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Biological Update of Georges Bank cod in Unit Areas 5Zj,m for 1978-93

by

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¹This series documents the scientific basis for the evaluation of fisheries resources in Atlantic Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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¹La présente série documente les bases scientifiques des évaluations des ressources halieutiques sur la côte atlantique du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

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Abstract

Total landings for cod in Div.5Zj,m in 1993 were 12538 t, lower than the long term average of 17000 t. Canadian landings decreased by about 3000 t from 1992 and USA landings were the lowest in the time series. The 1990 year class (age 3) continues to be dominant (50% in numbers) in landings. Size at age shows a decrease over long term averages. Canadian (1994) and USA (1993) surveys continue the decline in mean catch per tow. A catch rate standardization for Canadian vessels indicates a substantial decline in CPUE since 1990 which is consistent with other indices of abundance. Biomass and numbers of fish continue to decline and are now at the lowest observed in the 1978-93 time period. Catch projections for 1995, assuming a Canada/USA 1994 catch of 7500t, are about 1800 t at the $F_{0.1}$ reference level. Catches in 1994 at the $F_{0.1}$ reference level would be about 2600 t with a corresponding $F_{0.1}$ catch of about 2800 t in 1995.

Résumé

Les débarquements totaux de morue dans les subdivisions 5Zj,m étaient de 12 538 t en 1993, ce qui est inférieur à la moyenne à long terme (17 000 t). Les débarquements canadiens ont diminué d'environ 3 000 t depuis 1992, tandis que ceux des États-Unis atteignaient le plus bas niveau de la série chronologique. La classe d'âge de 1990 (âge 3) reste prédominante dans les débarquements (50 % en nombre). La taille selon l'âge diminue par rapport aux moyennes à long terme. Les relevés de recherche canadien (1994) et américain (1993) révèlent que les prises moyennes par trait continuent de diminuer. D'après les taux de prises standardisés des bateaux canadiens, les PUE accusent une baisse importante depuis 1990, ce qui est conforme aux autres indices d'abondance. La biomasse et le nombre de poissons continuent de diminuer et sont maintenant les plus bas de la période 1978-1993. Les projections de prises pour 1995, fondées sur des prises canadiennes et américaines de 7 500 t en 1994, sont d'environ 1 800 t au niveau de référence $F_{0.1}$. À ce même niveau de référence, les prises de 1994 seraient d'environ 2 600 t, aboutissant à des prises $F_{0.1}$ de 2 800 t en 1995.

Introduction

This report incorporates commercial catch data and research survey results to estimate stock status of cod for the 1978-93 time period in the two unit areas 5Zj,m. Definition of this management unit was based on analysis of tagging results, commercial, and survey catch distribution (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 by the USA in unit areas 5Zj and 5Zm are thought to be mis-reported with extensive discarding in the 1976-77 time period (Serchuk and Wood, 1981) 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. As well, the spatial distribution of foreign fleet catches in Subdiv. 5Ze are unknown and could therefore not be allocated to the 5Zj,m area. 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 and have been limited to the Canadian side of the international boundary since 1985. Landings have been dominated by otter trawlers, except in 1984 and 1989 (Table 1, Fig. 2). However, in recent years the proportion of total landings taken by fixed gears (longline and gillnet) have increased. The below average 1989 catch by otter trawlers reflects early closure of the fishery when the combined quota for Div. 4X+5 was exceeded.

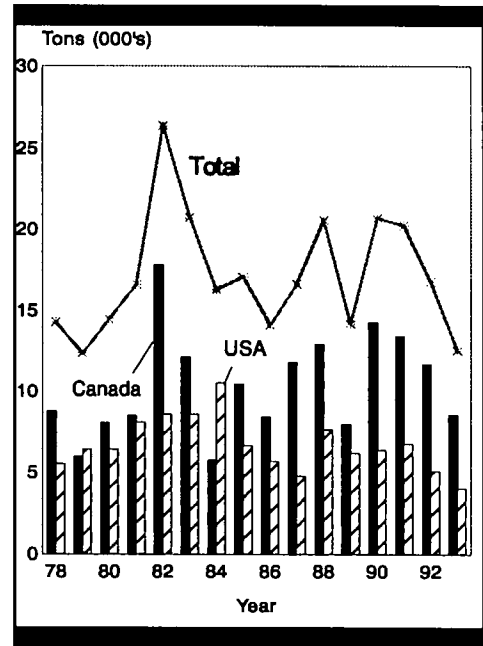


Figure 1 Canada & USA landings for 1978-93

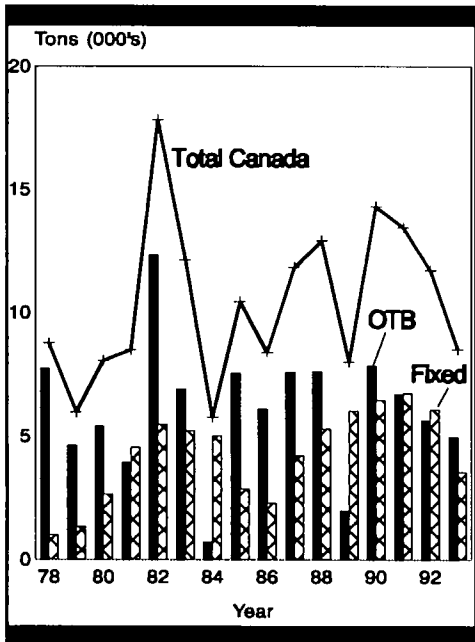


Figure 2 Canadian landings by gear sector

In 1990, a 6000 t increase over 1989 in Canadian landings was the result of a return to average catches by the OTB fleet and resulted in an overall catch of 14310 t, the second highest in the time series. Canadian landings in 1993 were 8519 t well below the previous 15 year average (10543 t). USA landings in 1993 were 4019 t, and continue to be below the longterm average. Management of the Canadian fishery has been by ITQ for <65' OTB since June 1992, EA's for offshore boats since 1984 and by competitive quota for fixed gear .

Catches by Canada and the USA in unit areas 5Zj and 5Zm for 1978-93 are summarized in Table

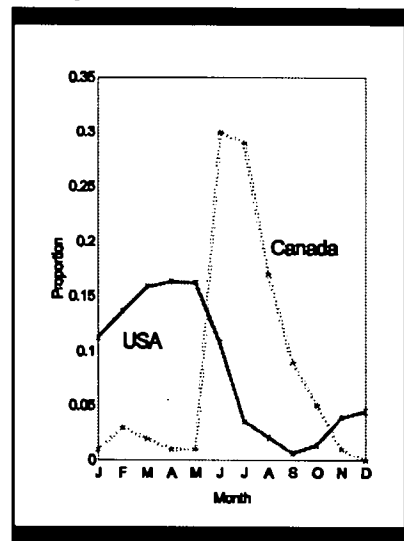


Figure 3 Proportional catch by month, 1985-93

2 and in Figure 1. Combined catches peaked at 26000 t in 1982, averaged about 15000 t between 1983-87 and increased to 20000 t in 1988. The reduction in 1989 to 14000 t was a result of decreased mobile gear catch by both Canada and the USA. Landings in 1991 were about 20000 t, decreased by 3000 t in 1992 and by an additional 4000 t in 1993 to 12538 t. Since 1985, Canada has continued to take about 65% of the total catch. The USA fishery typically is concentrated in the first half of the year while the opposite is true for the Canadian fishery (Figure 3). There has been some shift in the USA fishery towards the second quarter in recent years.

Industry Consultations

In addition to individual contacts, meetings with industry representatives were held April 21, 1994. Only the <65' mobile gear sector was represented. Participants were provided with a synopsis of stock assessment input data including landings, age and size of landings, survey indices and commercial catch rates for Georges Bank cod. In general, there was consensus on the trends evident in the data although concerns regarding catch rates were expressed. In particular, fishermen noted that the change to larger and square mesh in 1990 and later years would have some impact on catch rates. It was also noted that introduction of IQ's probably changed fishing practices in order to meet individual vessel requirements. A report on the March 1994 cod tagging experiment was also made and both parties acknowledged the contribution of the fisherman who participated in the tagging operations. Subsequent to the meeting one group of processors and fishing captains provided detailed written comments on the 1993 cod fishery. They observed that their 1993 fishery was an improvement over 1992 in terms of catch rates rather than the decline shown for the entire fleet.

Age Composition of the Commercial Catch

Sampling Intensity

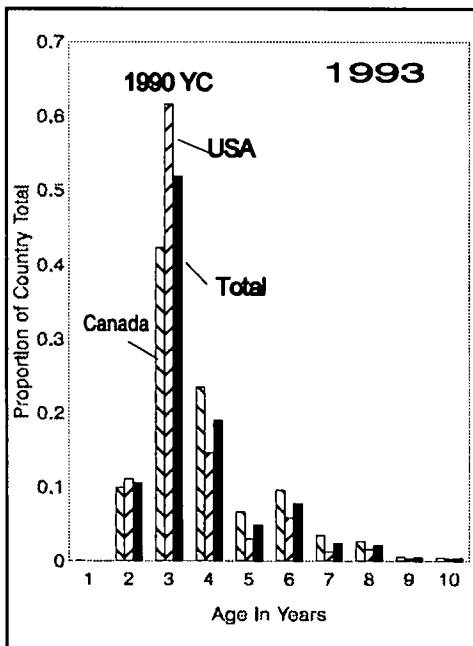


Figure 5. Percent catch at age for Canada & USA.

Sampling coverage of the Canadian fishery in 1982-84 averaged about one sample per 1000 t landed. 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. Since 1985 sampling has increased and in 1993, 51 samples were collected. A summary of sampling data is given in Table 3. Combinations of length and age samples used to estimate the 1993 catch at age for Canada and USA are shown in Table 4. Age length keys (ALK) combined by gear type within quarter were used to estimate Canadian catch at age. This is based on

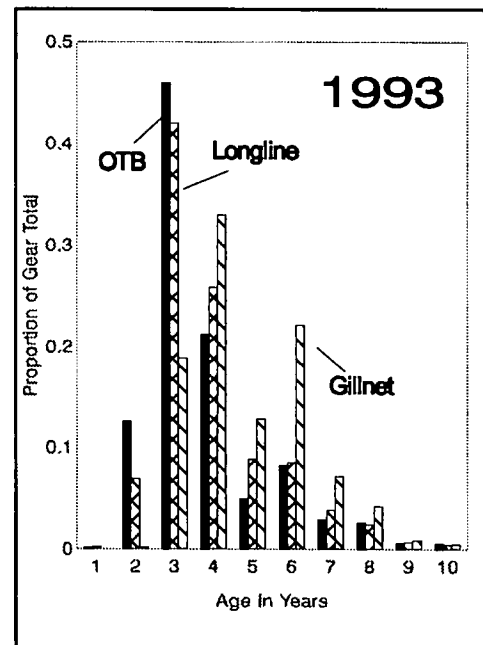


Figure 4. Percent catch at age for Canada

results of Hunt's study (1992) which concluded that no significant difference in probability of age at length exists between gears. USA catch at age was constructed by first combining samples by market type and month. A Canadian ALK were used to estimate catch at age for USA length samples where USA age data was not available in the second half of the year.

Age and Length Composition

A length-weight relationship derived from Canadian commercial sampling data was used. With round weight in kilograms and length in centimetres, $weight (kg) = 0.0000163 \times length^{2.9048}$, and was used for both Canadian and USA sampling data.

Estimated total removals at age are given in Table 5 by country for 1978-93. Canadian landings of 5Zj,m cod were dominated by the 1990 year class (43% by number) at age three in 1993 (Table 6, Figure 4) as well as in total catch at age (Fig 5). An analysis of Observer at sea sampling length samples indicated a very similar length distribution compared to that derived from landings with no evidence of discarding. Canadian landings by length are shown in Fig 6.

Mean length at age for Canadian samples are given in Table 7. There appears to be no trend in size or weight at age over the 16 year time series, although mean weights at age in 1990-93 are below the long term average. Total catch at age and mean weights are given in Table 8.

Canadian otolith samples show 79% within age reader agreement, and 5% of this total is due to unreadable (shifted or crystallized) otoliths. Exchange of otolith samples between Canada and USA show good agreement (89%). Aging comparisons are shown in Table 9. Ongoing studies of Georges Bank cod otolith characteristics continue to increase accuracy of age determinations. Results of a 1993 Canada/USA ageing workshop for cod (and haddock) will be presented at a future meeting.

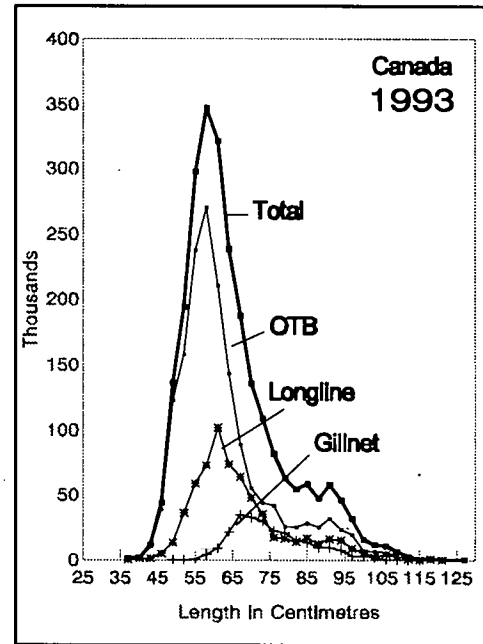


Figure 6 Canadian catch at length in 1993

Stock Abundance Trends

Research Surveys

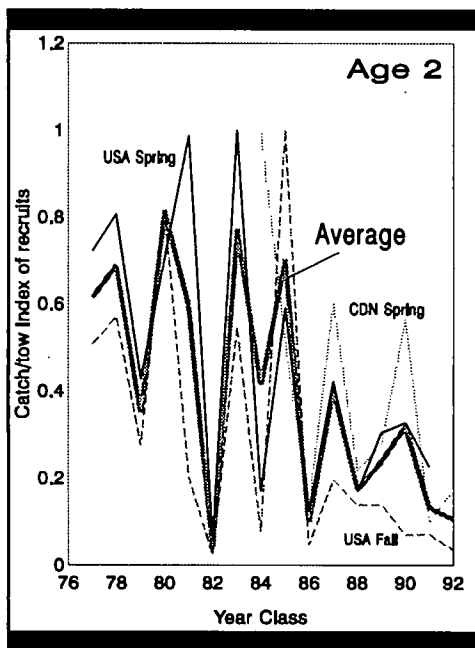


Figure 8 Survey index at age 2 standardized to maximum

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. The technique required selecting only sets within the 5Zj,m boundary and using strata areas also within the 5Zj,m boundary. They also document the vessel and gear conversion factors used to adjust results of the USA surveys to RV Albatross IV equivalents. The 1993 spring USA survey was conducted with the Albatross and did not require adjustment. The 1993 fall USA survey was conducted with the Delaware and therefore a conversion factor of 0.790 was used (Hayes and Buxton, 1992).

Results of analysis for each of the surveys are given in Table 10.

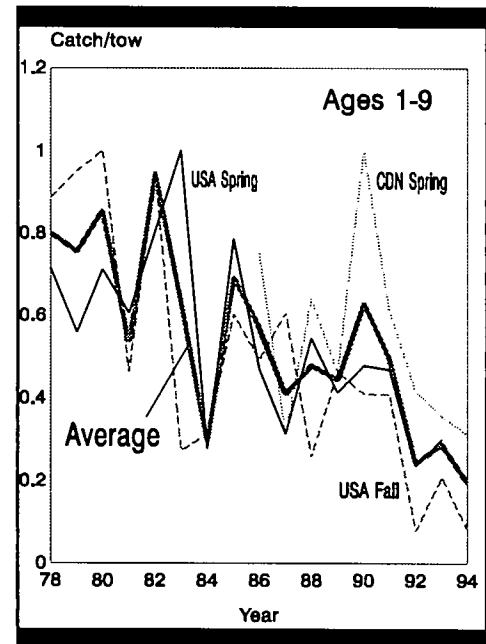


Figure 7 Survey indices of abundance standardized to maximum for ages 1-9

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 analyses (Anon, 1992). 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 1992 and 1993 Canadian surveys continue to show a marked decline. The 1993 USA fall survey catch per tow is even lower than that seen in 1991. The 1993 USA spring is at the lowest observed value, with the exception of the strong contribution of the 1990 year class. Preliminary results for the 1994 USA spring survey indicate a catch per tow of less than 1.0, only 40% of the 1993 previous low for the 5Ze area. The three surveys for ages 1-9, standardized to their maximum and excluding the USA spring 1982 survey, are summarized in 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). In general, all three surveys appear to track year class strength and provide a consistent index. The 1987 year class, which had been a substantial factor in the 1990-93 fishery, appears to be at the end of its contribution. The 1990 year class also appears to be above average in all three of the 1993 and the 1994 surveys, but the 1993 year class (age 1) appears to be the lowest in the time series.

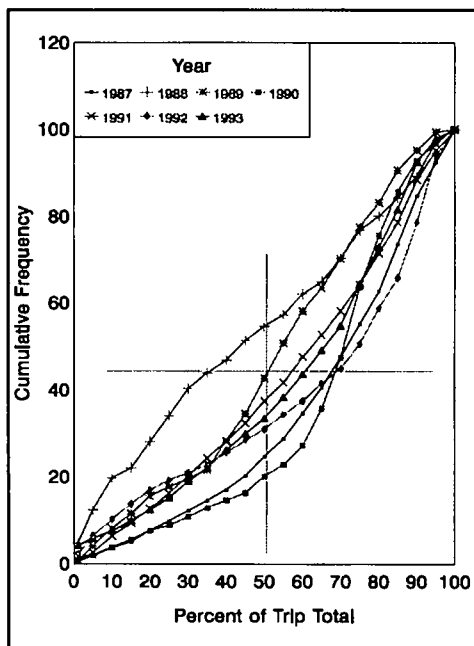


Figure 9. Percent of cod in OTB landings, 1987-93

Commercial Catch Rates

An analysis of otter trawl and longline gear catch rate was completed using a multiplicative standardization procedure. Only data for the 1987-93 time period were included because of changes in data recording in the earlier years. For each gear type, an analysis using individual vessels as a standard was conducted followed by a second analysis using only tonnage class as one of the standards. Both directed (defined as cod > 50% of total trip landings) and all trips with reported cod landings were analyzed. Standards used were vessel (or tonnage class), month and year.

Comparison of catch rate by year indicated very similar trends in both gear sectors between directed and all trips and between vessel and tonnage class standards and therefore the analysis was limited to estimates of CPUE derived from all trips and tonnage class standardizations.

The cumulative frequency distribution of the ratio of cod to total trip landings by OTB is shown in Figure 9. Overall, about 65% of trips reported cod as the main species landed and the trend was similar across years. The highest proportion of 'cod' trips occurred in 1990 and the lowest in 1988.

Results for otter trawlers catch rate standardization are given in Table 11 and in Figure 9. Over 3000 observations were included in the analysis and reported landings in June by TC 3 vessels accounted for the majority of observations. CPUE showed a general decline between 1987 and 1993 and there were significant annual differences. It was not possible to account for expected changes in catchability associated with use of larger

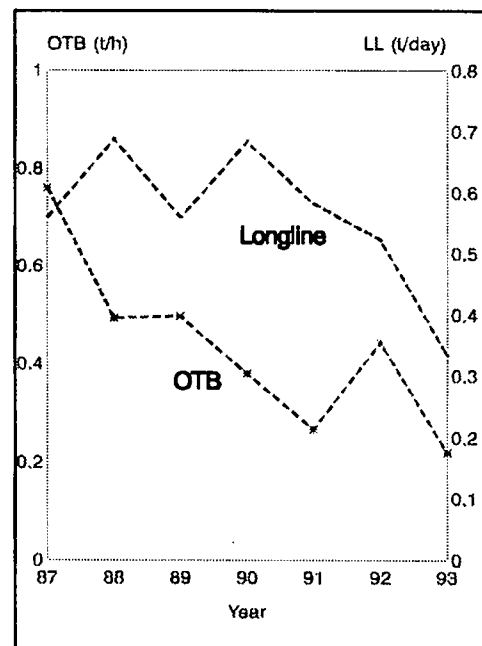


Figure 10 Standardized catch rates for OTB and longline, 1987-93

mesh and square mesh in the 1990-93 time period but it is expected that these factors would underestimate catch rates relative to the earlier part of the time series. As well, changes in fishing patterns required to avoid IQ overruns could bias CPUE in the recent part of the time series.

To address the observation of one group of processors/fishermen noted above (see Industry Consultations), a catch rate standardization was completed for the five identified vessels. This analysis confirmed an apparent increase in catch rate between 1992 and 1993 as well as a less substantial overall decline in the 1987-93 time period when compared to the combined fleet results.

A catch rate at age for otter trawlers was derived by partitioning the total CPUE into the proportional otter trawler catch at age. Very low catch rates at age 1 and age 8 are probably a reflection of partial recruitment to the gear rather than abundance.

Results for longliners are given in Table 12 and Figure 10. About 1500 observations were included in the analysis and reported landings in July by TC 2 vessels accounted for the majority. CPUE appeared to be variable without trend in the 1987-91 time period but showed a substantial decline in 1992 and again in 1993. Interpretation of these data is limited by both changes in measurement and recording of effort and by the low proportion of landings with effort data.

ESTIMATION OF STOCK PARAMETERS

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

$C_{a,y}$ = catch	a=1 to 8, y=1978 to 1993
$I_{1,a,y}$ = USA spring survey	a=1 to 8, y=1978 to 1993
$I_{2,a,y}$ = USA fall survey	a=0 to 7, y=1977 to 1993
$I_{3,a,y}$ = Canadian spring survey	a=1 to 8, y=1986 to 1994
$I_{4,a,y}$ = Canadian OTB C/E	a=2 to 7, y=1987 to 1993

The spring survey results were compared to beginning of year population abundance. The fall survey for ages 0-7 was also compared to beginning of year population abundance in year t+1 (ie fall 1977 ages 0-7 compared to 1978 population ages 1-8). The OTB catch rate at age was compared to mid-year population abundance. 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 3 to 7 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 by minimizing the objective function

$$Q = \sum_{1-4,a,y} (\ln(I_{1-4,a,y}) - \ln(i_{1-4,a}))^2$$

Analytical approximations of variance and bias for parameters and functions of parameters were derived following Gavaris (1993).

To derive the projected yield for the target year, y = t+2, the target fishing mortality rate at age and weight at age, as identified above, were used in the following calculations.

The population abundance at the beginning of year y = t+2 is obtained from the exponential decay model,

$$N_{a,t+2} = N_{a,t+1} \exp[-(F_{a,t+1} + M)]$$

The catch numbers at age and projected yield in year $y = t+2$ are derived using the catch equation and then applying the weight at age,

$$C_{a,t+2} = F_{a,t+2} N_{a,t+2} (1 - \exp[-(F_{a,t+2} + M)]) / (F_{a,t+2} + M)$$

$$\bullet_{t+2} = \bullet C_{a,t+2} W_a$$

Assessment Results

Population estimates derived from the above ADAPT formulation are given in Table 13 and in Figures 11 and 12. Parameter estimates, bias adjustment and the residuals for indices of abundance are given in Tables 14-16 and summarized in Figures 15-18.

Population parameter estimates have a relative error of 35 to 64% for ages 2 to 8 but the age one estimate has a relative error of over 85%. In general, catchabilities for survey indices show a flat top PR at ages 4 and older. The OTB catch rate slopes indicate a substantial increase between age 2 and 3 but are flat topped for ages 3 and older.

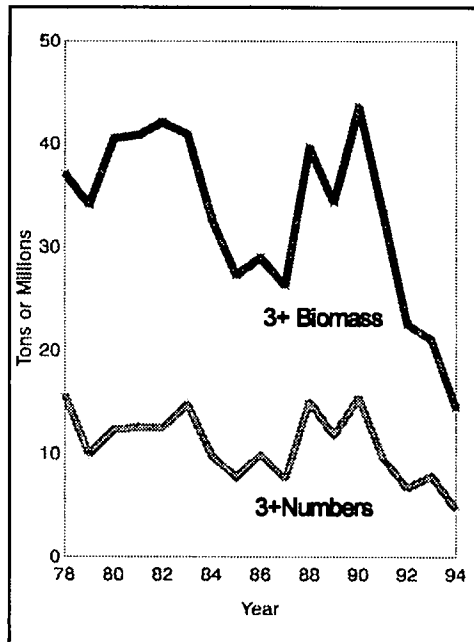


Figure 11 Population numbers and biomass for ages 3+.

As has been noted in the past, there appear to be strong year effects in the residuals for survey indices. The 1982 USA spring survey has relatively large positive residuals, the 1987 Canadian survey has all negative residuals and the 1994 Canadian survey has all positive residuals. However, residuals by age for all three surveys appear to be reasonably well balanced and without trend. Catch rate residuals also appear to be reasonably well balance and there does not appear to be any trend in residuals across years or ages. At age 2 there is no indication of

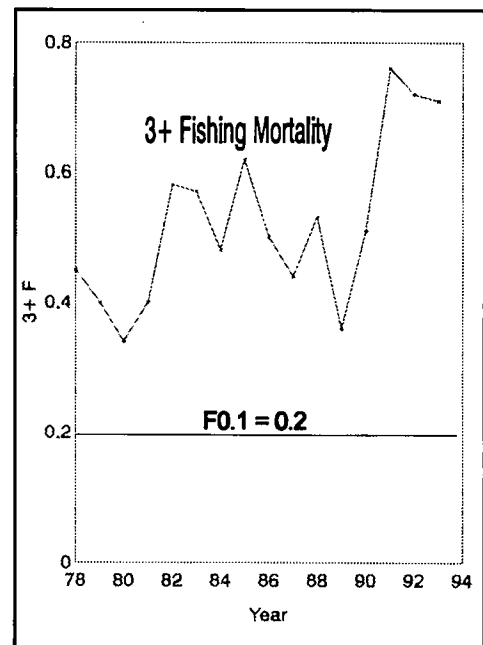


Figure 12. Fishing mortality for ages 3+ weighted by numbers.

a change in catchability between years in which diamond or square mesh were used.

The decline in adult biomass between 1990 and 1994 is substantial and in 1994 is at the lowest observed. The decline in numbers of fish is less dramatic but the 1994 value is also at the lowest observed. Fishing mortality increased rapidly between 1989 and 1991 to almost four times the $F_{0.1} = 0.2$ reference level. The decline seen in 1992 and 1993 still results in a fishing mortality of over three times $F_{0.1}$.

There are a number of concerns about the exploitation rates which this stock has experienced in recent years. There is little doubt that fishing mortalities in the 1990's are well above $F_{0.1}$ and could have exceeded F_{max} by a factor of two or more. The

fishery, in particular the mobile gear sector, is largely dependent on recruitment. This can result in substantial mortality at age two and, since fish at this age are up to 50% immature, a substantial loss in spawning potential for recruiting cohorts.

Prognosis

Catch projections were completed using the bias-adjusted beginning of year population abundance for 1994 derived from ADAPT. Partial recruitment was derived from the 1978-93 fishing mortality matrix and mean weights at age were the 1978-93 average. The estimate of recruitment (age one in 1994) was not well estimated from ADAPT and therefore an average value was used. The survey estimates of this year class (1993) indicate very low abundance and it would be inappropriate to use the long term average of about 6 million. The geometric mean of the four smallest year classes (1.6 million) was therefore used to reflect the expected low abundance. Recruitment for 1995 age one was set to 6 million.

Input for the catch projection is shown below:

Age	Population Numbers (000's) for 1994	Mean Weight Beginning of Year	Partial Recruitment
1	1600	0.74 kg	0.005
2	1214	1.18	0.288
3	1375	1.91	0.700
4	2486	2.94	1
5	344	4.34	1
6	165	5.80	1
7	176	7.41	1
8	42	9.17	1
9+	57	11.12	1

Landings in 1994 are expected to be less than those in 1993 and the 1994 management plan has set a provisional Canadian quota of 10000 t. Assuming Canadian and USA effort in 1994 will be similar to that in 1993, a catch of about 7500t could be taken and therefore a projection with this 1994 catch was used to estimate the 1995 $F_{0.1}$ reference catch. Results with an $F_{0.1}$ catch in 1994 and 7500 t in 1994 are summarized below and in Figure 13 and in detail in Table 17.

Year	Mid-Year 3+ Biomass	Yield 1+	Fishing Mortality
1994	10866	7500	0.71
1995	9130	1836	0.20

1994	14458	2616	0.20
1995	14802	2767	0.20

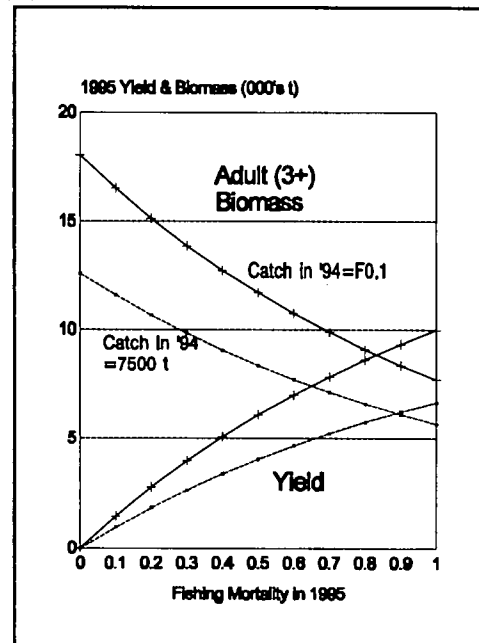


Figure 13 Projected yield in 1995 with two 1994 catch options

Management Considerations

Management of this resource in recent years has not been based on recommended catch quotas and introduction of ITQ's in 1992 and 1993 for the OTB fleet may have changed exploitation patterns. In 1993 the OTB fleet was allowed to fish during the spawning season. Exploitation rates have increased and spawning stock biomass (3+) is much lower than the average and may be at its lowest level. The fishery is mostly recruitment driven and recruitment has been variable and appears to be poor for 1993 and 1994. Total catches in 1994 of the same magnitude as taken in 1992/93 (~12000 t) could

result in fishing mortalities in excess of 1.0 and would result in a further reduction in stock biomass.

An immediate and substantial reduction in exploitation rates for both Canada and the USA is required if the decline in stock biomass is to be slowed or reversed. Distribution and migration studies suggest that the proportion of the total stock outside the Canadian zone would limit the results of unilateral management action by Canada due to loss of biomass to the USA zone through migration and potential harvesting by the USA. Consistent management objectives by the USA and Canada are required for the total stock.

Additional Studies

A tagging experiment was completed in March, 1994. Approximately 4000 cod were tagged and released in the 5Zj,m area on both sides of the International Maritime Boundary. Cod (and haddock) were tagged with yellow T-bar tags encoded with a dual Canada/USA return address. Most tagged fish were in either spawning or post-spawning condition. Length of tagged fish ranged from less than 40 cm to over 120 cm with modes at about 65 cm and 95 cm.

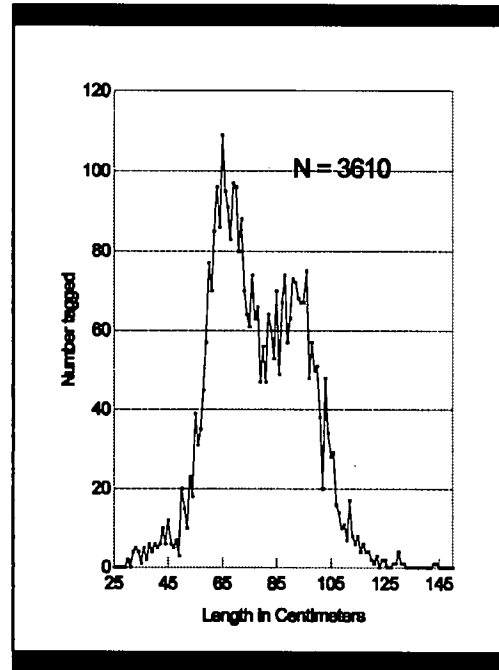


Figure 14 Length frequency of tagged cod, March 1994

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Table 1. Nominal landings (t) of cod by gear and month for Canada in unit areas 5Zjm. (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	
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	

Table 2. Summary of total catches (t) by Canada and the USA in unit areas 5Zjm for 1978-1993.

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

* preliminary

Table 3. Canadian and USA commercial landings samples for 1978-93.

	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

* preliminary

Table 4. Summary of commercial samples used to estimate catch at age in 1993.

GEAR	MONTH	WEIGHT (t)	LENGTHS	AGES	WEIGHT	GEAR TOTAL
a. Canadian catch						
OTB	JAN	835				
+MISC	FEB	1001	1069	---271	-----1924	
	MAR	88				
	APR	394				
	MAY	17	2374	-- 407	----- 1619	
	JUN	1207				
	JUL	595				
	AUG	163	2262	-- 334	----- 882	----- 4956
	SEP	124				
	OCT	238				
	NOV	179	1986	-- 275	----- 531	
	DEC	114				
LL	JAN	4				
	FEB	30				
	MAR	166				
	APR	76	340	--- 95	----- 846	----- 2387
	MAY	148				
	JUN	422				
	JUL	514				
	AUG	462	1334	-- 218	----- 1237	
	SEP	261				
	OCT	122				
	NOV	118	868	-- 228	----- 304	
	DEC	63				
GN	JUN	287				
	JUL	367	867	-- 141	----- 915	
	AUG	261				
	SEP	212	1058	-- 177	----- 260	----- 1175
	OCT	48				
Grand Total						----- 8519
b. USA catch						
	JAN	459				
	FEB	395	1106	-- 274	-----1311	
	MAR	457				
	APR	670				
	MAY	893	546	-- 166	-----1985	
	JUN	421				
	JUL	122				
	AUG	67	50	-- 0'	-----233	
	SEP	45				
	OCT	32				
	NOV	291	513	-- 0'	----- 491	
	DEC	168				
Grand Total						-----4019

* Canadian ages used to generate catch at age

Table 5. Catch at age of cod in numbers (000's) for Canada, USA and total, in 5Zjm, 1978-1993.

	AGEGROUP									TOTAL
	1	2	3	4	5	6	7	8	9	
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
91 CDN	11	493	512	1241	585	516	74	47	15	3483
USA	0	137	261	669	350	263	20	10	3	1713
TOT	11	630	773	1910	935	779	94	57	18	5196
92 CDN	70	1790	902	292	546	187	176	25	21	4009
USA	16	567	349	140	362	62	57	0	5	1558
TOT	86	2358	1251	432	908	250	233	25	27	5567
93 CDN	4	252	1068	594	171	244	91	69	17	2510
USA	0	162	900	214	44	88	19	24	6	1457
TOT	4	414	1968	808	215	332	110	93	23	3967

Table 6. Percent catch at age for Canada/USA landings, 1978-93.

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

Table 7. Mean size at age of cod in 5Zj,m derived from Canadian and USA samples combined, 1978-93.

(a) Length (cm)

Year	Age group							
	1	2	3	4	5	6	7	8
1978	39.5	48.8	60.7	68.3	73.7	81.4	88.5	92.9
1979	42.7	51.1	57.9	73.0	76.8	87.7	95.4	99.3
1980	41.8	50.7	60.7	69.6	80.7	85.5	92.5	95.1
1981	42.6	51.1	59.8	67.9	78.5	87.9	93.2	97.9
1982	40.6	50.0	62.3	70.7	79.3	84.8	96.1	97.9
1983	44.0	51.0	59.9	67.2	75.4	84.3	90.9	99.2
1984	45.3	52.7	60.6	69.3	77.9	85.1	94.5	98.6
1985	43.0	50.2	57.3	71.0	77.9	84.3	91.4	99.1
1986	43.4	50.9	60.5	69.5	80.5	87.7	94.5	98.1
1987	39.8	50.9	60.9	72.8	81.5	89.9	94.6	98.3
1988	40.9	51.4	59.8	68.6	79.5	85.4	94.0	98.2
1989	41.4	52.5	59.0	70.3	79.5	85.6	91.9	100.7
1990	41.7	51.8	60.7	68.6	76.8	84.0	92.8	100.4
1991	46.2	52.6	61.4	67.9	76.2	81.9	88.7	100.0
1992	46.7	51.6	60.7	70.7	75.8	83.2	89.1	97.8
1993	42.6	52.0	59.3	65.5	74.6	81.1	87.3	94.4
Mean	42.6	51.2	60.1	69.4	77.8	85.0	92.2	98.0

Table 8. Commercial fishery catch at age and mean weight at age for 5Zj,m cod

		Catch															
		78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
1	2	10	1	19	6	40	10	12	28	14	10	1	7	11	86	4	
2	121	814	987	603	2682	1319	269	2792	326	3666	320	740	678	626	2358	414	
3	3588	399	1495	1443	1686	3416	911	1221	2188	865	3653	652	3196	783	1251	1967	
4	1076	1774	265	1249	1429	1474	1346	631	513	1099	646	1837	962	1939	432	809	
5	307	545	916	155	1066	466	511	941	304	144	861	193	1195	953	908	215	
6	110	149	345	595	189	283	290	224	400	121	144	314	116	790	250	332	
7	83	22	109	169	345	31	230	96	58	167	102	56	122	93	233	110	
8	21	45	20	65	157	71	31	100	39	37	143	25	10	56	25	93	
1+	5308	3758	4138	4298	7560	7100	3598	6017	3856	6113	5879	3818	6286	5251	5543	3944	
2+	5306	3748	4137	4279	7554	7060	3588	6005	3828	6099	5869	3817	6279	5240	5457	3940	
3+	5185	2934	3150	3676	4872	5741	3319	3213	3502	2433	5549	3077	5601	4614	3099	3526	
4+	1597	2535	1655	2233	3186	2325	2408	1992	1314	1568	1896	2425	2405	3831	1848	1559	

		Weight (Mid-Year)															
		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.71	0.89	0.84	0.88	0.77	0.97	1.05	0.91	0.93	0.73	0.79	0.81	0.83	1.11	1.15	0.88	
2	1.31	1.49	1.46	1.50	1.40	1.49	1.64	1.42	1.48	1.48	1.52	1.62	1.56	1.63	1.54	1.57	
3	2.46	2.15	2.47	2.36	2.66	2.38	2.45	2.09	2.45	2.50	2.36	2.27	2.46	2.55	2.46	2.31	
4	3.47	4.21	3.67	3.42	3.83	3.31	3.62	3.89	3.66	4.19	3.51	3.77	3.52	3.42	3.84	3.08	
5	4.34	4.89	5.65	5.21	5.35	4.64	5.08	5.09	5.60	5.81	5.40	5.40	4.89	4.77	4.70	4.50	
6	5.79	7.18	6.68	7.22	6.51	6.39	6.58	6.41	7.19	7.73	6.65	6.69	6.33	5.89	6.16	5.73	
7	7.37	9.18	8.39	8.57	9.36	7.96	8.91	8.10	8.91	8.95	8.78	8.22	8.46	7.41	7.51	7.08	
8	8.49	10.31	9.09	9.89	9.90	10.29	10.10	10.24	9.96	10.01	9.99	10.72	10.65	10.52	9.85	8.88	

		Weight (Beginning-Year)																
		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.49	0.69	0.63	0.70	0.55	0.75	0.91	0.71	0.74	0.50	0.55	0.58	0.59	0.95	0.98	0.98	0.97	
2	0.96	1.03	1.14	1.12	1.11	1.07	1.26	1.22	1.16	1.17	1.05	1.13	1.12	1.16	1.31	1.34	1.27	
3	1.80	1.68	1.92	1.86	2.00	1.83	1.91	1.85	1.86	1.92	1.87	1.86	2.00	1.99	2.00	1.89	1.96	
4	2.92	3.22	2.81	2.90	3.01	2.97	2.93	3.09	2.76	3.20	2.96	2.98	2.83	2.90	3.13	2.75	2.93	
5	3.88	4.12	4.88	4.37	4.28	4.22	4.10	4.29	4.67	4.61	4.76	4.35	4.30	4.10	4.01	4.16	4.09	
6	5.01	5.58	5.71	6.39	5.83	5.85	5.52	5.71	6.05	6.58	6.21	6.01	5.85	5.37	5.42	5.19	5.33	
7	6.53	7.29	7.76	7.56	8.22	7.20	7.55	7.30	7.56	8.02	8.23	7.39	7.52	6.85	6.65	6.60	6.70	
8	7.91	8.72	9.14	9.11	9.21	9.81	8.97	9.55	8.98	9.45	9.45	9.70	9.36	9.43	8.54	8.17	8.71	
9	9.11	9.11	12.20	9.04	10.73	10.64	10.78	11.38	10.97	11.04	10.61	10.55	11.84	12.12	11.73	11.35	11.73	

Table 9a. Canadian/USA ageing comparison matrix of Georges Bank cod otoliths collected from the 1993

Nancy Munroe (USA ager)

	1	2	3	4	5	6	7	8	8	9+	Tot
1											
2		7									7
3		1	47								48
4			4	7							11
5					1						1
6					1	10					11
7							3	1	1		5
8								1	1		2
9								1			1
10										1	1
TOT		8	51	7	2	10	3	3	2	1	87

M-I. Buzeta (Canadian ager)

Number aged by both age readers = 87/90 = 97%

Percent agreement = 77/87 = 88.51%

Overaged by Canadian reader vs. USA reader = 7/10 = 7%

Underaged by Canadian reader vs. USA reader = 3/10 = 3%

Table 9b. Canadian ageing comparison matrix of initial and subsequent age assignment for Georges Bank cod otoliths from a commercial sample collected during the 1993 fishery. (CST, crystallized or unreadable otolith)

Initial reading

	1	2	3	4	5	6	7	8	9	10	CST	TOT
1	2											2
2		28	3									31
3			18								2	20
4				5	1							6
5				1	27	1	1				2	32
6					1	6	4	1				12
7							8	1	4			13
8								1	3			4
9												
10												
CST								1		1	5	7
TOT	2	28	21	6	29	7	13	4	7	1	9	127

Subsequent reading

Number aged both times = 95%

Percent agreement = 79% (includes detection of crystallization)

Initial reading relative to subsequent = +15% , -2%

Table 10. Indices of abundance for 5Zj,m cod- survey catch per tow and OTB catch rate
USA surveys adjusted for door and vessel conversion factors (Hunt and Buzeta, 1993)

USA SPRING																
	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
1	0.27	0.69	0.03	1.70	0.79	0.69	0.20	0.08	1.13	0.00	0.58	0.21	0.13	1.31	0.14	0.00
2	0.00	2.65	2.96	1.57	11.58	3.63	0.22	3.67	0.62	2.17	0.45	1.55	0.62	1.12	1.20	0.83
3	5.10	0.22	2.90	2.43	24.99	6.33	0.81	1.15	2.05	0.46	5.05	0.47	3.14	0.92	0.65	2.32
4	1.12	2.57	0.28	1.73	22.29	1.36	1.22	1.92	0.55	0.98	0.50	2.39	1.09	1.63	0.17	0.47
5	1.61	1.00	3.01	0.07	16.98	1.06	0.48	2.75	0.78	0.00	0.84	0.46	1.18	0.83	0.45	0.08
6	0.34	0.34	0.59	0.60	0.00	0.66	0.39	0.60	0.98	0.34	0.08	0.54	0.29	0.69	0.27	0.33
7	1.37	0.17	0.12	0.31	5.55	0.28	0.34	0.35	0.05	0.28	0.03	0.07	0.30	0.08	0.29	0.08
8	0.19	0.22	0.08	0.12	1.24	0.11	0.00	0.45	0.21	0.06	0.14	0.06	0.03	0.03	0.05	0.08

USA FALL **																	
	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
1	0.10	0.21	0.32	0.60	0.60	0.00	1.47	0.06	2.24	0.22	0.29	0.18	0.41	0.36	0.00	0.00	0.00
2	0.00	2.64	2.96	1.43	4.24	1.05	0.12	2.84	0.39	5.20	0.24	1.02	0.72	0.72	0.36	0.37	0.14
3	6.31	0.26	2.93	0.76	2.19	1.29	0.42	0.14	1.80	0.11	1.53	0.33	1.68	0.79	0.13	1.31	0.19
4	1.26	5.10	0.21	1.21	1.69	0.08	0.89	1.03	0.30	0.35	0.23	2.13	0.28	1.49	0.16	0.28	0.28
5	0.35	0.73	2.71	0.05	0.48	0.12	0.05	1.68	0.03	0.00	0.19	0.25	0.77	0.21	0.02	0.00	0.03
6	0.27	0.11	0.44	0.35	0.02	0.00	0.03	0.05	0.00	0.00	0.00	0.44	0.10	0.37	0.06	0.07	0.00
7	0.33	0.11	0.16	0.04	0.05	0.00	0.03	0.06	0.03	0.02	0.00	0.00	0.04	0.04	0.00	0.02	0.00
8	0.04	0.16	0.05	0.05	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00

** ages 0-7 in year t-1 used as beginning of year ages 1-8 in year t

CANADA SPRING									
	86	87	88	89	90	91	92	93	94
1	1.81	0.12	0.36	0.84	0.26	2.75	0.12	0.07	0.03
2	8.33	4.31	1.08	5.01	1.81	2.31	4.69	0.82	1.45
3	7.50	1.55	12.85	1.77	7.97	3.23	2.81	3.96	1.59
4	0.76	1.81	1.36	3.90	4.49	3.74	0.94	1.43	2.9
5	1.61	0.39	2.02	0.58	10.11	1.99	1.48	0.85	1.9
6	1.04	0.21	0.23	0.76	1.23	2.70	1.04	1.73	0.42
7	0.52	0.44	0.19	0.09	2.51	0.33	0.69	0.63	0.83
8	0.08	0.21	0.43	0.19	0.33	0.56	0.21	0.61	0.19

CANADA OTB CATCH RATE							
	87	88	89	90	91	92	93
2	0.51	0.04	0.19	0.05	0.06	0.25	0.03
3	0.11	0.36	0.12	0.20	0.05	0.10	0.10
4	0.11	0.04	0.15	0.06	0.10	0.03	0.05
5	0.01	0.04	0.01	0.06	0.03	0.04	0.01
6	0.01	0.01	0.02	0.01	0.02	0.01	0.02
7	0.01	0.00	0.00	0.00	0.00	0.01	0.01

Table 11. Catch rate standardization for Canadian otter trawlers 1987-93
using month and tonnage class as standards

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.539
MULTIPLE R SQUARED..... 0.290

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	8.532E3	8.532E3	
REGRESSION	13	8.532E2	6.563E1	98.678
TYPE 1	6	4.576E2	7.626E1	114.670
TYPE 2	6	3.924E2	6.540E1	98.333
TYPE 3	1	1.297E1	1.297E1	19.497
RESIDUALS	3137	2.086E3	6.651E-1	
TOTAL	3151	1.147E4		

REGRESSION COEFFICIENTS

CATEGORY	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
87	INTERCEPT	-1.161	0.048	3151
7				
2				
88	1	-0.432	0.073	197
89	2	-0.422	0.097	95
90	3	-0.693	0.060	399
91	4	-1.047	0.051	965
92	5	-0.539	0.056	564
93	6	-1.241	0.058	566
6	7	0.426	0.036	1424
8	8	-0.236	0.051	369
9	9	-0.236	0.069	172
2	10	1.537	0.085	119
11	11	-0.287	0.120	51
10	12	0.368	0.076	137
3	13	0.130	0.029	1496

STANDARDS USED VARIABLE NUMBERS: 7 13

PREDICTED CATCH RATE

YEAR	LN TRANSFORM		RETRANSFORMED		CATCH	EFFORT
	MEAN	S.E.	MEAN	S.E.		
87	-0.6048	0.0025	0.761	0.038	7608	10001
88	-1.0366	0.0039	0.494	0.031	7620	15436
89	-1.0273	0.0074	0.497	0.043	1987	3995
90	-1.2983	0.0022	0.380	0.018	7854	20651
91	-1.6516	0.0012	0.267	0.009	6698	25064
92	-1.1443	0.0016	0.444	0.018	5638	12704
93	-1.8459	0.0019	0.220	0.010	4890	22230

Table 12. Catch rate standardization for longline using days fished with month and tonnage class as standards

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.377
 MULTIPLE R SQUARED..... 0.142

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	8.489E2	8.489E2	
REGRESSION	16	1.550E2	9.689E0	15.005
TYPE 1	6	9.364E1	1.561E1	24.170
TYPE 2	9	5.670E1	6.300E0	9.757
TYPE 3	1	1.152E1	1.152E1	17.840
RESIDUALS	1453	9.382E2	6.457E-1	
TOTAL	1470	1.942E3		

REGRESSION COEFFICIENTS

CATEGORY	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
87	INTERCEPT	-1.108	0.099	1470
6				
3				
88	1	0.211	0.101	111
89	2	0.063	0.086	217
90	3	0.203	0.089	184
91	4	0.041	0.087	214
92	5	-0.066	0.086	245
93	6	-0.511	0.080	342
2	7	0.593	0.119	60
3	8	0.638	0.090	110
4	9	0.677	0.110	66
7	10	0.147	0.062	344
8	11	0.215	0.067	255
9	12	0.281	0.086	125
10	13	0.061	0.108	70
1	14	0.476	0.194	19
5	15	0.292	0.100	80
2	16	0.250	0.059	1170

STANDARDS USED VARIABLE NUMBERS: 10 2

PREDICTED CATCH RATE

YEAR	LN TRANSFORM		RETRANSFORMED		CATCH	EFFORT
	MEAN	S.E.	MEAN	S.E.		
87	-0.8978	0.0076	0.561	0.049	3212	5728
88	-0.6865	0.0169	0.689	0.089	4335	6288
89	-0.8978	0.0076	0.561	0.049	4425	7892
90	-0.6945	0.0146	0.685	0.082	5202	7597
91	-0.8565	0.0141	0.582	0.069	4706	8079
92	-0.9639	0.0134	0.523	0.060	4474	8549
93	-1.4093	0.0133	0.335	0.039	2387	7120

Table 13. Population estimates for 5Zj.m cod derived from ADAPT using survey and OTB catch rates

Population Numbers (Bias Adjusted)																	
	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
1	11355	9410	9164	17184	6252	4544	13507	4542	21569	7129	13999	4056	5311	10968	2705	1487	315
2	2209	9295	7695	7502	14052	5113	3684	11049	3708	17634	5824	11452	3320	4342	8970	2137	1214
3	10537	1699	6873	5407	5597	9078	2993	2773	6520	2741	11120	4479	8707	2104	2988	5210	1375
4	3522	5381	1030	4275	3121	3057	4341	1626	1165	3359	1461	5799	3077	4237	1014	1315	2486
5	1082	1910	2800	603	2370	1262	1169	2336	760	490	1755	612	3086	1649	1714	440	344
6	245	608	1070	1464	354	976	612	495	1062	348	271	658	326	1445	488	582	165
7	310	101	363	564	660	119	543	239	202	507	175	91	255	162	468	173	176
8	61	179	63	199	309	228	69	236	108	113	264	51	24	98	49	173	42
9	0	31	106	33	104	111	123	28	103	54	59	87	19	11	30	17	57
1+	29321	28613	29165	37231	32818	24487	27040	23324	35198	32373	34928	27285	24124	25015	18426	11533	6175
2+	17966	19203	20000	20047	26566	19944	13533	18783	13629	25244	20930	23229	18813	14047	15720	10046	5860
3+	15757	9908	12305	12545	12514	14830	9850	7733	9921	7610	15106	11777	15493	9706	6751	7909	4646
4+	5220	8209	5432	7138	6918	5753	6857	4961	3401	4870	3985	7298	6787	7601	3763	2699	3271
Population Biomass (Bias Adjusted)																	
	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
1	5523	6528	5729	12021	3427	3400	12256	3230	15870	3577	7671	2363	3154	10385	2655	1460	306
2	2125	9553	8767	8387	15626	5459	4642	13502	4288	20684	6118	12911	3729	5048	11756	2870	1545
3	18920	2850	13198	10032	11169	16572	5720	5121	12146	5257	20785	8318	17372	4196	5983	9829	2696
4	10290	17322	2891	12410	9385	9075	12733	5019	3220	10750	4324	17298	8698	12293	3174	3621	7280
5	4197	7864	13655	2638	10131	5323	4794	10025	3549	2259	8347	2663	13255	6757	6875	1828	1408
6	1226	3393	6115	9348	2061	5707	3381	2824	6420	2287	1683	3957	1907	7758	2642	3020	881
7	2025	735	2818	4267	5428	854	4096	1742	1529	4068	1441	676	1916	1111	3115	1141	1179
8	485	1558	573	1810	2845	2240	619	2256	974	1069	2497	495	226	925	415	1410	367
9	0	284	1287	300	1115	1180	1322	324	1129	591	628	916	227	130	348	195	671
1+	44791	50087	55034	61214	61187	49811	49562	44042	49125	50542	53495	49596	50484	48602	36962	25373	16331
2+	39269	43560	49304	49193	57760	46411	37306	40812	33255	46965	45823	47233	47330	38217	34308	23913	16025
3+	37143	34007	40538	40806	42134	40951	32664	27310	28967	26281	39705	34322	43601	33169	22552	21043	14481
4+	18223	31157	27339	30773	30965	24380	26945	22190	16821	21024	18920	26004	26229	28974	16569	11214	11784
Population Numbers (Mid-Year Bias Adjusted)																	
	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	
1	10291	8524	8306	15565	5664	4099	12237	4111	19535	6454	12683	3675	4810	9935	2410	1346	
2	1943	8023	6484	6503	11384	3959	3207	8587	3200	14128	5122	10017	2666	3623	6921	1728	
3	7672	1336	5472	4160	4199	6421	2241	1854	4766	2034	8173	3734	6206	1494	2038	3682	
4	2634	3951	798	3229	2053	1964	3236	1139	779	2471	976	4301	2289	2788	687	724	
5	823	1450	2060	467	1571	898	784	1616	527	370	1118	454	2163	953	1048	281	
6	162	475	791	1009	215	738	396	327	751	252	165	425	235	867	304	339	
7	238	80	273	424	407	92	368	165	153	373	101	51	164	94	296	93	
8	45	139	46	146	193	170	46	160	78	83	159	33	17	57	30	104	
1+	23807	23979	24229	31504	25687	18341	22515	17959	29789	26164	28497	22689	18548	19811	13734	8297	
2+	13517	15455	15923	15939	20023	14242	10278	13848	10254	19709	15814	19014	13739	9876	11324	6951	
3+	11574	7432	9439	9436	8639	10283	7071	5262	7054	5582	10692	8997	11073	6253	4403	5223	
4+	3902	6095	3968	5276	4440	3862	4831	3407	2288	3548	2519	5263	4867	4759	2365	1541	
Population Biomass (Mid-Year Bias Adjusted)																	
	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	
1	7275	7577	6944	13729	4333	3980	12886	3728	18148	4686	9969	2973	3997	11068	2767	1189	
2	2545	11987	9466	9722	15961	5899	5243	12176	4720	20923	7785	16197	4159	5894	10671	2715	
3	18882	2872	13504	9809	11187	15263	5492	3868	11662	5075	19280	8473	15278	3806	5022	8497	
4	9138	16638	2926	11028	7873	6498	11711	4427	2853	10345	3425	16222	8062	9534	2642	2230	
5	3567	7087	11634	2437	8408	4165	3985	8221	2955	2147	6040	2450	10580	4545	4930	1261	
6	939	3411	5277	7288	1401	4719	2609	2096	5397	1943	1098	2844	1486	5107	1869	1944	
7	1757	737	2288	3631	3808	729	3283	1337	1368	3334	883	415	1388	698	2224	655	
8	379	1433	422	1446	1914	1749	463	1642	775	833	1592	349	176	602	297	928	
1+	44481	51742	52461	59089	54884	43002	45671	37496	47876	49287	50072	49924	45126	41254	30422	19419	
2+	37206	44164	45518	45360	50551	39022	32785	33767	29728	44601	40103	46951	41129	30186	27655	18230	
3+	34661	32177	36051	35638	34590	33123	27542	21591	25008	23678	32318	30753	36970	24291	16984	15515	
4+	15779	29305	22547	25829	23403	17861	22051	17723	13346	18603	13038	22281	21692	20485	11962	7018	
Fishing Mortality (Bias Adjusted)																	
	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	
1	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00			
2	0.06	0.10	0.15	0.09	0.24	0.34	0.08	0.33	0.10	0.26	0.06	0.07	0.26	0.17	0.34	0.24	
3	0.47	0.30	0.27	0.35	0.40	0.54	0.41	0.67	0.46	0.43	0.45	0.18	0.52	0.53	0.62	0.54	
4	0.41	0.45	0.33	0.39	0.71	0.76	0.42	0.56	0.67	0.45	0.67	0.43	0.42	0.70	0.64	1.14	
5	0.38	0.38	0.45	0.33	0.69	0.52	0.66	0.59	0.58	0.39	0.78	0.43	0.56	1.02	0.88	0.78	
6	0.69	0.32	0.44	0.60	0.89	0.39	0.74	0.69	0.54	0.49	0.89	0.75	0.50	0.93	0.84	1.00	
7	0.35	0.28	0.40	0.40	0.86	0.34	0.63	0.59	0.38	0.45	1.03	1.13	0.75	1.01	0.80	1.21	
8	0.48	0.33	0.43	0.45	0.82	0.42	0.69	0.63	0.51	0.45	0.91	0.78	0.61	1.00	0.84	0.91	
3+	0.45	0.40	0.34	0.40	0.58	0.57	0.48	0.62	0.50	0.44	0.53	0.36	0.51	0.76	0.72	0.71	

Table 14. Parameter estimates derived from ADAPT

Parameter	PAR. EST.	STD. ERR.	REL. ERR.	BIAS	REL. BIAS
ORTHOGONALITY OFFSET..... 0.002561					
MEAN SQUARE RESIDUALS 0.653403					
Popn 1	6.229E0	8.610E-1	1.382E-1	7.974E-3	1.280E-3
2	7.239E0	4.938E-1	6.822E-2	6.204E-3	8.570E-4
3	7.288E0	3.521E-1	4.830E-2	-1.700E-3	-2.332E-4
4	7.881E0	3.805E-1	4.828E-2	-1.137E-2	-1.443E-3
5	5.949E0	4.870E-1	8.187E-2	-1.663E-2	-2.795E-3
6	5.226E0	5.374E-1	1.028E-1	-3.379E-2	-6.465E-3
7	5.314E0	5.881E-1	1.107E-1	-3.893E-2	-7.325E-3
8	3.915E0	6.448E-1	1.647E-1	-4.658E-2	-1.190E-2
USS 1	4.138E-5	8.000E-6	2.175E-1	8.208E-7	1.984E-2
2	2.190E-4	4.602E-5	2.101E-1	4.003E-6	1.828E-2
3	3.741E-4	7.587E-5	2.028E-1	6.503E-6	1.738E-2
4	4.476E-4	9.071E-5	2.027E-1	7.609E-6	1.700E-2
5	6.260E-4	1.313E-4	2.097E-1	1.182E-5	1.887E-2
6	6.712E-4	1.408E-4	2.097E-1	1.266E-5	1.886E-2
7	8.490E-4	1.724E-4	2.030E-1	1.586E-5	1.868E-2
8	1.021E-3	2.138E-4	2.095E-1	2.283E-5	2.236E-2
USF 1	3.685E-5	8.283E-6	2.248E-1	7.943E-7	2.155E-2
2	1.421E-4	2.926E-5	2.060E-1	2.453E-6	1.726E-2
3	1.577E-4	3.121E-5	1.980E-1	2.633E-6	1.670E-2
4	2.185E-4	4.325E-5	1.980E-1	3.700E-6	1.694E-2
5	1.460E-4	3.087E-5	2.115E-1	3.161E-6	2.165E-2
6	1.996E-4	4.685E-5	2.347E-1	4.724E-6	2.366E-2
7	1.775E-4	4.157E-5	2.343E-1	4.340E-6	2.446E-2
8	5.924E-4	1.955E-4	3.300E-1	3.219E-5	5.433E-2
CDN 1	5.916E-5	1.753E-5	2.964E-1	2.127E-6	3.595E-2
2	5.117E-4	1.425E-4	2.785E-1	1.627E-5	3.180E-2
3	8.741E-4	2.398E-4	2.744E-1	2.812E-5	3.217E-2
4	8.730E-4	2.396E-4	2.744E-1	2.849E-5	3.264E-2
5	1.468E-3	4.074E-4	2.774E-1	5.159E-5	3.514E-2
6	1.560E-3	4.349E-4	2.788E-1	5.837E-5	3.742E-2
7	2.158E-3	6.076E-4	2.816E-1	8.752E-5	4.056E-2
8	3.241E-3	9.271E-4	2.861E-1	1.517E-4	4.680E-2
OTB 2	1.860E-5	5.785E-6	3.111E-1	7.585E-7	4.078E-2
3	3.793E-5	1.175E-5	3.098E-1	1.553E-6	4.093E-2
4	3.896E-5	1.209E-5	3.104E-1	1.594E-6	4.091E-2
5	2.894E-5	9.037E-6	3.122E-1	1.262E-6	4.362E-2
6	3.251E-5	1.018E-5	3.132E-1	1.456E-6	4.479E-2
7	2.629E-5	8.275E-6	3.148E-1	1.285E-6	4.887E-2

Table 15. Bias adjustment for population estimates

	PAR. EST.	STD. ERR.	REL. ERR.	BIAS	REL. BIAS
Age 1	507	437	0.86	192	0.38
2	1393	688	0.49	178	0.13
3	1463	515	0.35	88	0.06
4	2647	1007	0.38	162	0.06
5	383	187	0.49	39	0.10
6	186	100	0.54	21	0.11
7	203	120	0.59	27	0.13
8	50	32	0.64	8	0.16

Table 16. Residuals for survey and catch rate indices used in ADAPT

RESIDUALS BEGINNING OF YEAR INDICES)

USA Spring																
	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
1	-0.55	0.57	-2.54	0.87	1.12	1.30	-1.03	-0.85	0.24	0.00	0.01	0.21	-0.54	1.03	0.18	0.00
2	0.00	0.26	0.56	-0.05	1.33	1.18	-1.30	0.42	-0.27	-0.58	-1.05	-0.49	-0.17	0.15	-0.52	0.52
3	0.26	-1.06	0.12	0.18	2.48	0.62	-0.32	0.10	-0.17	-0.80	0.19	-1.28	-0.04	0.14	-0.56	0.14
4	-0.34	0.07	-0.50	-0.10	2.77	0.01	-0.46	0.97	0.05	-0.43	-0.27	-0.08	-0.24	-0.16	-1.01	-0.26
5	0.87	-0.18	0.54	-1.68	2.44	0.29	-0.42	0.63	0.49	0.00	-0.27	0.18	-0.49	-0.23	-0.89	-1.29
6	0.73	-0.18	-0.19	-0.49	0.00	0.01	-0.05	0.59	0.32	0.38	-0.82	0.20	0.28	-0.34	-0.22	-0.22
7	1.65	0.69	-0.94	-0.43	2.29	1.03	-0.30	0.55	-1.23	-0.42	-1.60	-0.10	0.33	-0.54	-0.31	-0.66
8	1.11	0.19	0.23	-0.52	1.38	-0.75	0.00	0.63	0.64	-0.65	-0.65	0.15	0.20	-1.20	0.01	-0.77

USA Fall																	
	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
1	-1.43	-0.50	-0.05	-0.05	0.96	0.00	1.08	-1.03	1.04	-0.18	-0.58	0.17	0.72	-0.14	0.00	0.00	0.00
2	0.00	0.69	1.00	0.29	0.75	0.37	-1.47	0.59	-0.30	0.73	-1.24	-0.47	0.41	0.14	-1.29	0.15	-0.35
3	1.33	-0.03	1.00	-0.11	0.91	-0.10	-0.12	-1.14	0.56	-1.37	-0.14	-0.77	0.19	0.85	-1.31	0.43	-0.19
4	0.49	1.47	-0.07	0.26	0.91	-2.12	-0.06	1.06	0.16	-0.74	-0.33	0.52	-0.88	0.46	-0.36	-0.06	-0.73
5	0.88	0.97	1.89	-0.56	0.33	-0.43	-1.23	1.60	-1.31	0.00	-0.30	1.03	0.54	-0.15	-2.55	0.00	-0.62
6	1.71	-0.10	0.73	0.18	-1.26	0.00	-1.40	-0.68	0.00	0.00	0.00	1.21	0.43	0.25	-0.51	-0.56	0.00
7	1.79	1.82	0.91	-0.91	-0.85	0.00	-1.16	0.35	-0.18	-1.50	0.00	0.00	-0.12	0.33	0.00	-0.48	0.00
8	0.10	0.42	0.30	-0.85	0.00	-0.81	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00

Canadian Spring									
	86	87	88	89	90	91	92	93	94
1	0.35	-1.26	-0.84	1.24	-0.21	1.42	-0.34	-0.37	0.00
2	1.48	-0.74	-1.02	-0.16	0.05	0.02	-0.00	-0.34	0.71
3	0.27	-0.44	0.28	-0.80	0.04	0.55	0.05	-0.18	0.22
4	-0.29	-0.48	0.06	-0.26	0.51	0.00	0.03	0.18	0.25
5	0.37	-0.61	-0.24	-0.44	0.80	-0.20	-0.55	0.22	0.66
6	-0.46	-0.95	-0.61	-0.30	0.88	0.18	0.29	0.59	0.37
7	0.18	-0.91	-0.68	-0.78	1.52	-0.06	-0.37	0.47	0.64
8	-1.48	-0.55	-0.68	0.15	1.44	0.57	0.29	0.10	0.16

RESIDUALS (MID-YEAR INDICES)

Canadian OTB catch rates							
	87	88	89	90	91	92	93
2	0.67	-0.84	0.03	-0.08	-0.20	0.62	-0.19
3	0.39	0.15	-0.14	-0.17	-0.13	0.26	-0.36
4	0.13	0.06	-0.09	-0.39	-0.13	-0.04	0.45
5	-0.54	0.12	-0.19	-0.05	0.22	0.19	0.24
6	-0.27	0.23	0.11	-0.28	-0.18	-0.04	0.41
7	-0.12	-0.07	-0.73	0.15	-0.17	0.06	0.89

Table 17. Results of catch projections with two options for 1994 catches - $F_{0.1}$ and a 7500 t catch

Projected Population Numbers
(Mid-Year)

	94	95
1	1449	5435
2	1070	1154
3	1166	796
4	2049	807
5	284	1373
6	136	190
7	145	91
8	35	97
1+	6334	9944
2+	4885	4508
3+	3814	3354
4+	2649	2559

Projected Population Biomass
(Mid-Year)

	94	95
1	1520	5698
2	1691	1823
3	2844	1941
4	7063	2781
5	1321	6395
6	808	1127
7	1063	670
8	338	948
1+	16648	21383
2+	15129	15685
3+	13438	13862
4+	10593	11921

Projected Fishing Mortality

	94	95
1	0.00	0.00
2	0.06	0.06
3	0.14	0.14
4	0.20	0.20
5	0.20	0.20
6	0.20	0.20
7	0.20	0.20
8	0.20	0.20

Projected Catch Numbers

	94	95
1	1	5
2	62	66
3	163	111
4	410	161
5	57	275
6	27	38
7	29	18
8	7	19
1+	756	695
2+	755	690
3+	693	623
4+	530	512

Projected Catch Biomass

	94	95
1	2	6
2	97	105
3	398	272
4	1413	556
5	264	1279
6	162	225
7	213	134
8	68	190
1+	2616	2767
2+	2614	2761
3+	2517	2656
4+	2119	2384

Projected Population Numbers
(Mid-Year)

	94	95
1	1448	5435
2	999	1151
3	991	687
4	1634	566
5	226	827
6	109	115
7	116	55
8	28	59
1+	5550	8894
2+	4102	3459
3+	3103	2308
4+	2112	1621

Projected Population Biomass
(Mid-Year)

	94	95
1	1518	5698
2	1578	1818
3	2418	1677
4	5633	1950
5	1054	3850
6	644	679
7	848	403
8	270	571
1+	13962	16646
2+	12445	10948
3+	10866	9130
4+	8448	7453

Projected Fishing Mortality

	94	95
1	0.00	0.00
2	0.20	0.06
3	0.50	0.14
4	0.71	0.20
5	0.71	0.20
6	0.71	0.20
7	0.71	0.20
8	0.71	0.20

Projected Catch Numbers

	94	95
1	5	5
2	204	66
3	491	96
4	1156	113
5	160	165
6	77	23
7	82	11
8	20	12
1+	2193	492
2+	2188	487
3+	1985	420
4+	1494	324

Projected Catch Biomass

	94	95
1	5	6
2	322	105
3	1197	235
4	3984	390
5	745	770
6	456	136
7	600	81
8	191	114
1+	7500	1836
2+	7495	1830
3+	7173	1725
4+	5976	1491

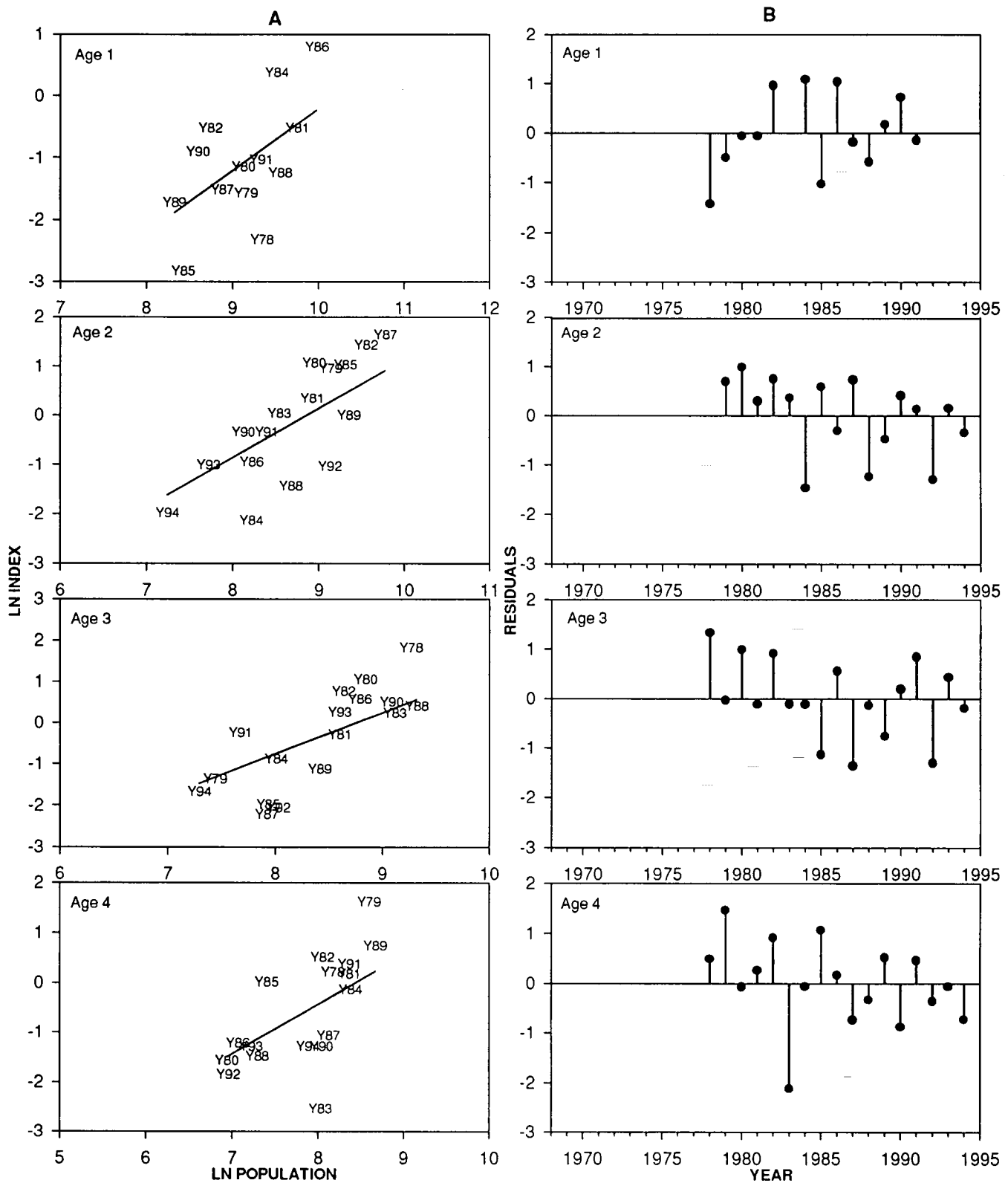


Fig.15a. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the USA fall survey for cod in unit areas 5Zj and 5Zm.

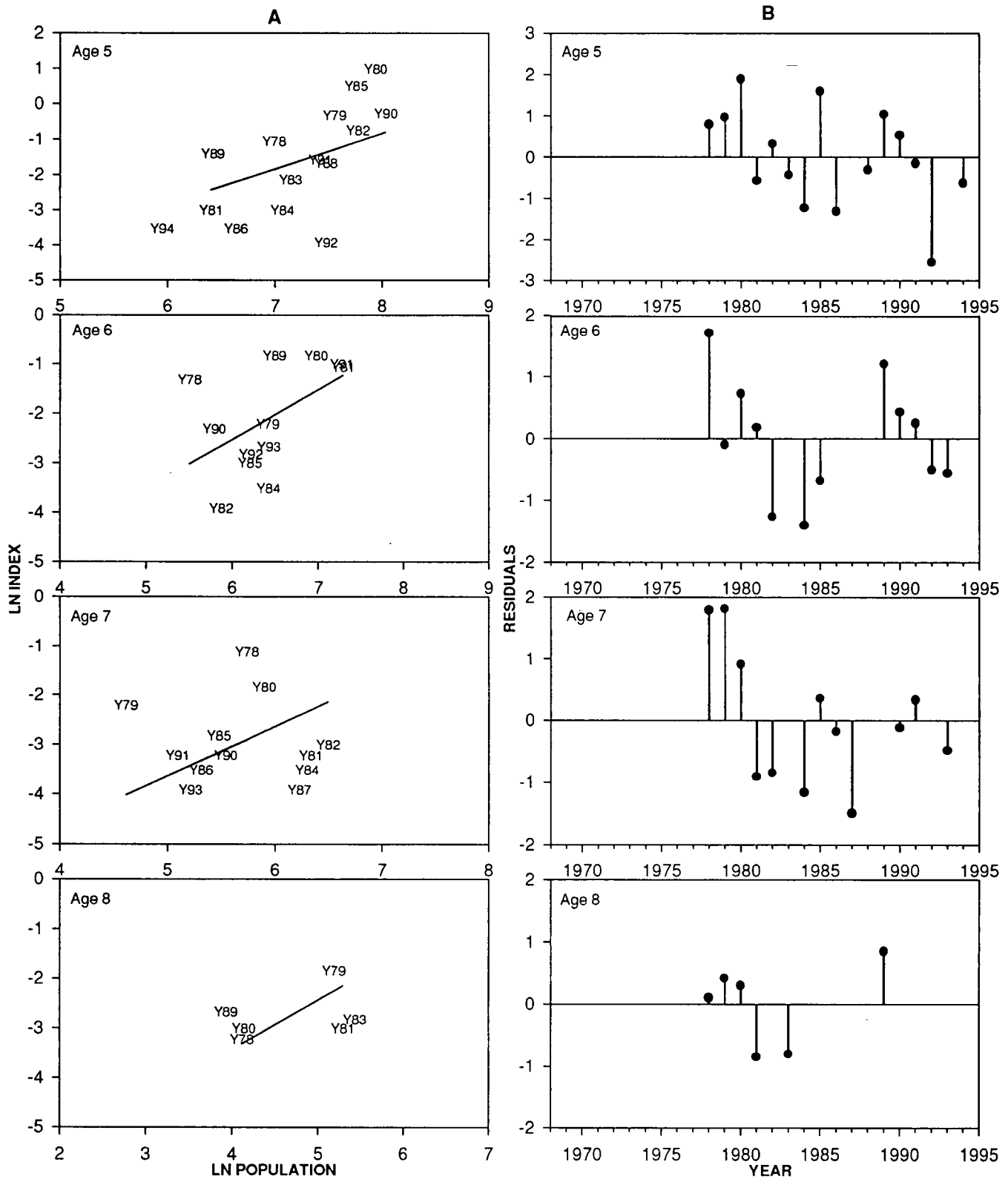


Fig.15b. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the USA fall survey for cod in unit areas 5Zj and 5Zm.

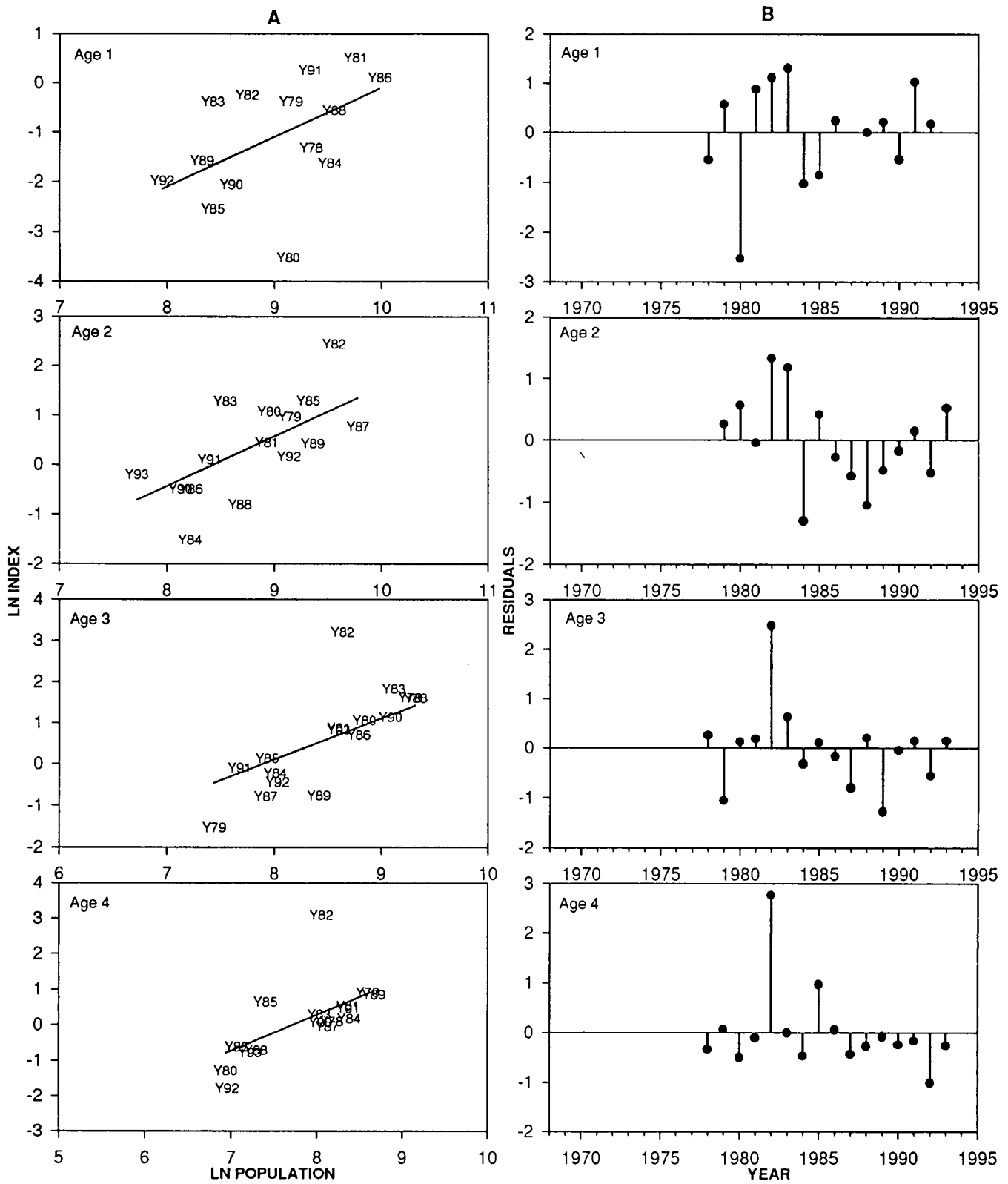


Fig.16a. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the USA spring survey for cod in unit areas 5Zj and 5Zm.

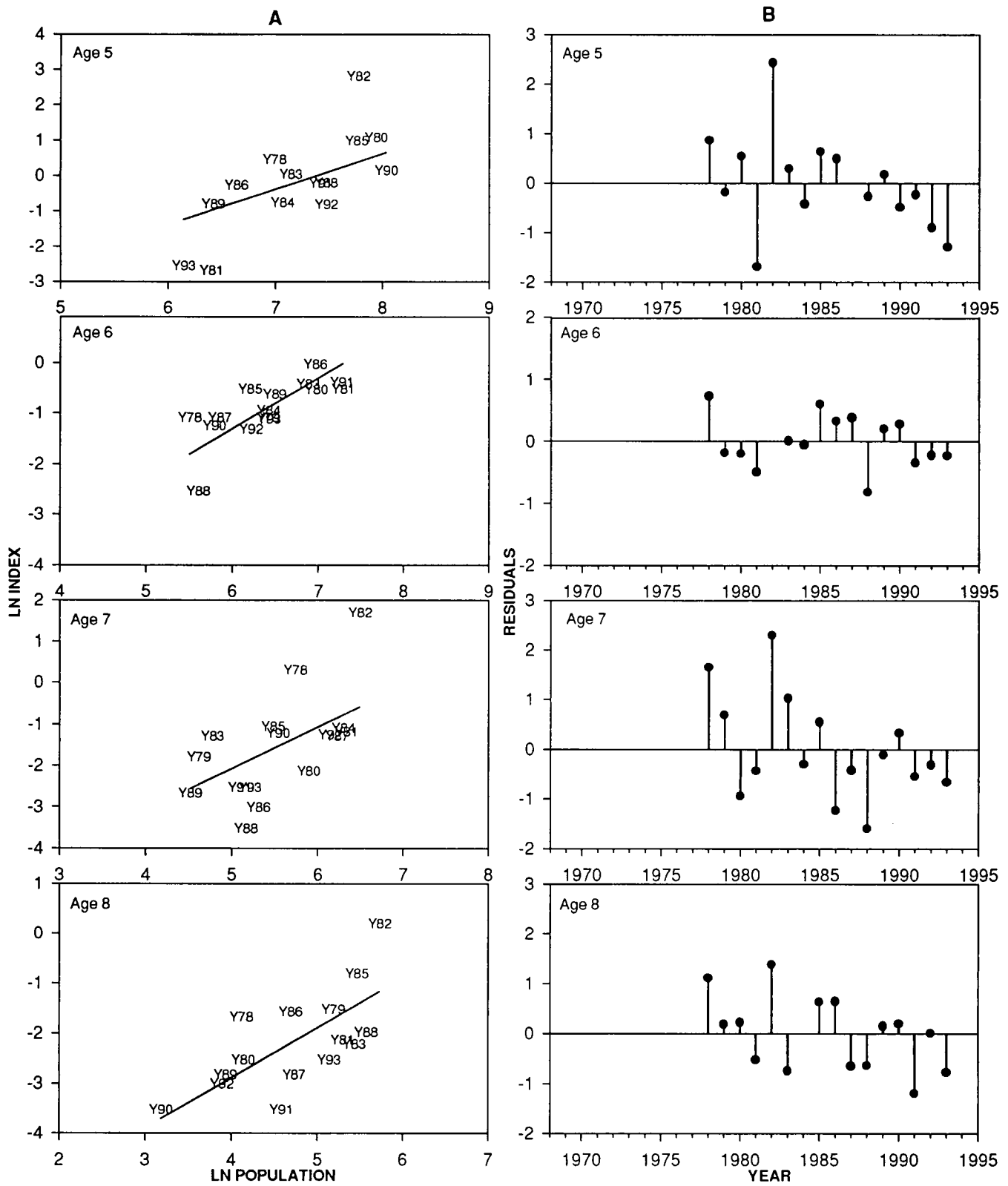


Fig.16b. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the USA spring survey for cod in unit areas 5Zj and 5Zm.

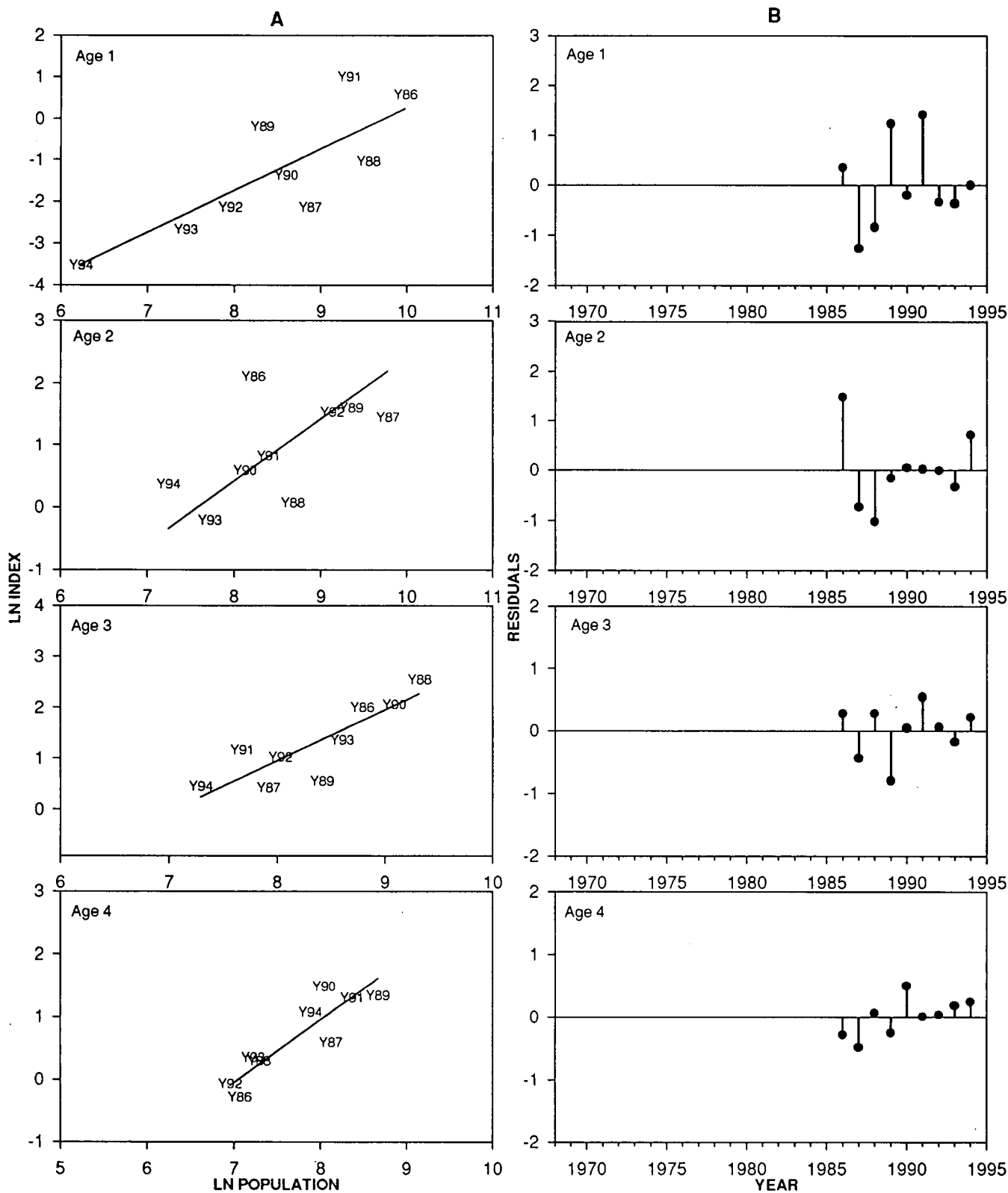


Fig.17a. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the Canadian spring survey for cod in unit areas 5Zj and 5Zm.

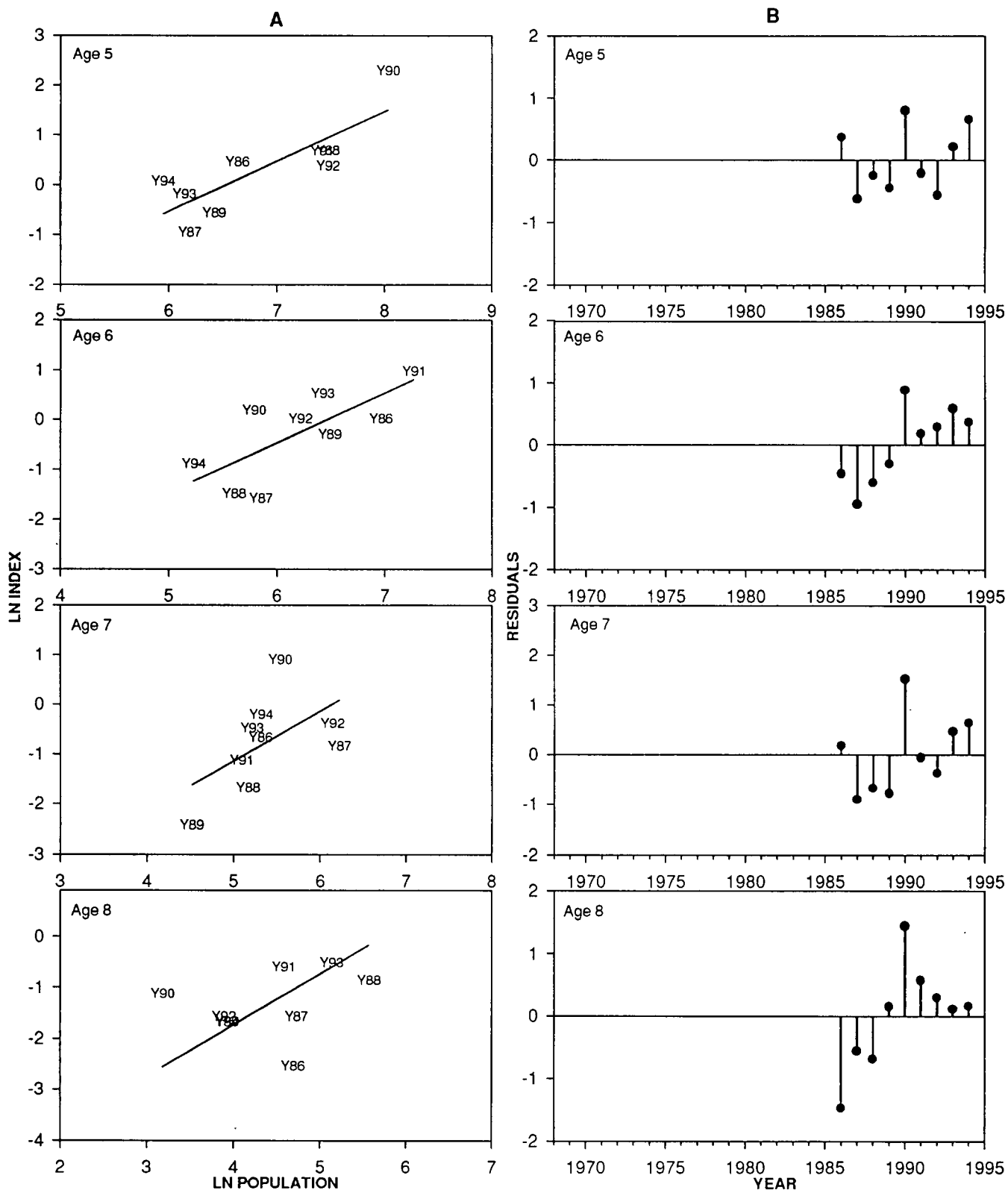


Fig. 17b. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the Canadian spring survey for cod in unit areas 5Zj and 5Zm.

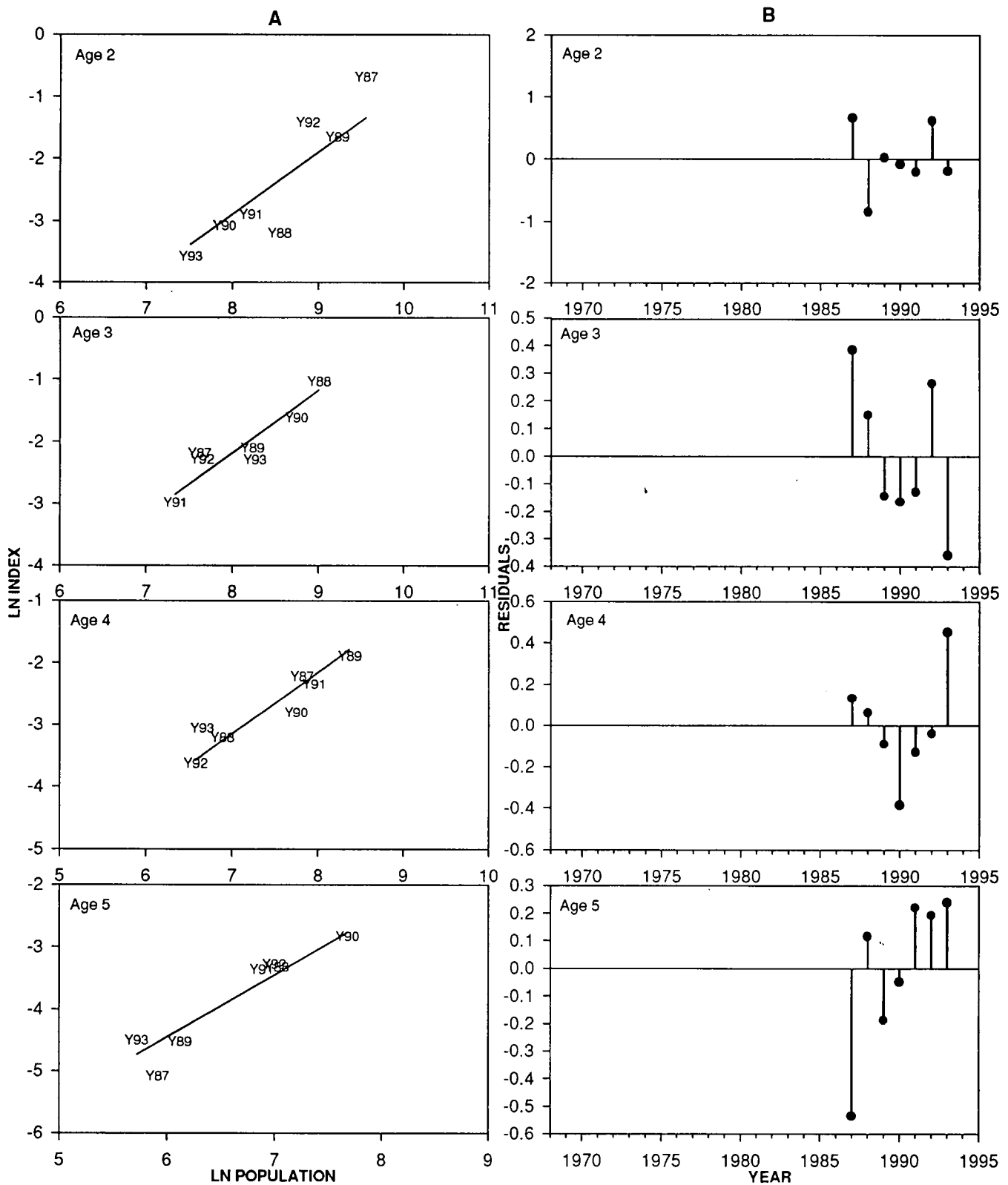


Fig.18a. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the Canadian commercial OTB catch rate for cod in unit areas 5Zj and 5Zm.

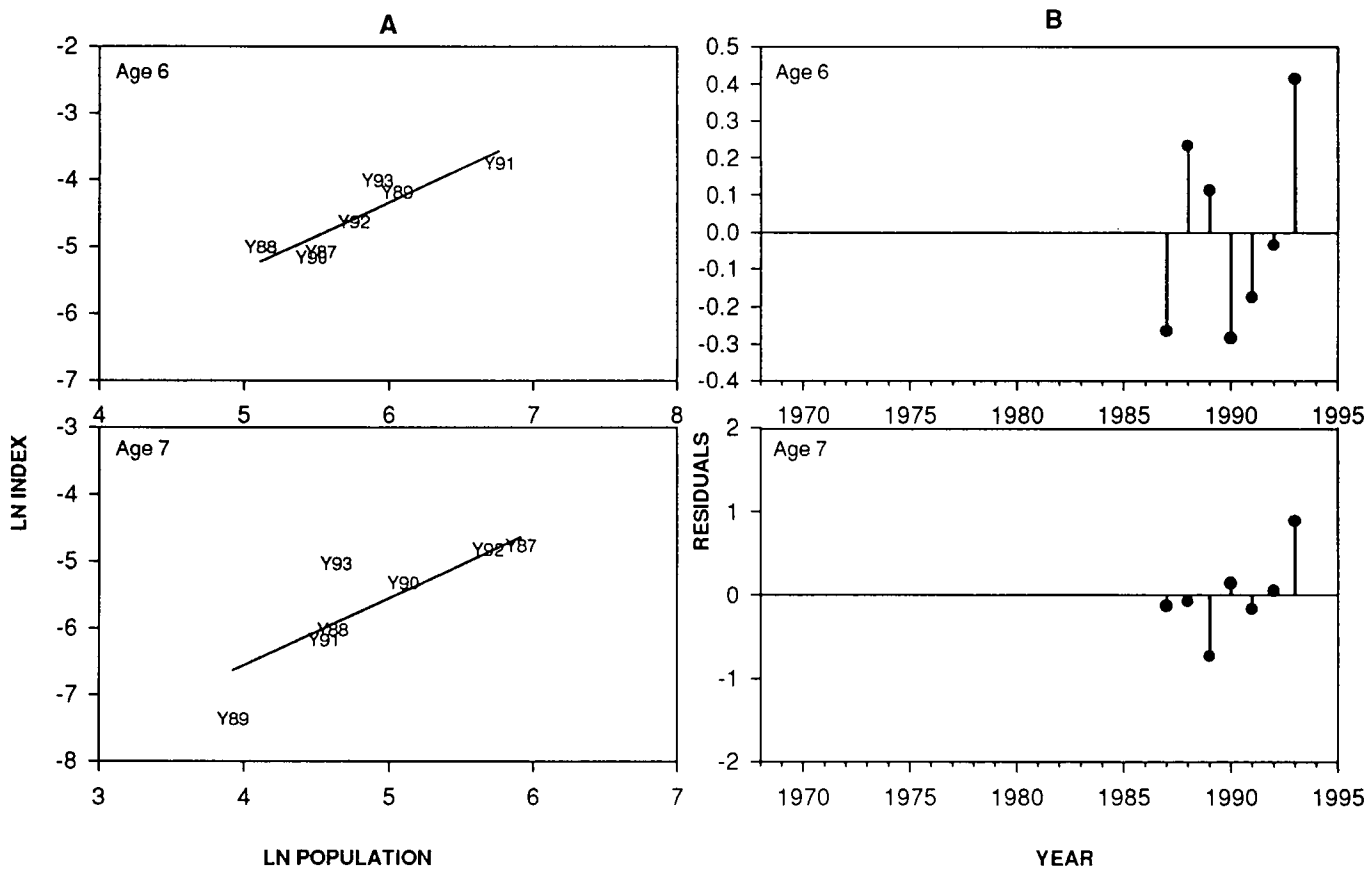


Fig.18b. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the Canadian commercial OTB catch rate for cod in unit areas 5Zj and 5Zm.