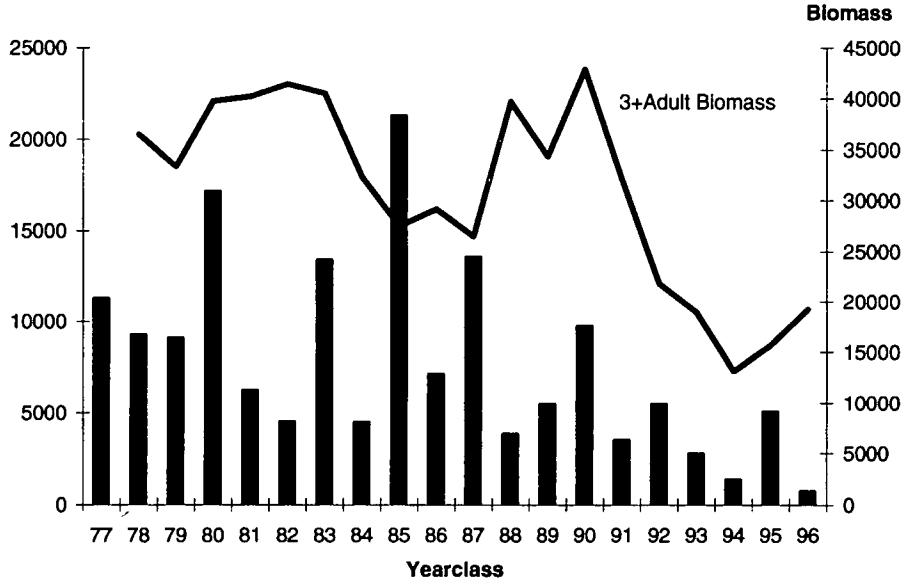


Figure 13. Percent exploitaiton rate from ADAPT for 5Zj,m cod

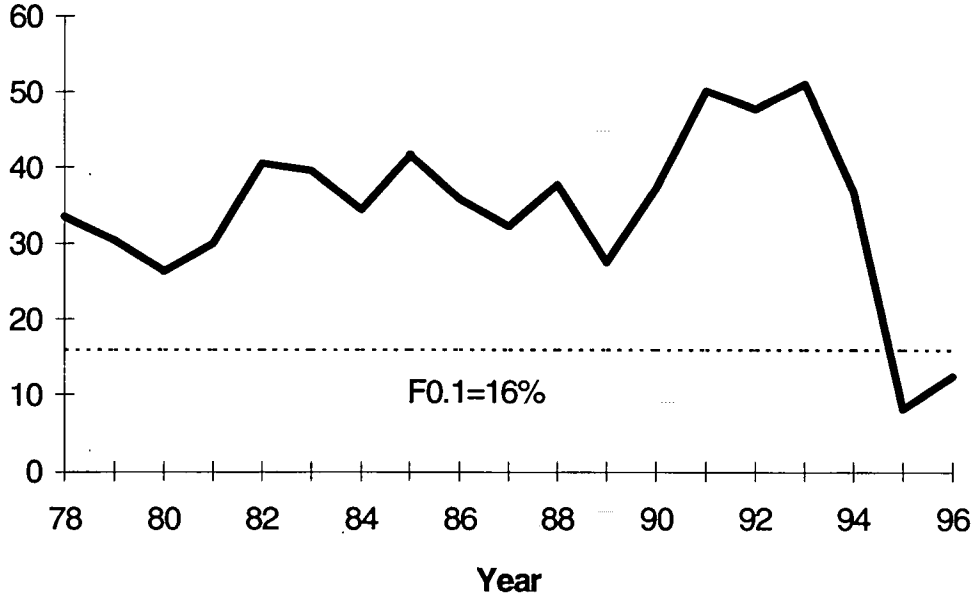


Figure 14. Retrospective parttern in estimates of abundance at age 2 by yearclass.

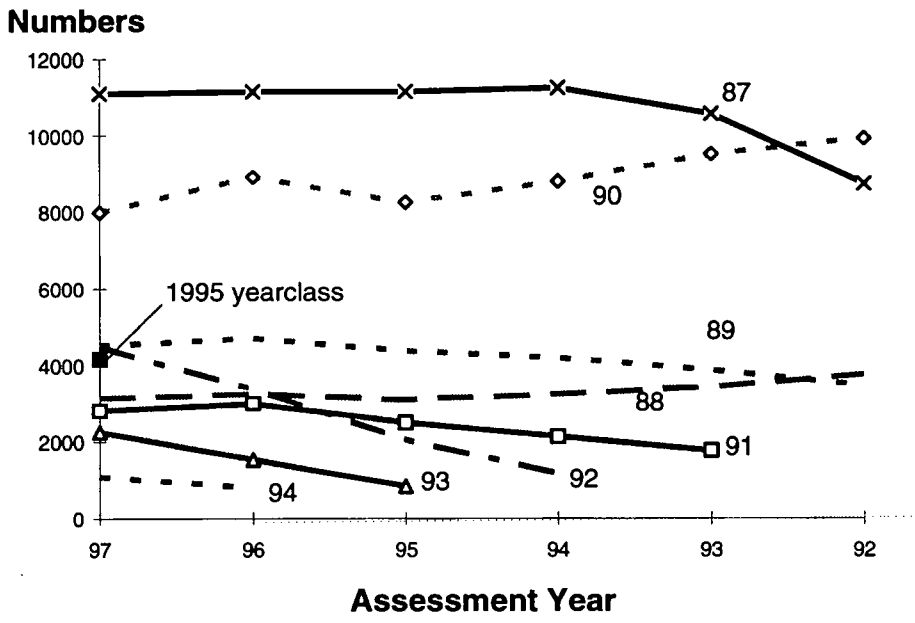


Figure 15. Yield projection for 1997 and resultant impact on adult biomass in 1998 for 5Zj,m cod

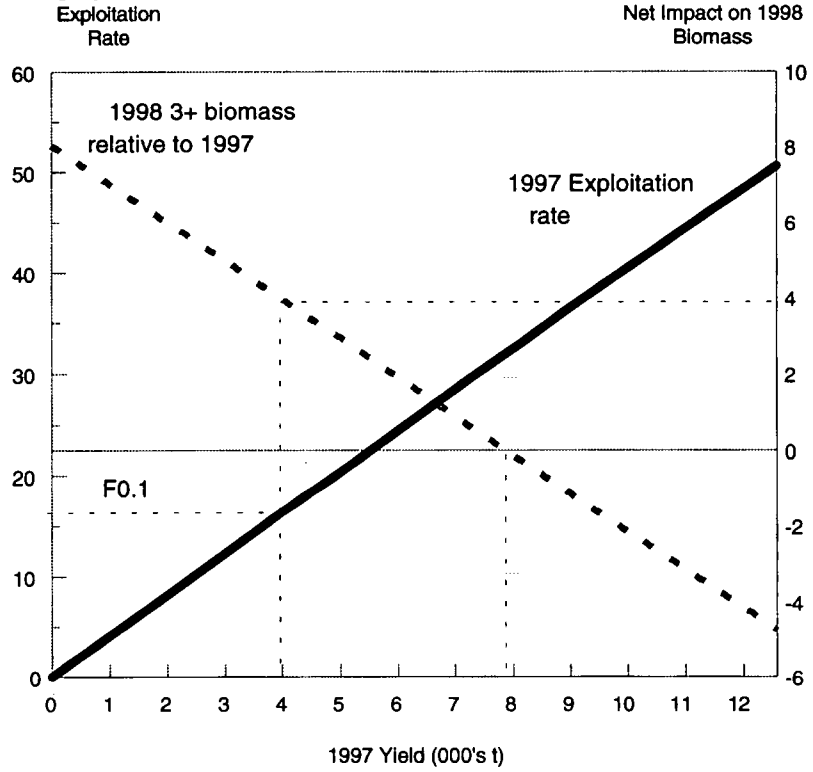


Figure 16. Uncertainty in exploitation rate and biomass associated with 1997 yield projection

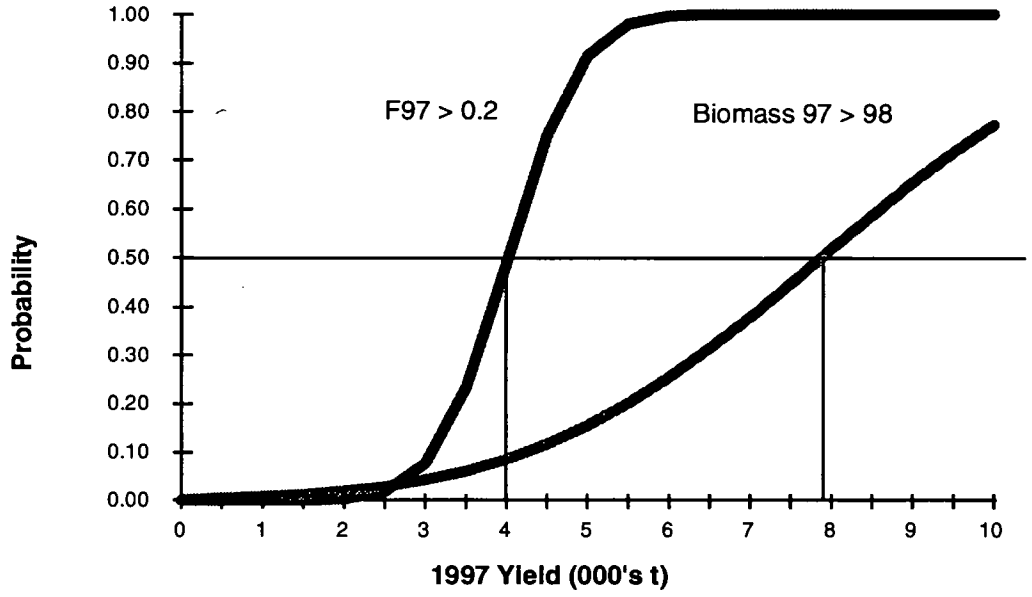


Figure 17. Comparison of recruits at age 1 and adult biomass for 5Zj,m cod

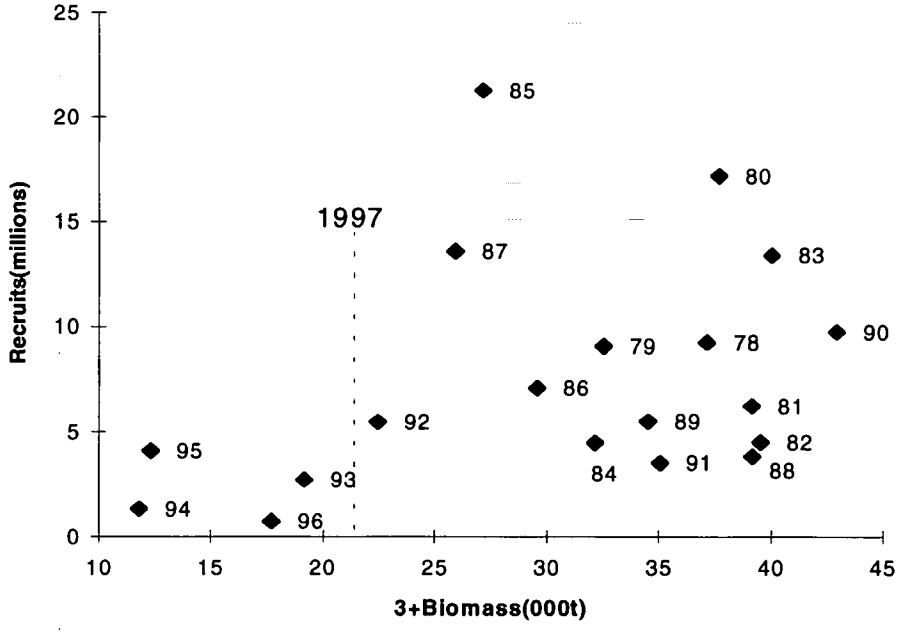


Figure 18. Comparison of landings of cod in 5Zj,m with 5Z

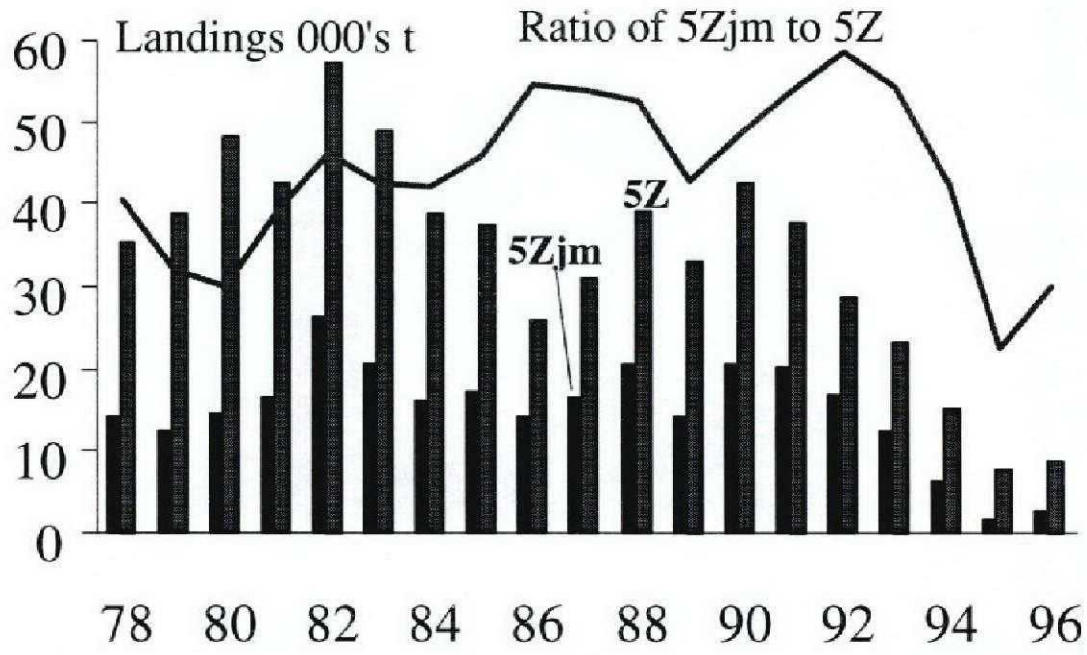


Figure 19. Comparison of adult biomass trends in 5Zj,m with 5Z

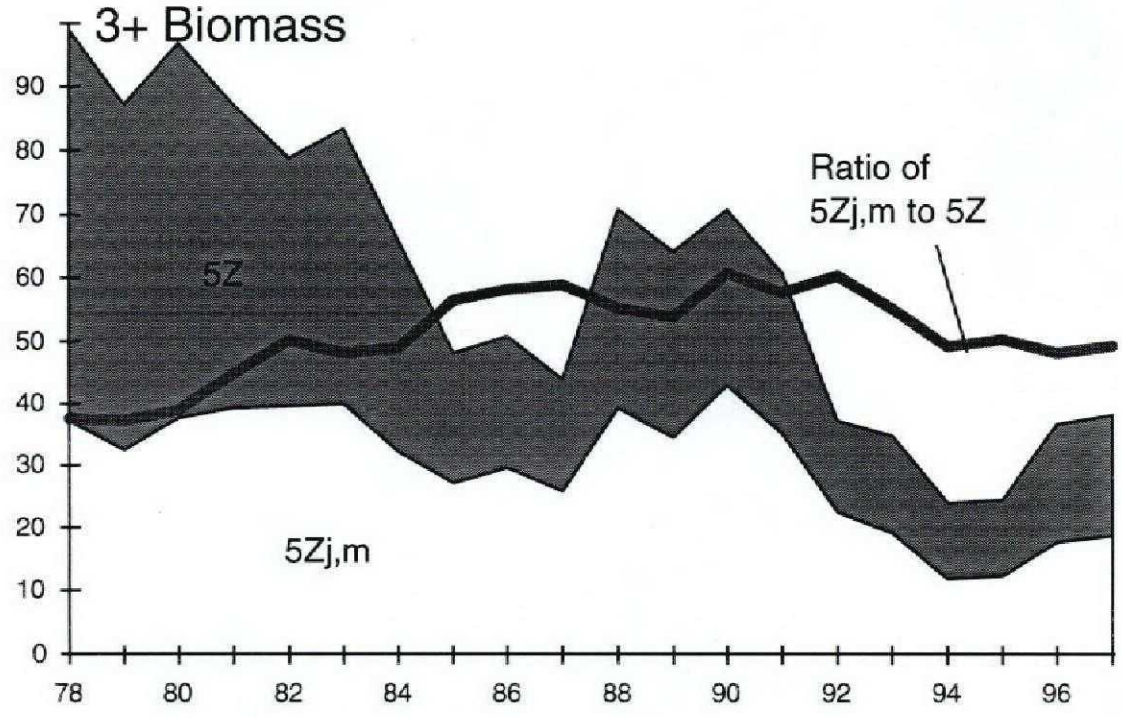


Figure 20. Comparison of recruits at age 1 in 5Zj,m with 5Z

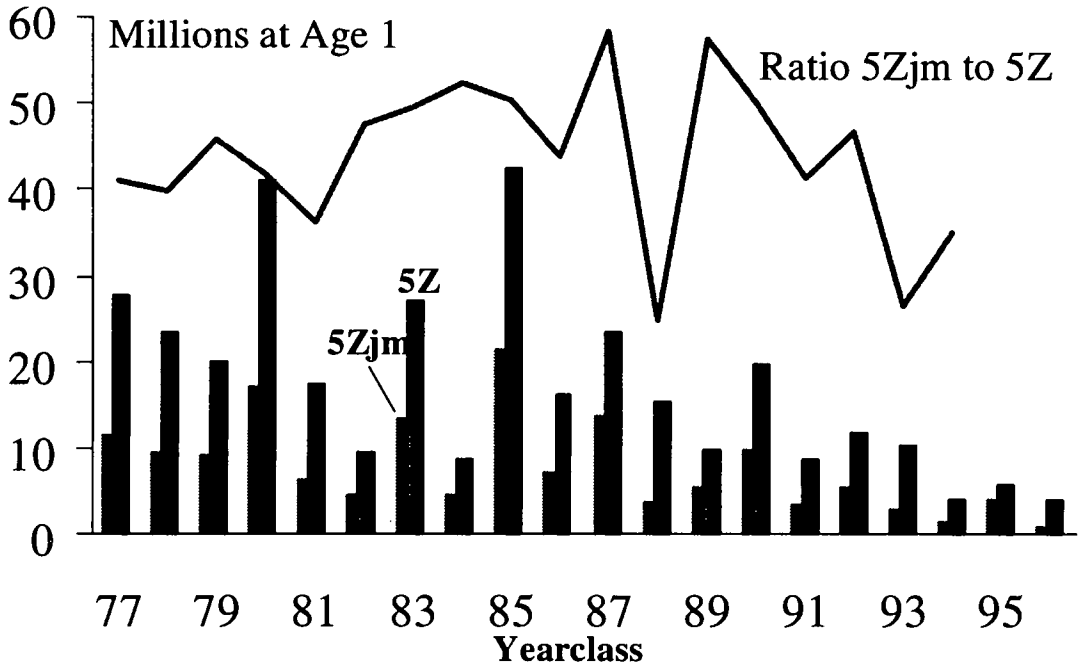


Figure 21. Comparison of fishing mortality rate in 5Zj,m with 5Z