Biological Update of Georges Bank Cod in Unit Areas 5Zj,m for 1978-94

by

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Abstract

Total landings for cod in Div.5Zj,m are estimated to be 7,200 t . Canadian landings decreased by about 3,200 t from 1993 to the lowest since 1978; USA landings were also the lowest in the time series. The 1990 year class at age 4 continues to be dominant (42% in numbers) in landings. Canadian and USA surveys mean catch per tow continue the decline which started in 1990. A catch rate standardization for Canadian vessels indicates a substantial decline in CPUE. An ADAPT formulation using the three survey indices and the otter trawl CPUE was used to estimate stock abundance. Biomass and numbers of fish continue to decline and are now at the lowest observed in the 1978-94 time period. Exploitation rates have been greater than 40% and peaked near 50% in the 1990's. Recruitment since the 1990 year classes appears to be well below average. Catch projection for 1995 at the $F_{0.1}$ reference level indicates a yield of about 2,500 t with no substantial increase in stock biomass. Exploitation at a level lower than $F_{0.1}$ is required in order for stock rebuilding to occur.

Résumé

On estime que les débarquements totaux de morue provenant des divisions 5Zj,m se chiffrent à 7 200 t. Les débarquements canadiens ont diminué d'environ 3 200 t par rapport à 1993, pour atteindre leur plus bas seuil depuis 1978; ceux des États-Unis sont tombés à leur plus bas niveau de la série chronologique. La classe d'âge de 1990 (âge 4) était prédominante (42 % du nombre) dans les débarquements. Les relevés de recherche canadiens et américains confirment le déclin des prises moyennes par trait amorcé en 1990. Le taux de prises normalisé des navires canadiens dénote une baisse importante des PUE. Une analyse ADAPT fondée sur les indices des trois relevés de recherche et sur les PUE au chalut à panneaux a servi à estimer l'abondance du stock. La biomasse et le nombre de poissons continuent de diminuer; ils ont atteint le plus bas niveau enregistré dans la période 1978-1994. Les taux d'exploitation ont été supérieurs à 40 %, culminant à près de 50 %, dans les années 1990. Le recrutement depuis l'apparition de la classe d'âge de 1990 semble très inférieur à la moyenne. Les projections pour 1995 au niveau de référence $F_{0,1}$ dénotent un rendement d'environ 2 500 t et une baisse constante de la biomasse du stock. Une exploitation à un niveau inférieur à $F_{0,1}$ s'impose pour permettre la reconstitution du stock.

Introduction

This report incorporates commercial catch data and research survey results for the 1978-95 time period to the estimate stock status of cod in the two unit areas 5Zj and 5Zm (5Zj,m). (Appendix, Fig 1). Definition of this management unit was based on analysis of tagging results and commercial and survey catch distribution (Hunt, 1990).

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.

Trends in Reported Landings

Catches of 5Zj,m cod prior to 1978 are considered under-reported for both domestic and foreign fleets with substantial discarding (Hunt and Buzeta, 1994). Therefore, the present analysis is limited to the 1978-present time period.

Fishery by Country and Gear

Canadian catches of Georges Bank cod are taken primarily between June 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. 1). In recent years the proportion of total landings taken by fixed gears (longline and gillnet) has 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. Canadian landings in 1994 were 5,300t and well below the previous 15 year average (10,500t). Total allowable Canadian catch in 1994 was 6,000t and the fishery was closed until June 1st.. 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 .

The USA fishery is typically concentrated in the first half of the year. There has been some shift in the USA fishery towards the second quarter in recent years as well as a complete closure from January to July in 1995. USA landings in 1994 are estimated to be about 2,000t. Ongoing changes in the USA reporting system precludes a more precise estimate at this time. Expansion of the USA defined closed area (Appendix Fig. 1) in the vicinity of the international boundary and extension of the closure until July had a substantial impact on the USA fishery.

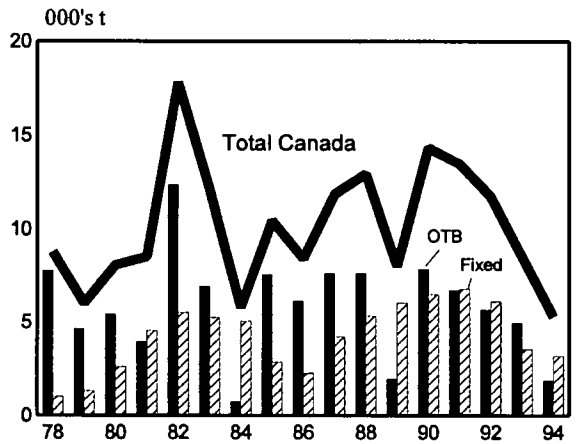

Figure 1. Canadian landings (000's t) by mobile (OTB) and longline and gillnet (fixed) gear type.

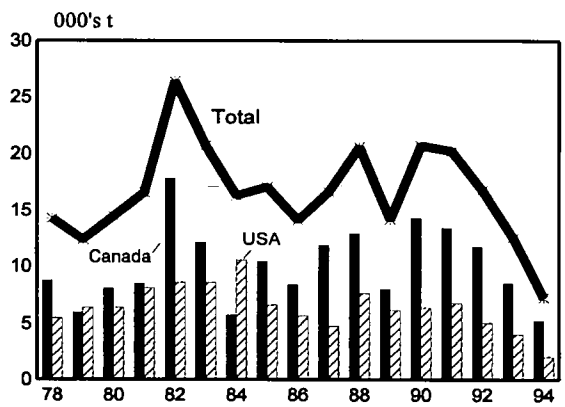

Figure 2. Landings (000's t) of cod from 5Zj,m by Canada and the U.S.A

Catches by Canada and the USA in 5Zj,m for 1978-94 are summarized in Table 2, Fig. 2). Combined catches peaked at 26,000 t in 1982, averaged 15,000 t between 1983-87 and increased to 20,000 t in 1988. The reduction in 1989 to 14,000 t was a result of decreased mobile gear catch by both Canada and the USA. Landings in 1991 were about 20,000 t, decreased by 3,000 t in 1992, by an additional 4,000 t in 1993 to 12,538 t and were the lowest observed in 1994 at 7,277 t. Since 1985, Canada has continued to take about 65% of the total catch.

Industry Consultations

In addition to individual contacts, meetings with industry representatives were held March 27th, 1995 in Yarmouth and Shelburne, N.S. 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. There was a general 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 had 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. Closure until June in 1994, a lower TAC, avoidance of 'cod' areas to ensure filling the haddock TAC and redirection for flounder probably had a negative impact on mobile catch rates in 1994. Fishermen noted that the Georges Bank fishery had become more of a mixed species with reductions in targeting for cod.

A detailed analysis of longline catch rate in 1994 was not possible because the unit of effort (days fished) was not available. Fishermen indicated that longliner catch rates were higher in 1994 compared to 1993.

Age Composition of the Commercial Catch

Sampling Intensity

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 to about one sample per 500 t. Both landings samples and observer samples were used to estimate catch at age for 1994. A summary of sampling data is given in Table 3. Combinations of length and age samples used to estimate the 1994 catch at age for Canada 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 results of Hunt's study (1993) which concluded that no significant difference in probability of age at length exists between gears.

No sampling data were available for 1994 USA landings. Therefore the Canadian mobile gear catch at age was prorated to reflect the 2,000t estimated USA catch.

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,

$$\text{weight (kg)} = 0.0000163 \times \text{length}^{2.9048}$$

Precision of ageing estimates was derived from inter- and intra-reader comparisons of otolith exchange samples. 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 agreements of 78 and 83%. These are somewhat below results of previous exchanges (87 and 89), but represent samples which were randomly selected. There appears to be a bias by which 76% of the disagreements have been assigned as 1 year older. Ageing comparisons are shown in Table 5a-d. Ongoing studies of Georges Bank cod otolith characteristics continue to increase accuracy of age determinations. No age specific bias is detected in the Canada/USA exchanges or the Canadian precision test.

The inter-ager comparison for the two Canadian age readers shows 82% agreement. There appears to be a negative bias in the comparison, primarily due to an age 3 and 4 disagreement. Only one of the three samples as read by the secondary age reader has been entered into the database, and the agreement in that case was 90%. Training and comparisons between the Canadian age readers continues.

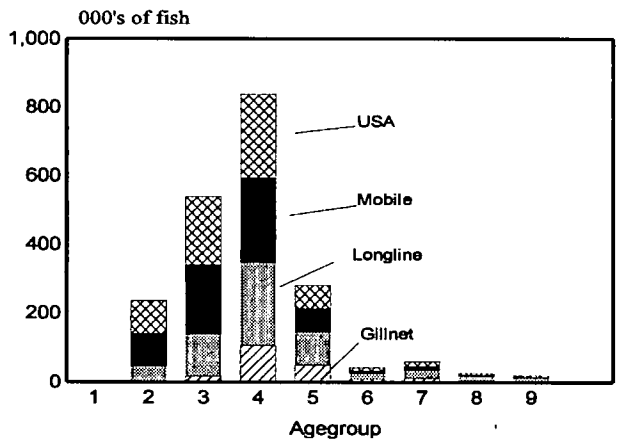

Figure 3. Canadian catch at age (000's) in 1994.

Estimated total removals at age are given in Table 6 by country for 1978-94. Canadian landings of 5Zj,m cod were dominated by the 1990 year class (41% by number) at age four in 1994 (Table 7, Fig 3). An analysis of Observer at sea length samples indicated a very similar length distribution compared to that derived from landings with no evidence of discarding.

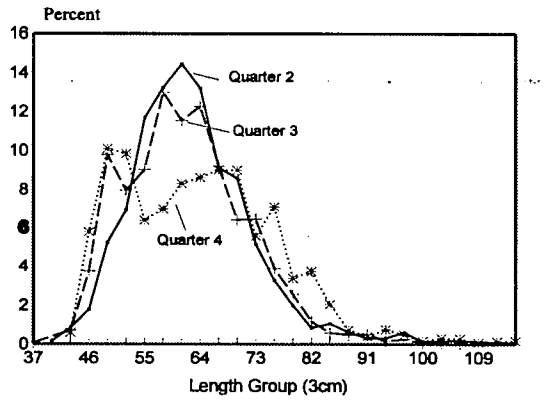

Figure 4. Percent catch at length for Canadian mobile gear in 1994.

Catch at length for mobile gear is shown in Figure 4 and shows a dominant mode at about 60 cm. Smaller fish (~50 cm) were taken in the third and fourth quarters.

Mean length at age from Canadian samples are given in Table 8. 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 9a.

Stock Abundance Trends

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 Hayes and Buxton (1992) were used to adjust results of the USA surveys to RV Albatross IV equivalents. Results of analysis for each of the surveys are given in Table 9b.

The 1982 USA spring survey is influenced by one tow of 1,000 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 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).

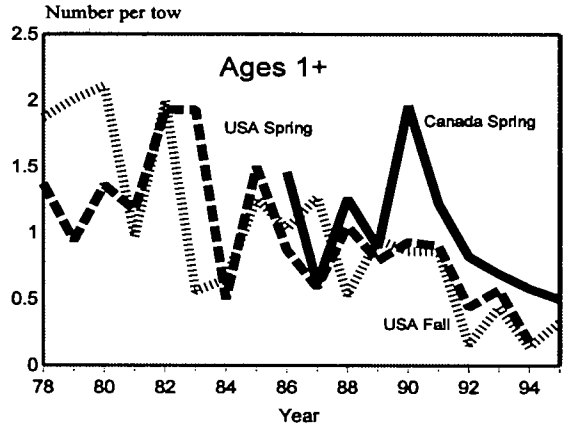

Figure 5. Standardized (to mean) research survey catch per tow in numbers

The Canadian surveys show a marked decline since 1990. The 1994 USA fall survey catch per tow has a slight increase from 1993 but remains near the lowest observed. The 1994 USA spring is at the lowest observed value. The three surveys for ages 1+ in number per tow, standardized to their average and excluding the USA spring 1982 survey, are shown in Figure 5. In general, all three surveys appear to track year class strength and provide a consistent index. Weight per tow in the 1995 Canadian survey is shown in the Appendix, Figure 2.

Commercial Catch Rates

An analysis of mobile gear catch rate was completed using a multiplicative standardization procedure. Only data for the 1987-94 time period were included because of changes in data recording in the earlier years. Both directed (defined as cod > 50% of total trip landings) and all trips with reported cod landings were analyzed. Standards used were tonnage class, month and year.

Comparison of catch rate by year indicated very similar trends between directed and all trips but a slight increase for directed trips in 1994. However, the proportion of directed trips decreased from about 60-70% in 1987-93 to about 30% in 1994 (Fig 6). This is consistent with the observation by fishermen that cod were 'avoided' in 1994 and that the fishery in 1994 was for mixed species with much less targetting for cod.

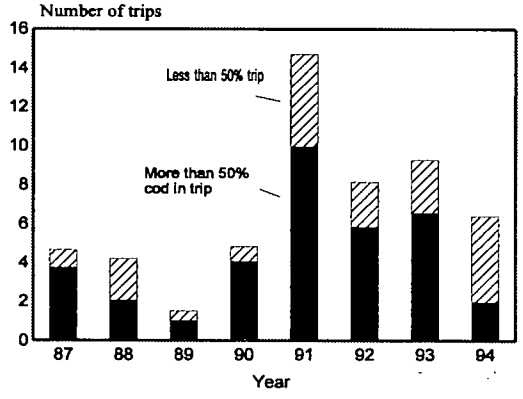

Figure 6. Number of mobile gear directed and total trips for cod.

The otter trawler catch rate standardization results are given in Table 10. Over 3,200 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 1994 and there were significant annual

differences. It was not possible to account for expected changes in catchability associated with use of larger mesh and square mesh in the 1990-94 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. The apparent change in spatial distribution of mobile gear effort is shown in Appendix, Figure 3.

In the absence of trip length estimates for 1994, catch rate standardization for longliners was not possible. A longline catch per trip for TC 2 vessels in July and August for 1987-94 was assumed to represent the fishing pattern for this gear sector. The general decline and the apparent increase in 1994 appeared to be consistent with fishermen's observations.

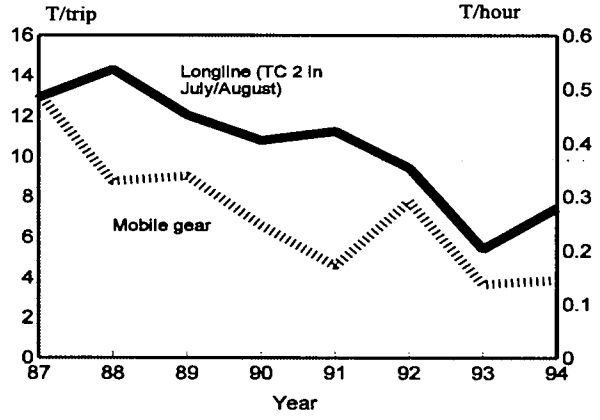

Figure 7. Catch rates for mobile (standardized) and longline (observed) gears.

The standardized mobile gear and unstandardized longliner catch rate indices are shown in Fig 7.

A catch rate at age for otter trawlers(Table 10) 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.

ESTIMATION OF STOCK PARAMETERS

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

$C_{a,y}$ = catch
a=1 to 8, y=1978 to 1994

$I_{1,a,y}$ = USA spring survey
a=1 to 8, y=1978 to 1994

$I_{2,a,y}$ = USA fall survey
a=0 to 7, y=1977 to 1994

$I_{3,a,y}$= Canadian spring survey
a=1 to 8, y=1986 to 1995

$I_{4,a,y}$ = Canadian OTB C/E
a=2 to 7,y=1987 to 1994

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 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 11. Parameter estimates, bias adjustment and the residuals for indices of abundance are given in Tables 12a-e.

Population parameter estimates have a relative error of 35 to 60% for ages 1 to 8, similar to those seen in other ADAPT-based analytical assessments. 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 generally flat topped for older ages.

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, 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). However, residuals by age for all three surveys appear to be reasonably well balanced and without trend within cohorts. 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 a change in catchability between years in which diamond or square mesh were used. Contrary to the perception that catch rates in 1993 and 1994 would underestimate abundance, residuals are positive with an implied overestimation of abundance. Residuals for the four indices are shown in the Appendix, Figures 4 and 5.

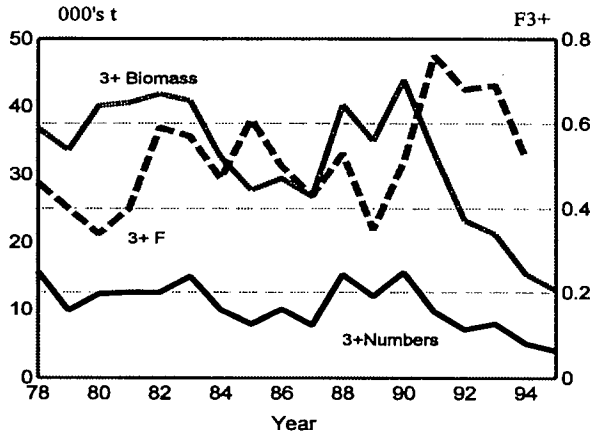

Figure 8. Population biomass, numbers and fishing mortality derived from ADAPT

The decline in adult biomass between 1990 and 1995 is substantial and in 1995 is the lowest observed (Fig 8). The decline in numbers of fish is less dramatic but the 1995 value is also 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 1994, due to reduced effort, still results in a fishing mortality of over twice the $F_{0.1}$. The rate of

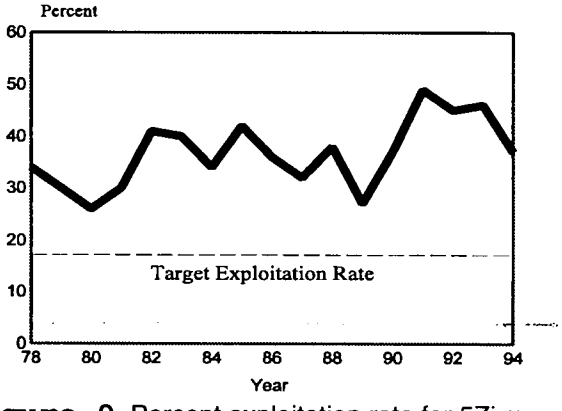

Figure 9. Percent exploitation rate for 5Zj,m cod derived from ADAPT.

exploitation for the stock has been over 30% for most of the time series, above 40% in 1991-93 and about 37% in 1994 (Fig 9).

Spawning stock biomass (40% age 2, 75% age

3 and 100% age 4, Hunt, 1995) also declined between 1990 and 1995 and is at the lowest observed level. Recruitment since the 1990 year class has been well below average and it appears that the 1994 year class will contribute very little to the stock (Figure 10).

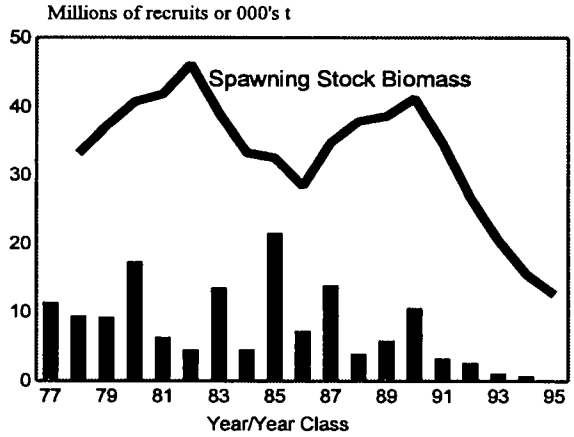

Figure 10. Spawning stock biomass (000's t) and recruits at age 1 (millions).

Prognosis

Catch projections were completed using the bias-adjusted beginning of year population abundance for 1995 derived from ADAPT. Partial recruitment was derived from the 1991-94 fishing mortality matrix, to reflect possible changes in PR associated with both gear and season. Mean weights at age were the 1978-94 average. Recruitment for 1996 age one was set to 3.54 million, the geometric mean of the eight smallest year classes.

Input for the catch projection is shown below:

Age	Population (000's) '95 Begining of Year	Mean Weight	Partial Recruitment
1	760	0.79 kg	0.005
2	877	1.26	0.310
3	1557	1.94	0.766
4	958	2.95	1
5	1102	4.00	1
6	218	5.42	1
7	69	6.65	1
8	67	8.22	1
9+	33	10.92	1

The **combined** Canada and USA $F_{0.1}$ catch in 1995 is estimated to be about 2,500 t and details of the projection are given in Table 13. There is about a 20% relative error associated with the projected catch. However, even fishing at the $F_{0.1}$ reference level will not result in any substantial increase stock biomass between 1995 and 1996.

Given the extremely low spawning stock biomass in 1994 (13,000 t compared to the recent 10 year average of 28,000 t) and low levels of recruitment since 1990, a stock rebuilding strategy should be considered.

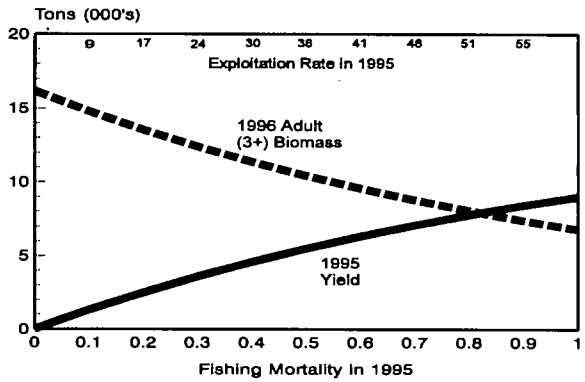

Figure 11. Projected 1995 yield and 1996 biomass at selected fishing mortality and exploitation rates in 1995.

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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
94	OT	1	0	0	0	0	777	410	115	128	263	117	82	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	8	7	10	14	9	1327	1434	1229	717	288	150	83	5277

Table 2.Summary of total catches (t) by Canada and the USA in unit areas 5Zjm for 1978-1994. USA catches for 1994 were estimated.

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	2000	7277

Table 3. Canadian and USA commercial landings samples for 1978-94. Canadian 1994 lengths include IOP samples. Sampling data for USA in 1994 are not yet available.

	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	-	-	-	104	25845	1268

Table 4. Summary of commercial and IOP (lengths only) samples used to estimate 1994 catch at age for 5Zj,m cod. (mobile gear catch at age prorated with USA total landings).

Gear	Month	Tons	# Len	# Ages	Tons	Tons	Tons	Grand Total
OTB	Jan	8						
+ Misc	Feb	7						
	Mar	10						
	Apr	14						
	May	9						
	Jun	784	3515	222	832			
	Jul	414	6432	184				
	Aug	117	583	67		1959	3959	
	Sep	128	3072	31	659			
	Oct	265	2867					
	Nov	120	1537	139				
	Dec	128	340	54	468			
USA						2000		7277
Longline	Jun	409	1215	169	409			
	Jul	481	3800	113				
	Aug	869	661	49		2287		
	Sep	492	401	61				
	Oct	5						
	Nov	30			1677			
Gillnet	Jun	133	276	45	133			
	Jul	539	819	99		1031		
	Aug	243	327					
	Sep	97						
	Oct	18			898			
Age Keys	Q2			436				
	Q3			639				
	Q4			193				

Table 5a. Comparison matrix for the age assignments by the Canadian and USA age readers to otoliths from the Canadian spring survey (N200).

USA age reader Nancy Munroe (across) , Canadian age reader Maria-Ines Bureta (down)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	-	TOT
1	3	1															4
2		18	1														19
3			12	2													14
4			1	18	2												21
5					7	1	1									1	10
6						3	2										5
7							14	2									16
8							1	1	1							1	4
9								2	2	2	1						7
10																1	1
11																	
12																	
13																	
14													1				1
15														1			1
-			1	4		3	2		2	1						1	14
TOT	3	19	15	24	9	7	20	5	5	3	1		1	1		4	117
Percent agreement for spring exchangeincluding unreadable otoliths 79/117=																	68%
Percent agreement excluding unreadable otoliths 78/100=																	78%

Table 5b. Comparison matrix for the age assignments by the Canadian and USA age readers to otoliths from the fall USA survey (AL9406).

USA age reader Nancy Munroe (across) , Canadian age reader Maria-Ines Bureta (down)

	1	2	3	4	5	6	7	8	-	TOT
1	6	2								8
2		11	1							12
3		1	13							14
4				9	2					11
5					1					1
6							1			1
7								1		1
8										
-									1	1
TOT	6	14	14	9	3		1	1	1	49
Percent agreement for fall exchange 41/49=										84%
Percent agreement excluding unreadable otoliths 40/48=										84%

Table 5c. Comparison matrix for the precision test by the primary age reader. Samples were selected randomly from the 94 commercial fishery.

First reading by primary age reader M-I Buzeta (down) , second reading by primary age reader M-I Buzeta (across).

	1	2	3	4	5	6	7	8	9	10	11	12	13	-	TOT
1		1													1
2		11	1												12
3			9												9
4				14	1									1	16
5					13		1								14
6					1	4	1								6
7							3	3						1	7
8								4	1						5
9									4					2	6
10															
11													1		1
12															
13															
-														2	2
TOT		12	10	14	15	4	5	7	5				1	6	79
Percent agreement including unreadable otoliths 60/79=															76%
Percent agreement excluding unreadable otoliths 58/73=															79%

Table 5d. Comparison matrix for the two Canadian age readers. Samples were from the August commercial fishery.

Primary age reader M-I Buzeta (across) , secondary age reader Laura Brown (down)

	1	2	3	4	5	6	7	8	9	-	TOT
1											
2		22								1	23
3		2	20								22
4			10	34	2						46
5				2	9		1				12
6						1					1
7						1					1
8								1			1
9								1	1		2
-				2						1	3
TOT		24	30	38	11	2	1	2		2	111
Percent agreement including unreadable otoliths 89/111=											80%
Percent agreement excluding unreadable otoliths 88/107=											82%

Table 6. Catch at age of cod in numbers (000's) for Canada, USA and total, in 5Zjm ,1978-1994.

		AGEGROUP								
		1	2	3	4	5	6	7	8	9	TOTAL
78	CDN	2	62	2017	667	205	78	57	12	12	3112
	USA	0	59	1571	409	102	32	26	9	0	2208
	TOT	2	121	3588	1076	307	110	83	21	12	5320
79	CDN	0	371	328	763	302	55	18	9	4	1850
	USA	10	443	71	1011	243	94	4	36	0	1912
	TOT	10	814	399	1774	545	149	22	45	4	3762
80	CDN	1	775	1121	214	420	125	32	11	14	2713
	USA	0	212	374	51	496	220	77	9	19	1458
	TOT	1	987	1495	265	916	345	109	20	33	4171
81	CDN	2	145	608	504	134	380	87	51	21	1932
	USA	17	458	835	745	21	215	82	14	15	2402
	TOT	19	603	1443	1249	155	595	169	65	36	4334
82	CDN	6	1283	1358	1105	742	164	221	97	21	4997
	USA	0	1399	328	324	324	25	124	60	16	2600
	TOT	6	2682	1686	1429	1066	189	345	157	37	7597
83	CDN	27	744	2506	1212	201	54	10	17	12	4783
	USA	13	575	910	262	265	229	21	54	27	2356
	TOT	40	1319	3416	1474	466	283	31	71	39	7139
84	CDN	0	26	118	375	340	123	72	19	18	1091
	USA	10	243	793	971	171	167	158	12	53	2578
	TOT	10	269	911	1346	511	290	230	31	71	3669
85	CDN	4	2146	904	383	497	139	45	38	9	4165
	USA	8	646	317	248	444	85	51	62	5	1866
	TOT	12	2792	1221	631	941	224	96	100	14	6031
86	CDN	19	235	1283	365	143	215	29	19	9	2317
	USA	9	91	905	148	161	185	29	20	16	1564
	TOT	28	326	2188	513	304	400	58	39	25	3881
87	CDN	14	2595	602	741	91	79	117	22	15	4276
	USA	0	1071	263	358	53	42	50	15	9	1861
	TOT	14	3666	865	1099	144	121	167	37	24	6137
88	CDN	10	232	2360	324	421	69	61	111	29	3617
	USA	0	88	1293	322	440	75	41	32	10	2301
	TOT	10	320	3653	646	861	144	102	143	39	5918
89	CDN	0	318	284	918	124	179	31	23	37	1914
	USA	0	422	368	919	69	135	25	2	4	1944
	TOT	0	740	652	1837	193	314	56	25	41	3858
90	CDN	7	339	1769	617	799	95	102	8	14	3750
	USA	0	339	1427	345	396	21	20	2	0	2550
	TOT	7	678	3196	962	1195	116	122	10	14	6300
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
94	CDN	2	141	340	593	213	34	47	22	18	1410
	USA*	1	98	208	254	71	10	13	5	2	663
	TOT	3	239	548	847	284	44	60	27	21	2073

*prorated from the Canadian mobile numbers assuming 2,000 t catch

Table 7. Percent catch at age for Canada/USA landings, 1978-94.

	Year																
Age	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
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	0.2
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	11.7
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	26.7
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	41.3
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	13.8
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	2.2
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	2.9
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	1.3

Table 8. Mean size at age of cod in 5Zj,m derived from Canadian and USA samples combined, 1978-93.Samples for 1994 are Canadian only.

Length (cm)

	Age group							
Year	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
1994	43.0	50.3	59.6	69.8	75.3	86.0	89.4	93.0
Mean	42.6	51.1	60.1	69.4	77.7	85.1	92.0	97.7

Table 9. Input data for ADAPT
a). Catch at age and mean weights at age

Catch

	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
1	2	10	1	19	6	40	10	12	28	14	10	1	7	11	86	4	3
2	121	814	987	603	2682	1319	269	2792	326	3666	320	740	678	626	2358	414	239
3	3588	399	1495	1443	1686	3416	911	1221	2188	865	3653	652	3196	783	1251	1967	548
4	1076	1774	265	1249	1429	1474	1346	631	513	1099	646	1837	962	1939	432	809	847
5	307	545	916	155	1066	466	511	941	304	144	861	193	1195	953	908	215	284
6	110	149	345	595	189	283	290	224	400	121	144	314	116	790	250	332	44
7	83	22	109	169	345	31	230	96	58	167	102	56	122	93	233	110	60
8	21	45	20	65	157	71	31	100	39	37	143	25	10	56	25	93	27
1+	5308	3758	4138	4298	7560	7100	3598	6017	3856	6113	5879	3818	6286	5251	5543	3944	2052
2+	5306	3748	4137	4279	7554	7060	3588	6005	3828	6099	5869	3817	6279	5240	5457	3940	2049
3+	5185	2934	3150	3676	4872	5741	3319	3213	3502	2433	5549	3077	5601	4614	3099	3526	1810
4+	1597	2535	1655	2233	3186	2325	2408	1992	1314	1568	1896	2425	2405	3831	1848	1559	1262

Weight (Mid-Year)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
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	0.91
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	1.46
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	2.41
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	3.83
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	4.80
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	7.09
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	7.86
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	8.93

Weight (Beginning-Year)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
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	0.69	0.69	0.79
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	1.13	1.26
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	1.95	1.94
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	2.97	2.95
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	3.85	4.00
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	5.65	5.42
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	6.71	6.65
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	7.95	8.22
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	9.66	10.92

b) Indices of abundance

USA SPRING SURVEY

	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
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	0.10
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	0.37
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	0.29
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	0.36
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	0.09
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	0.02
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	0.06
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	0.00

USA FALL SURVEY

	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
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	0.02
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	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	0.54
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	0.39
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	0.28
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	0.14
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	0.04
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	0.00

CANADIAN SPRING SURVEY

	86	87	88	89	90	91	92	93	94	95
1	1.78	0.12	0.36	0.80	0.26	2.76	0.12	0.07	0.03	0.08
2	8.19	4.31	1.08	4.98	1.81	2.35	4.69	0.82	1.45	0.45
3	7.41	1.55	12.85	1.76	7.97	3.27	2.81	3.96	1.59	2.99
4	0.77	1.81	1.36	3.92	4.49	3.80	0.94	1.43	2.96	1.82
5	1.60	0.39	2.02	0.59	10.11	2.03	1.48	0.85	1.09	1.25
6	1.03	0.21	0.23	0.76	1.23	2.76	1.04	1.73	0.42	0.45
7	0.51	0.44	0.19	0.10	2.51	0.34	0.69	0.63	0.83	0.11
8	0.08	0.21	0.43	0.19	0.33	0.58	0.21	0.61	0.19	0.16

CANADIAN MOBILE GEAR CATCH RATE

	87	88	89	90	91	92	93	94
2	0.330	0.027	0.132	0.030	0.036	0.162	0.018	0.022
3	0.073	0.240	0.084	0.131	0.033	0.068	0.064	0.046
4	0.071	0.027	0.104	0.040	0.062	0.018	0.030	0.056
5	0.004	0.024	0.007	0.039	0.023	0.025	0.007	0.016
6	0.004	0.005	0.010	0.004	0.015	0.006	0.011	0.002
7	0.006	0.002	0.000	0.003	0.001	0.005	0.004	0.003

Table 10. Results of catch rate standardization (month and tonnage class) for Canadian mobile gear

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.515
MULTIPLE R SQUARED..... 0.266

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	9.392E3	9.392E3	
REGRESSION	13	7.530E2	5.792E1	89.223
TYPE 1	7	5.044E2	7.206E1	111.001
TYPE 2	5	2.190E2	4.381E1	67.478
TYPE 3	1	1.388E1	1.388E1	21.380
RESIDUALS	3207	2.082E3	6.492E-1	
TOTAL	3221	1.223E4		

REGRESSION COEFFICIENTS

CATEGORY	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
87	INTERCEPT	-0.740	0.049	3221
6				
2				
88	1	-0.398	0.073	189
89	2	-0.367	0.101	81
90	3	-0.685	0.059	399
91	4	-1.048	0.050	969
92	5	-0.524	0.055	556
93	6	-1.270	0.058	479
94	7	-1.211	0.075	182
7	8	-0.428	0.035	914
8	9	-0.644	0.047	379
9	10	-0.652	0.063	185
11	11	-0.703	0.116	52
10	12	-0.069	0.068	161
3	13	0.132	0.029	1510

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	CATCH	EFFORT
87	-1.0352	0.0023	0.491	0.024	7608	15500
88	-1.4330	0.0041	0.329	0.021	7620	23131
89	-1.4019	0.0095	0.339	0.033	1987	5862
90	-1.7206	0.0025	0.247	0.012	7854	31759
91	-2.0836	0.0015	0.172	0.007	6698	38917
92	-1.5590	0.0020	0.291	0.013	5638	19390
93	-2.3054	0.0023	0.138	0.007	4890	35483
94	-2.2461	0.0045	0.146	0.010	1885	12904

Table 11a. Parameter estimates from ADAPT for 5Zj,m cod with three survey indices (ages 1-8) and Canadian commercial mobile gear catch rate (ages 2-7).

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.001042
MEAN SQUARE RESIDUALS 0.647973

Parameter		PAR. EST.	STD. ERR.	REL. ERR.	BIAS	REL. BIAS
Age	1	6.834E0	5.963E-1	8.725E-2	3.408E-3	4.987E-4
	2	6.874E0	4.220E-1	6.140E-2	3.468E-3	5.045E-4
	3	7.412E0	3.452E-1	4.657E-2	-3.238E-4	-4.369E-5
	4	6.917E0	3.480E-1	5.031E-2	-9.883E-3	-1.429E-3
	5	7.068E0	3.874E-1	5.481E-2	-1.370E-2	-1.938E-3
	6	5.470E0	4.425E-1	8.090E-2	-1.599E-2	-2.924E-3
	7	4.319E0	4.259E-1	9.861E-2	-1.357E-2	-3.142E-3
	8	4.324E0	5.388E-1	1.246E-1	-3.582E-2	-8.282E-3
USP	1	4.281E-5	9.006E-6	2.104E-1	8.361E-7	1.953E-2
	2	2.120E-4	4.298E-5	2.028E-1	3.821E-6	1.803E-2
	3	3.550E-4	6.958E-5	1.960E-1	6.059E-6	1.707E-2
	4	4.160E-4	8.151E-5	1.959E-1	7.088E-6	1.704E-2
	5	5.751E-4	1.162E-4	2.020E-1	1.029E-5	1.789E-2
	6	6.053E-4	1.225E-4	2.024E-1	1.131E-5	1.868E-2
	7	7.950E-4	1.562E-4	1.964E-1	1.462E-5	1.839E-2
	8	1.000E-3	2.080E-4	2.080E-1	2.082E-5	2.082E-2
USF	1	3.538E-5	7.768E-6	2.195E-1	7.801E-7	2.204E-2
	2	1.364E-4	2.706E-5	1.984E-1	2.331E-6	1.710E-2
	3	1.619E-4	3.100E-5	1.915E-1	2.645E-6	1.634E-2
	4	2.249E-4	4.305E-5	1.915E-1	3.787E-6	1.684E-2
	5	1.459E-4	2.966E-5	2.034E-1	2.906E-6	1.992E-2
	6	2.173E-4	4.921E-5	2.265E-1	5.558E-6	2.558E-2
	7	1.917E-4	4.336E-5	2.262E-1	5.141E-6	2.682E-2
	8	6.014E-4	1.976E-4	3.286E-1	3.243E-5	5.392E-2
CDN	1	5.237E-5	1.409E-5	2.690E-1	1.645E-6	3.141E-2
	2	4.726E-4	1.236E-4	2.616E-1	1.409E-5	2.982E-2
	3	9.179E-4	2.376E-4	2.589E-1	2.745E-5	2.991E-2
	4	9.407E-4	2.433E-4	2.587E-1	2.897E-5	3.079E-2
	5	1.374E-3	3.561E-4	2.592E-1	4.254E-5	3.096E-2
	6	1.619E-3	4.232E-4	2.615E-1	5.327E-5	3.291E-2
	7	2.064E-3	5.409E-4	2.621E-1	7.053E-5	3.418E-2
	8	2.846E-3	7.498E-4	2.635E-1	1.108E-4	3.894E-2
OTB	2	1.170E-5	3.391E-6	2.897E-1	4.351E-7	3.717E-2
	3	2.567E-5	7.401E-6	2.883E-1	9.614E-7	3.745E-2
	4	2.561E-5	7.384E-6	2.883E-1	9.576E-7	3.739E-2
	5	2.123E-5	6.140E-6	2.892E-1	8.036E-7	3.785E-2
	6	2.077E-5	6.030E-6	2.903E-1	8.254E-7	3.975E-2
	7	1.672E-5	4.872E-6	2.914E-1	7.253E-7	4.339E-2

Table 11b. Results of bias adjustment for population estimates

Parameter		PAR. EST.	STD. ERR.	REL. ERR.	BIAS	REL. BIAS
Age	1	929	554	0.60	168	0.18
	2	966	408	0.42	89	0.09
	3	1655	571	0.35	98	0.06
	4	1010	351	0.35	51	0.05
	5	1174	455	0.39	72	0.06
	6	237	105	0.44	19	0.08
	7	75	32	0.43	6	0.08
	8	76	41	0.54	8	0.11

Table 12. Population estimates from ADAPT and residuals for indices

a) Beginning of year population numbers and biomass

Population Numbers (Bias Adjusted)

	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
1	11384	9367	9180	17303	6316	4561	13537	4551	21557	7243	13908	3968	5835	10596	3304	2650	1074	761
2	2226	9319	7660	7515	14149	5166	3698	11074	3715	17624	5918	11377	3248	4771	8665	2627	2166	877
3	10412	1713	6893	5378	5608	9158	3036	2784	6541	2747	11112	4555	8646	2046	3340	4961	1776	1557
4	3559	5278	1041	4291	3098	3065	4407	1661	1175	3375	1466	5793	3140	4186	967	1603	2282	958
5	1078	1940	2716	613	2383	1243	1176	2390	789	498	1769	616	3080	1700	1673	400	580	1102
6	249	605	1095	1395	361	986	596	501	1105	371	277	669	330	1441	530	548	133	218
7	281	104	360	584	604	125	551	226	207	543	194	97	264	165	465	207	148	69
8	60	155	65	197	326	182	74	243	98	117	294	67	28	106	51	170	70	67
9	0	30	86	36	102	125	85	33	109	45	62	111	32	14	36	19	55	33
1+	29248	28510	29098	37312	32946	24611	27161	23463	35296	32563	35000	27253	24603	25025	19029	13185	8285	5642
2+	17865	19144	19917	20009	26630	20050	13623	18912	13739	25320	21092	23285	18767	14429	15725	10535	7210	4882
3+	15639	9825	12258	12493	12481	14884	9925	7838	10024	7696	15175	11907	15519	9658	7061	7908	5045	4005
4+	5226	8112	5365	7115	6873	5726	6890	5053	3483	4949	4062	7352	6874	7612	3721	2947	3268	2448

Population Biomass (Bias Adjusted)

	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
1	5537	6498	5739	12105	3462	3413	12284	3237	15861	3634	7621	2312	3466	10032	3242	1821	739	598
2	2142	9577	8726	8402	15734	5515	4659	13532	4297	20672	6216	12827	3649	5548	11357	3528	2456	1107
3	18695	2874	13236	9979	11191	16718	5801	5142	12184	5269	20770	8460	17250	4079	6687	9358	3456	3028
4	10398	16992	2924	12456	9314	9102	12925	5127	3246	10804	4339	17279	8875	12148	3024	4414	6784	2830
5	4182	7988	13246	2680	10187	5241	4823	10255	3682	2295	8412	2681	13232	6967	6711	1664	2231	4411
6	1247	3375	6256	8909	2106	5769	3293	2857	6686	2441	1722	4024	1927	7734	2869	2846	753	1181
7	1834	760	2797	4420	4965	900	4161	1647	1566	4357	1599	714	1985	1129	3091	1369	996	461
8	475	1349	598	1790	2998	1788	666	2324	879	1106	2775	647	266	996	434	1386	559	553
9	0	274	1048	321	1096	1325	915	373	1193	495	662	1171	379	172	420	216	529	361
1+	44509	49688	54571	61061	61052	49770	49529	44494	49593	51073	54118	50114	51029	48806	37836	26602	18502	14530
2+	38972	43190	48832	48957	57590	46357	37245	41258	33732	47438	46497	47802	47563	38774	34594	24781	17763	13932
3+	36830	33613	40105	40555	41856	40842	32586	27725	29435	26766	40280	34975	43914	33226	23237	21253	15307	12825
4+	18135	30739	26869	30576	30665	24124	26785	22583	17252	21497	19510	26515	26664	29147	16550	11895	11851	9797

b) Mid-year population numbers and biomass

Population Numbers (Mid-Year Bias Adjusted)

	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
1	10317	8485	8320	15673	5721	4114	12265	4119	19525	6558	12600	3596	5285	9598	2953	2400	972
2	1958	8045	6452	6515	11473	4007	3219	8609	3207	14119	5207	9949	2601	4013	6641	2174	1845
3	7557	1349	5489	4134	4209	6495	2280	1865	4785	2040	8166	3804	6149	1439	2366	3449	1326
4	2668	3856	808	3244	2031	1972	3296	1171	788	2486	980	4295	2347	2740	642	1006	1621
5	819	1478	1983	476	1583	880	791	1666	554	377	1131	458	2158	1004	1008	243	370
6	166	472	813	945	223	748	381	333	791	273	171	436	238	863	344	306	98
7	211	83	270	443	352	97	377	153	158	406	119	56	173	97	293	127	103
8	43	117	49	144	209	127	51	167	68	87	188	47	20	65	32	102	49
1+	23740	23885	24185	31573	25802	18442	22660	18084	29875	26345	28563	22640	18971	19818	14279	9806	6383
2+	13423	15401	15865	15900	20081	14327	10395	13965	10351	19787	15962	19044	13685	10220	11327	7407	5411
3+	11465	7356	9413	9385	8607	10321	7175	5355	7144	5668	10756	9095	11084	6207	4685	5233	3566
4+	3908	6007	3924	5251	4398	3825	4896	3490	2359	3629	2590	5291	4936	4768	2319	1783	2240

Population Biomass (Mid-Year Bias Adjusted)

	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
1	7294	7543	6956	13824	4377	3995	12915	3736	18138	4761	9904	2909	4392	10692	3390	2119	881
2	2565	12019	9420	9740	16085	5970	5264	12208	4730	20910	7914	16088	4057	6529	10241	3415	2688
3	18597	2900	13548	9747	11214	15439	5588	3891	11708	5089	19263	8631	15139	3667	5829	7961	3193
4	9255	16239	2965	11077	7787	6526	11929	4554	2885	10410	3442	16200	8265	9372	2469	3098	6207
5	3551	7222	11197	2482	8473	4082	4020	8475	3104	2188	6111	2471	10555	4786	4743	1092	1777
6	962	3390	5429	6824	1450	4781	2510	2132	5690	2110	1138	2916	1506	5082	2116	1753	694
7	1559	766	2267	3790	3294	776	3355	1238	1407	3630	1047	458	1461	718	2199	896	806
8	368	1206	445	1426	2071	1311	512	1711	676	870	1874	506	218	679	319	903	441
1+	44152	51285	52227	58909	54751	42880	46092	37944	48338	49969	50693	50178	45594	41526	31305	21238	16687
2+	36858	43742	45271	45085	50374	38885	33178	34209	30200	45208	40790	47268	41202	30834	27915	19119	15806
3+	34293	31723	35851	35346	34289	32915	27914	22000	25470	24298	32875	31181	37145	24304	17674	15703	13119
4+	15696	28823	22304	25599	23075	17476	22326	18110	13762	19208	13613	22550	22006	20637	11845	7742	9925

c) Fishing mortality at age

Fishing Mortality (Bias Adjusted)

	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
1	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
2	0.06	0.10	0.15	0.09	0.24	0.33	0.08	0.33	0.10	0.26	0.06	0.07	0.26	0.16	0.36	0.19	0.13
3	0.48	0.30	0.27	0.35	0.40	0.53	0.40	0.66	0.46	0.43	0.45	0.17	0.53	0.55	0.53	0.58	0.42
4	0.41	0.46	0.33	0.39	0.71	0.76	0.41	0.54	0.66	0.45	0.67	0.43	0.41	0.72	0.68	0.82	0.53
5	0.38	0.37	0.47	0.33	0.68	0.53	0.65	0.57	0.55	0.39	0.77	0.43	0.56	0.97	0.92	0.90	0.78
6	0.67	0.32	0.43	0.64	0.86	0.38	0.77	0.68	0.51	0.45	0.85	0.73	0.49	0.93	0.74	1.11	0.45
7	0.40	0.27	0.41	0.39	1.00	0.32	0.62	0.64	0.37	0.42	0.87	1.02	0.72	0.98	0.81	0.88	0.59
8	0.49	0.39	0.41	0.46	0.76	0.56	0.62	0.61	0.58	0.43	0.77	0.53	0.49	0.88	0.78	0.93	0.55
1+	0.25	0.17	0.18	0.15	0.32	0.41	0.18	0.36	0.15	0.24	0.24	0.18	0.36	0.32	0.42	0.45	0.35
2+	0.41	0.26	0.27	0.28	0.40	0.51	0.37	0.44	0.39	0.31	0.40	0.22	0.47	0.56	0.50	0.57	0.40
3+	0.46	0.40	0.34	0.40	0.59	0.57	0.47	0.61	0.50	0.43	0.53	0.35	0.51	0.76	0.68	0.69	0.52

d) RESIDUALS (BEGINNING OF YEAR INDICES)

USA Spring survey

	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
1	-0.59	0.54	-2.57	0.83	1.07	1.26	-1.06	-0.89	0.20	0.00	-0.03	0.21	-0.66	1.05	-0.04	0.00	0.68
2	0.00	0.29	0.60	-0.01	1.35	1.20	-1.27	0.45	-0.24	-0.54	-1.02	-0.44	-0.11	0.09	-0.44	0.37	-0.27
3	0.32	-1.02	0.17	0.24	2.53	0.67	-0.29	0.15	-0.12	-0.75	0.25	-1.24	0.02	0.23	-0.61	0.25	-0.81
4	-0.28	0.16	-0.44	-0.03	2.85	0.06	-0.41	1.02	0.12	-0.36	-0.20	-0.01	-0.18	-0.07	-0.87	-0.37	-1.01
5	0.96	-0.11	0.66	-1.62	2.52	0.39	-0.34	0.70	0.54	0.00	-0.19	0.26	-0.41	-0.16	-0.77	-1.08	-1.35
6	0.81	-0.07	-0.11	-0.34	0.00	0.10	0.08	0.68	0.38	0.42	-0.74	0.29	0.37	-0.23	-0.17	-0.03	-1.45
7	1.82	0.72	-0.87	-0.40	2.45	1.04	-0.25	0.67	-1.19	-0.43	-1.64	-0.09	0.36	-0.49	-0.24	-0.72	-0.74
8	1.16	0.35	0.20	-0.49	1.34	-0.50	0.00	0.62	0.77	-0.67	-0.73	-0.10	0.06	-1.25	-0.01	-0.75	0.00

USA Fall survey

	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
1	-1.39	-0.46	-0.01	-0.02	0.99	0.00	1.12	-0.99	1.08	-0.15	-0.53	0.24	0.68	-0.06	0.00	0.00	0.00	-0.50
2	0.00	0.73	1.04	0.33	0.79	0.40	-1.44	0.63	-0.26	0.77	-1.21	-0.42	0.48	0.09	-1.20	0.00	-0.80	0.06
3	1.32	-0.06	0.97	-0.14	0.88	-0.14	-0.16	-1.17	0.53	-1.40	-0.16	-0.80	0.18	0.86	-1.44	0.47	-0.45	0.70
4	0.46	1.46	-0.11	0.23	0.89	-2.15	-0.11	1.01	0.13	-0.77	-0.36	0.49	-0.92	0.45	-0.32	-0.27	-0.64	0.54
5	0.80	0.95	1.92	-0.58	0.32	-0.41	-1.23	1.57	-1.34	0.00	-0.31	1.02	0.54	-0.17	-2.51	0.00	-1.08	0.49
6	1.61	-0.18	0.62	0.14	-1.37	0.00	-1.46	-0.78	0.00	0.00	0.00	1.11	0.33	0.17	-0.65	-0.55	0.00	1.00
7	1.82	1.71	0.84	-1.02	-0.84	0.00	-1.26	0.33	-0.28	-1.64	0.00	0.00	-0.23	0.24	0.00	-0.68	0.00	1.02
8	0.11	0.54	0.24	-0.86	0.00	-0.60	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00

Canadian Spring survey

	86	87	88	89	90	91	92	93	94	95
1	0.46	-1.15	-0.71	1.34	-0.17	1.59	-0.39	-0.74	-0.73	0.50
2	1.54	-0.66	-0.95	-0.08	0.16	0.03	0.12	-0.44	0.29	-0.01
3	0.21	-0.49	0.23	-0.86	0.00	0.55	-0.10	-0.16	-0.06	0.68
4	-0.36	-0.56	-0.01	-0.33	0.42	-0.04	0.02	-0.07	0.28	0.65
5	0.39	-0.56	-0.18	-0.36	0.87	-0.14	-0.45	0.41	0.27	-0.25
6	-0.55	-1.05	-0.67	-0.35	0.84	0.17	0.20	0.65	0.61	0.16
7	0.18	-0.93	-0.74	-0.69	1.53	0.00	-0.33	0.39	0.93	-0.34
8	-1.24	-0.46	-0.66	0.00	1.41	0.67	0.38	0.24	-0.04	-0.30

e) RESIDUALS (MID-YEAR INDICES)

Canadian Mobile gear catch rate

	87	88	89	90	91	92	93	94
2	0.69	-0.80	0.12	-0.01	-0.27	0.71	-0.40	-0.04
3	0.34	0.14	-0.15	-0.19	-0.13	0.09	-0.35	0.25
4	0.11	0.07	-0.05	-0.42	-0.12	0.05	0.11	0.25
5	-0.68	0.01	-0.27	-0.17	0.06	0.14	0.27	0.64
6	-0.34	0.24	0.15	-0.28	-0.17	-0.09	0.55	-0.07
7	-0.20	-0.20	-0.75	0.12	-0.18	0.09	0.67	0.45

Table 13. Results of catch projections for 5Zj,m cod using estimated numbers
NOTE that the projected catch is for combined Canadian and USA fisheries.

Projected Population Numbers

	95	96	97
1	760	3544	3544
2	877	621	2894
3	1557	675	478
4	958	1094	474
5	1102	642	733
6	218	738	431
7	69	146	495
8	67	46	98
9	33	45	31
1+	5642	7552	9177
2+	4882	4008	5633
3+	4005	3387	2739
4+	2448	2712	2262

Projected Population Biomass

	95	96	97
1	597	2455	2455
2	1107	715	3336
3	3028	1279	905
4	2830	3238	1403
5	4411	2746	3133
6	1181	4239	2473
7	461	1068	3619
8	553	417	879
9	361	485	335
1+	14529	16643	18540
2+	13932	14188	16084
3+	12825	13472	12748
4+	9797	12194	11843

Projected Population Numbers (Mid-Year)

	95	96
1	688	3208
2	772	546
3	1312	569
4	790	901
5	908	530
6	180	609
7	57	120
8	55	38
1+	4761	6521
2+	4073	3313
3+	3302	2767
4+	1990	2198

Projected Population Biomass (Mid-Year)

	95	96
1	613	2857
2	1160	821
3	3146	1364
4	2892	3300
5	4599	2683
6	1186	4018
7	474	999
8	547	378
1+	14617	16418
2+	14004	13561
3+	12844	12740
4+	9698	11377

Projected Fishing Mortality

	95	96
1	0.00	0.00
2	0.06	0.06
3	0.15	0.15
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

	95	96
1	2	9
2	48	34
3	201	87
4	158	180
5	182	106
6	36	122
7	11	24
8	11	8
1+	649	569
2+	647	561
3+	599	527
4+	398	440

Projected Total Catch Biomass

	95	96
1	2	8
2	72	51
3	482	209
4	578	660
5	920	537
6	237	804
7	95	200
8	109	76
1+	2495	2543
2+	2494	2535
3+	2422	2484
4+	1940	2275

ADJ.MEAN	2495	2535
REL.ERR.	0.196	0.189
REL.BIAS	0.064	0.066

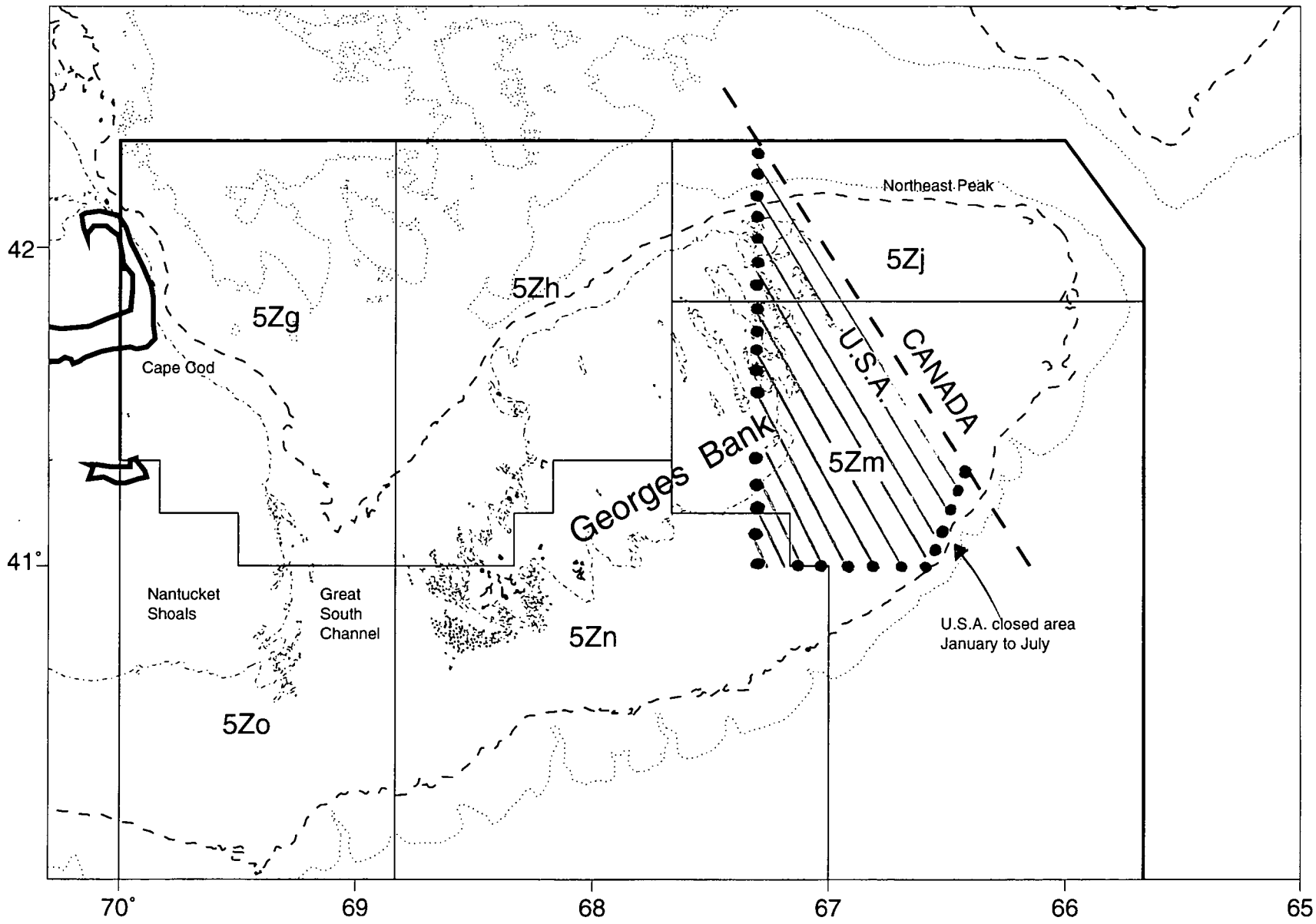


Figure 1. Canadian fisheries statistical unit areas in NAFO Division 5Ze.

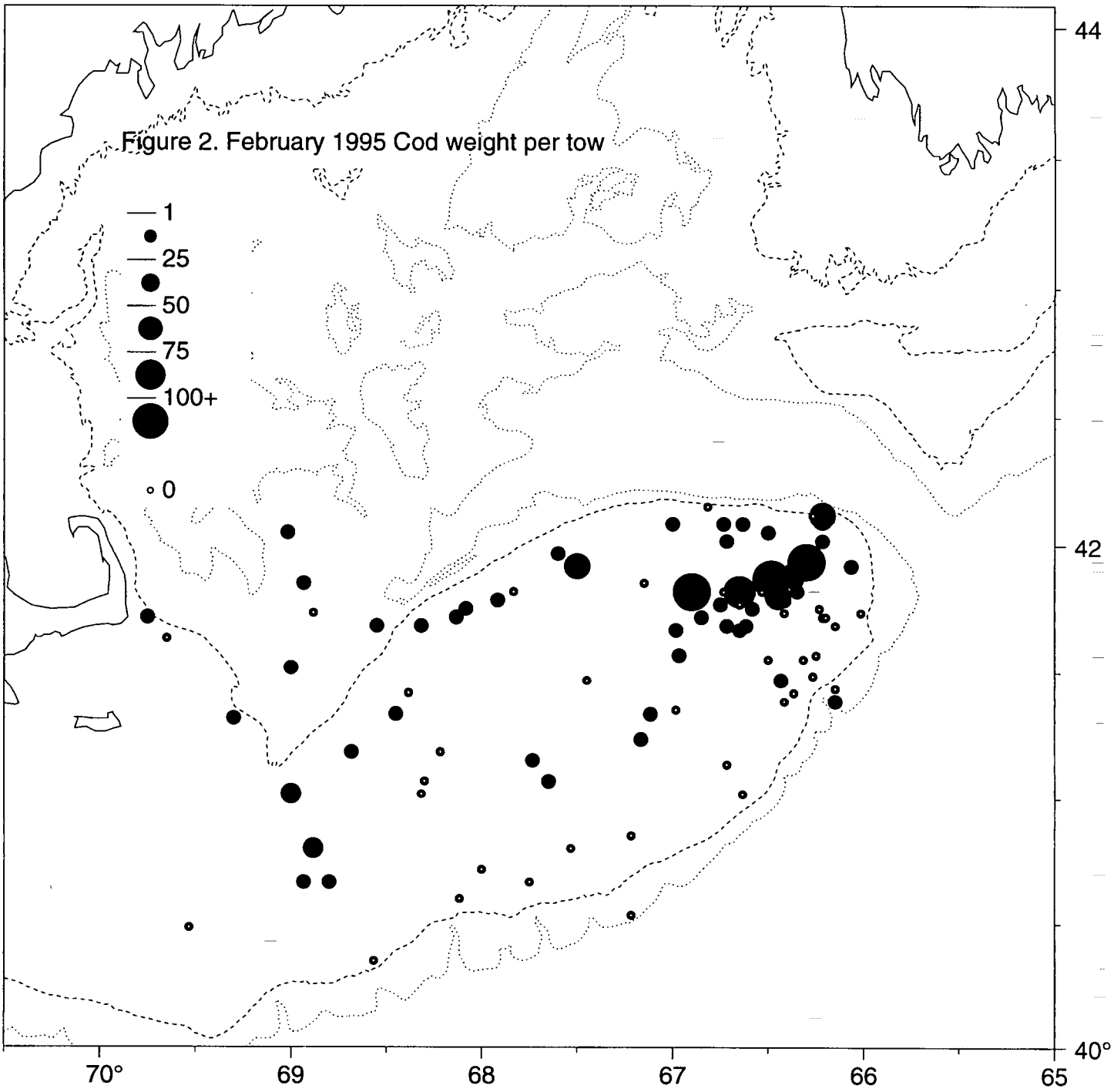
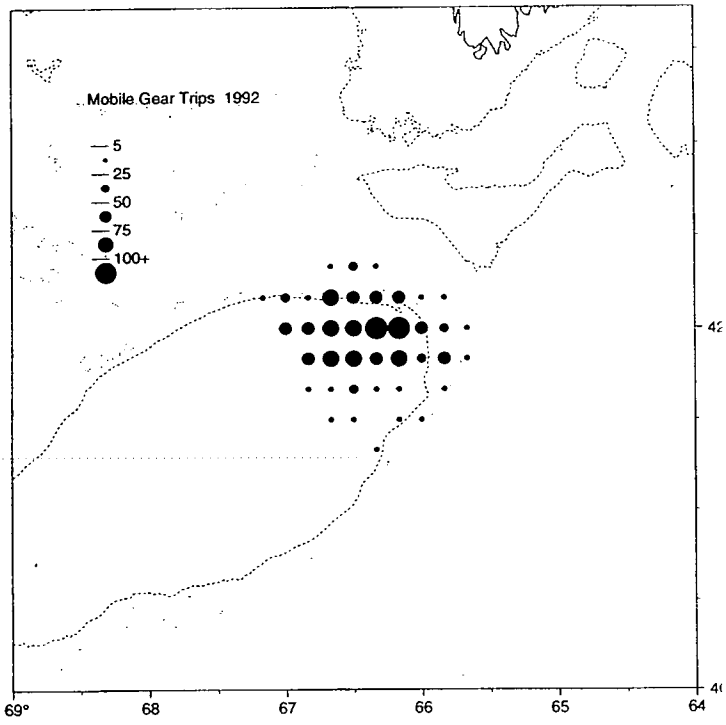
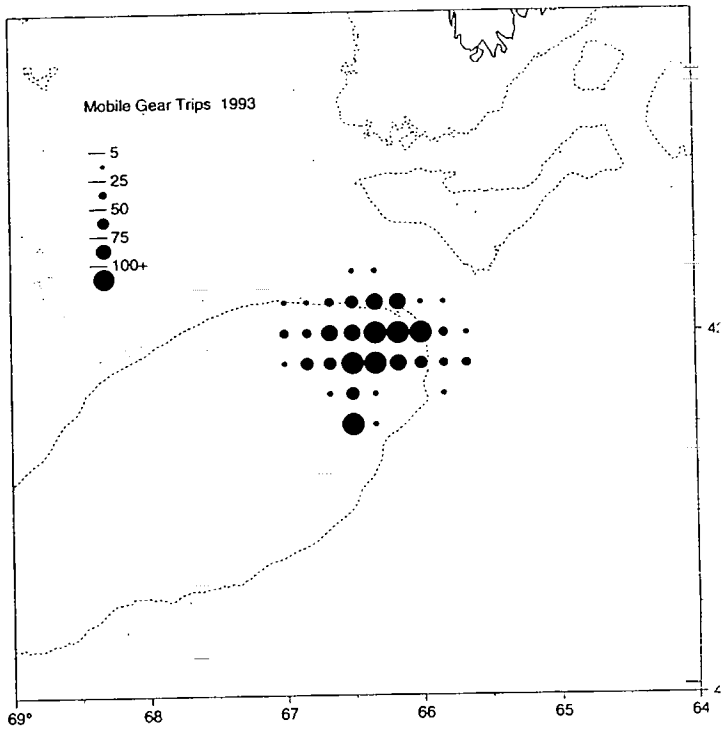
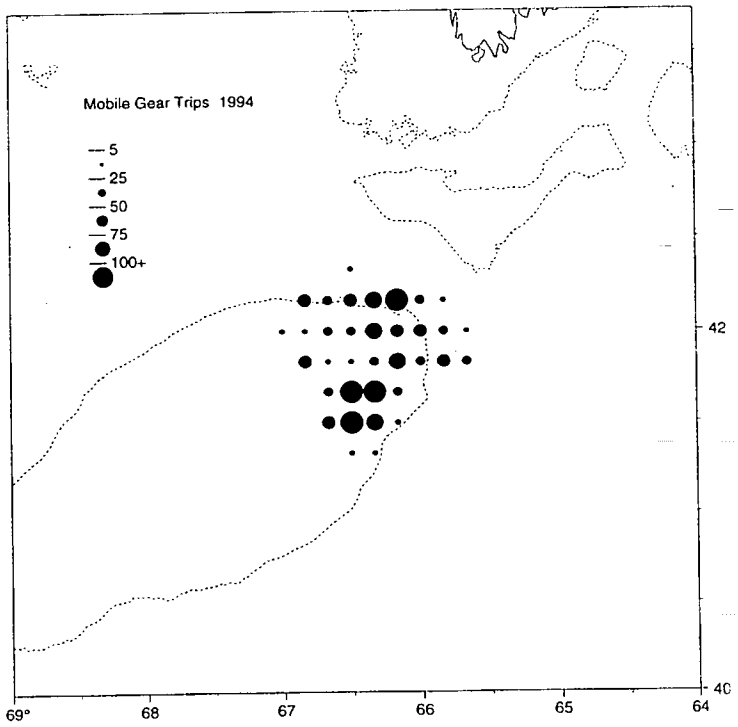


Figure 2. February 1995 Cod weight per tow

Figure 3. Distribution of effort (number of trips) for Canadian mobile gear in 1992-94.







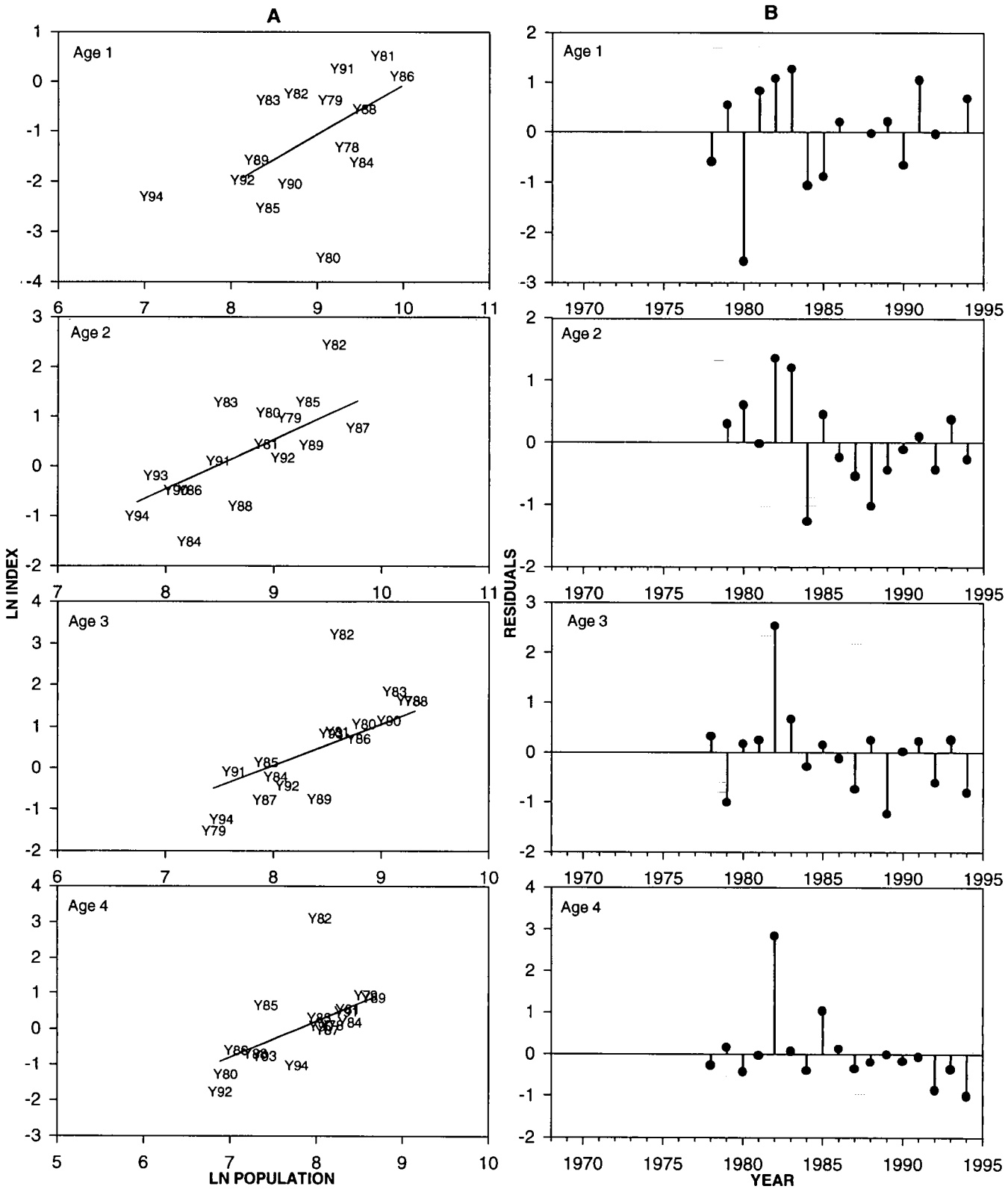


Figure 4a. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the USA spring survey for cod in unit areas 5Zj and 5Zm.

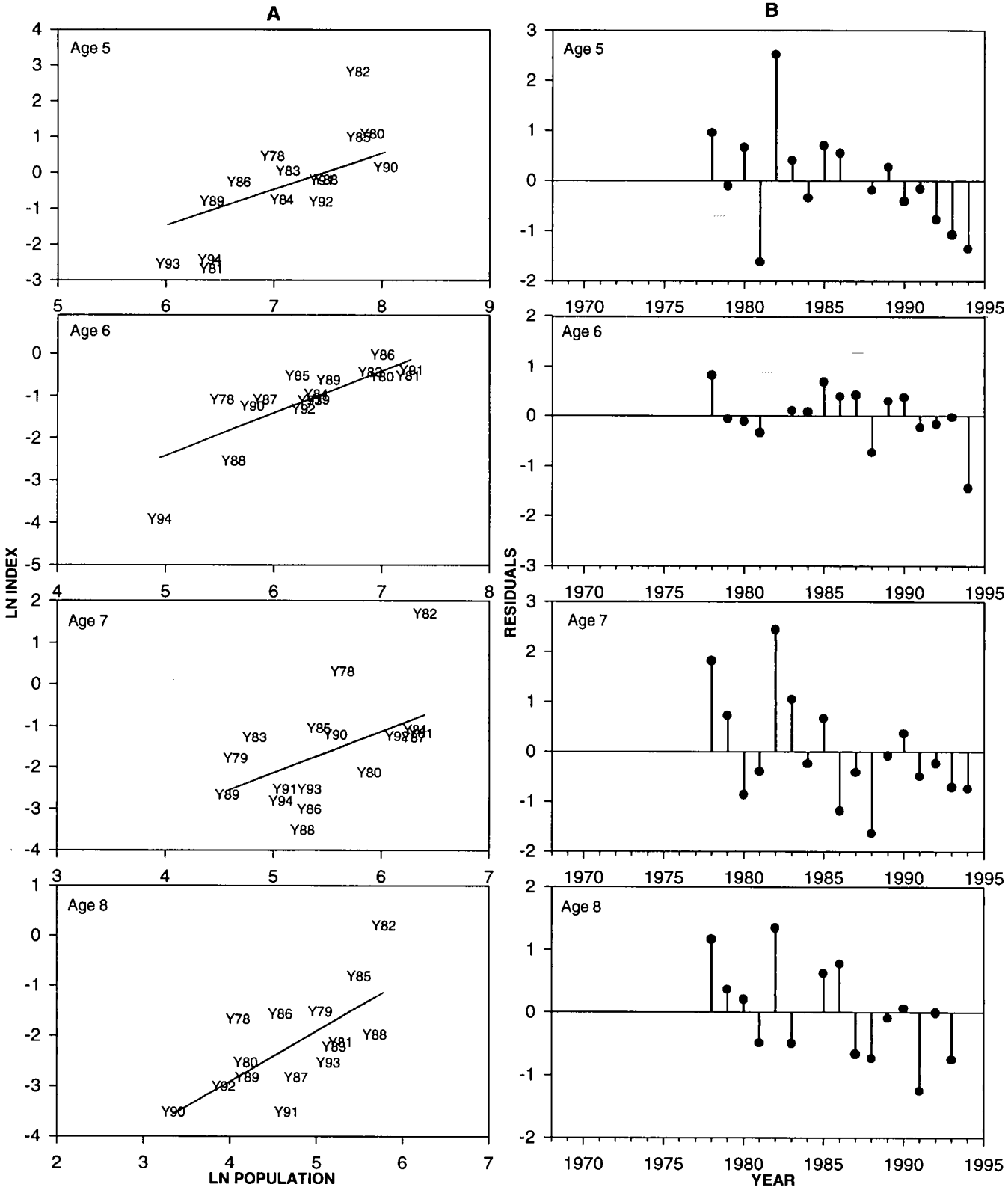


Figure 4a. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the USA spring survey for cod in unit areas 5Zj and 5Zm.

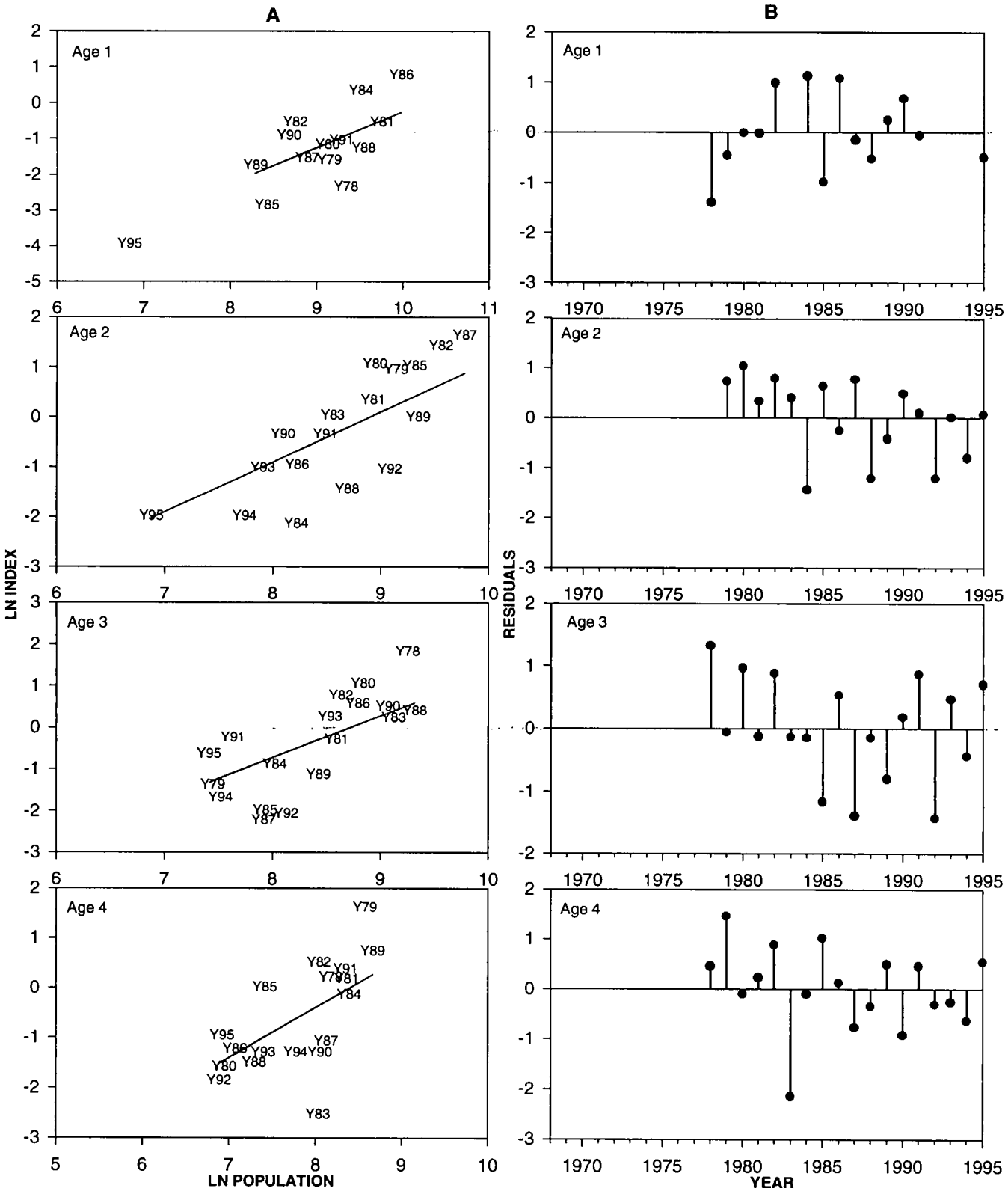


Figure 4b. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the USA fall survey for cod in unit areas 5Zj and 5Zm.

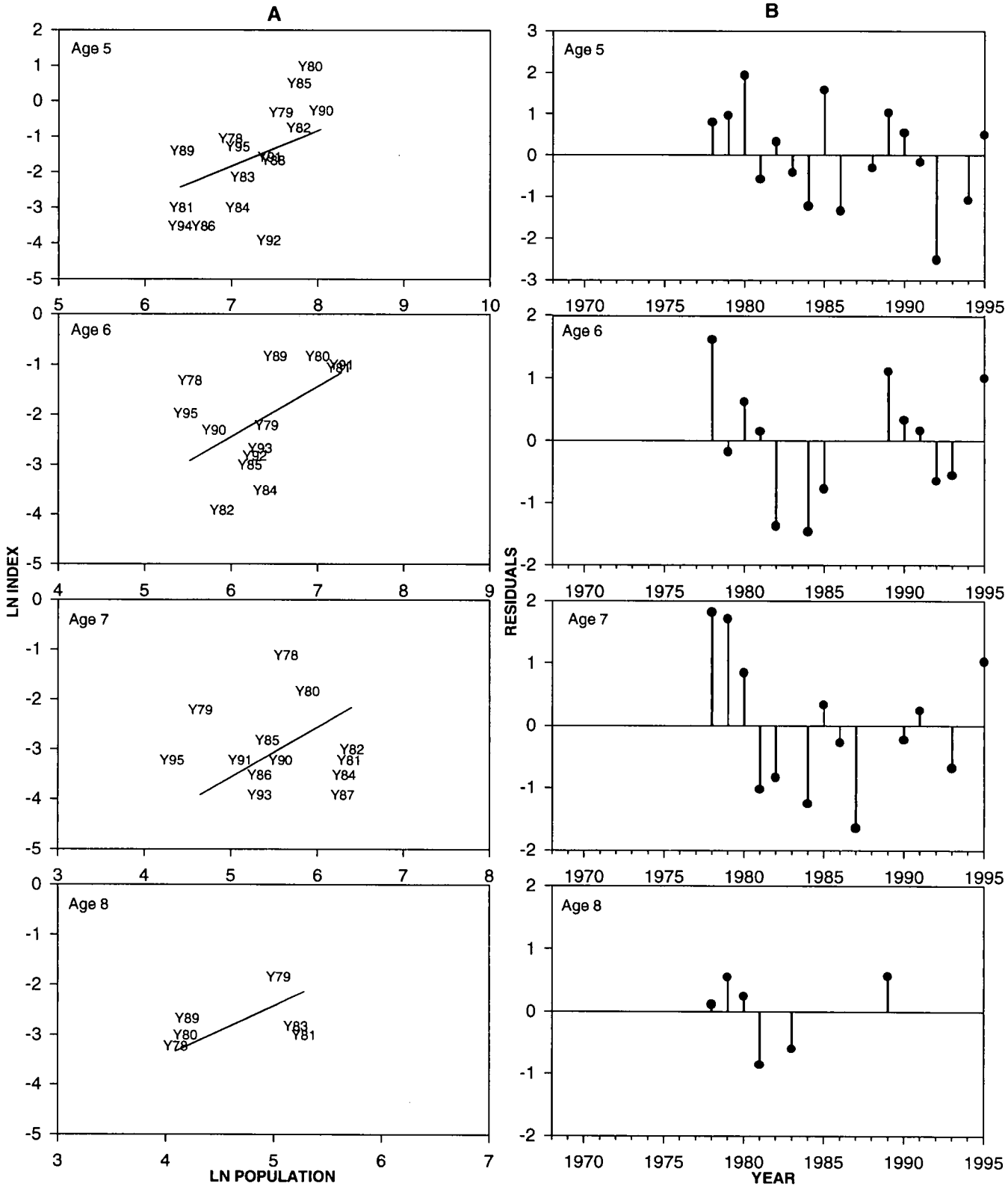


Figure 4b. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the USA fall survey for cod in unit areas 5Zj and 5Zm.

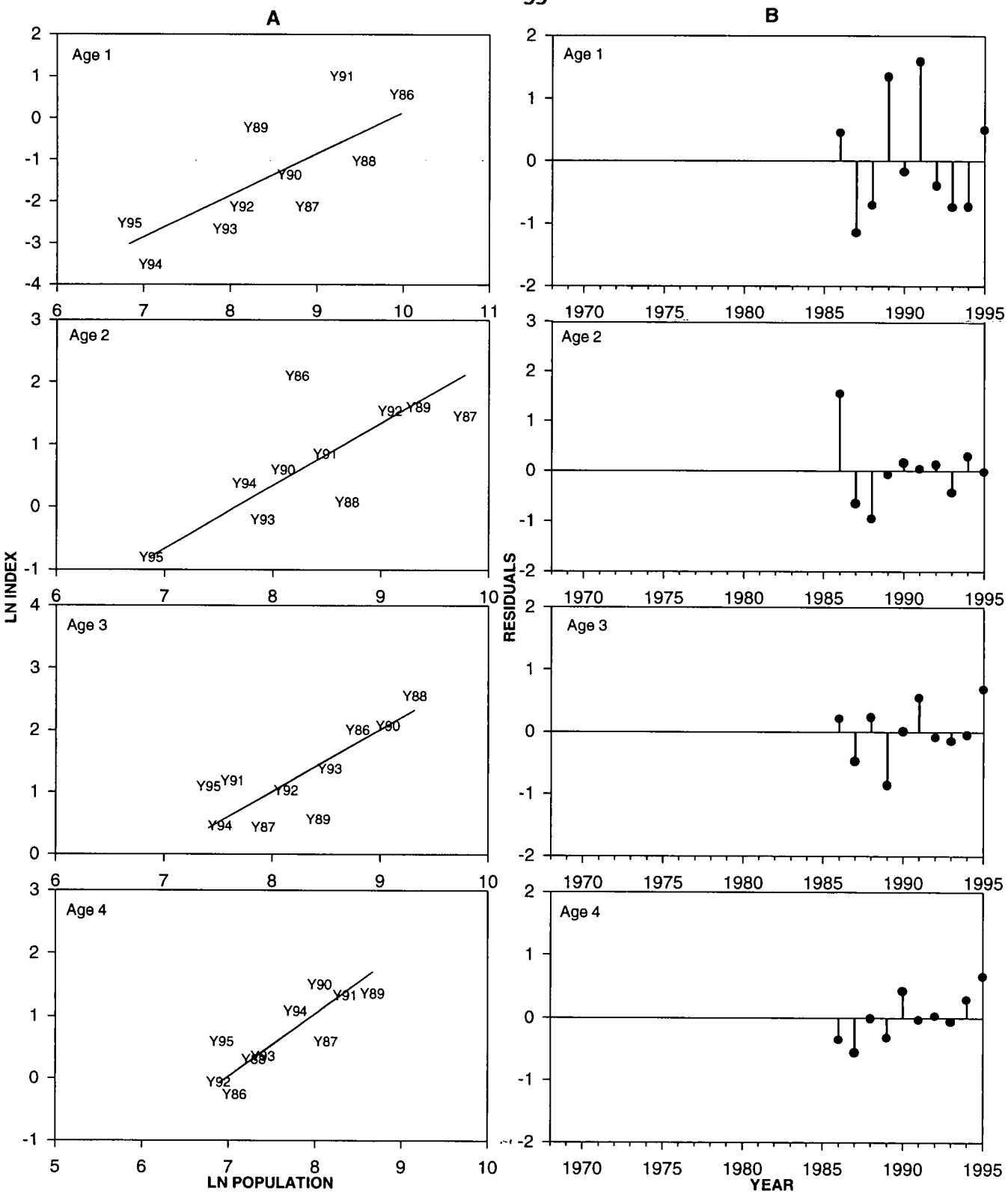


Figure 4c. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the Canadian spring survey for cod in unit areas 5Zj and 5Zm.

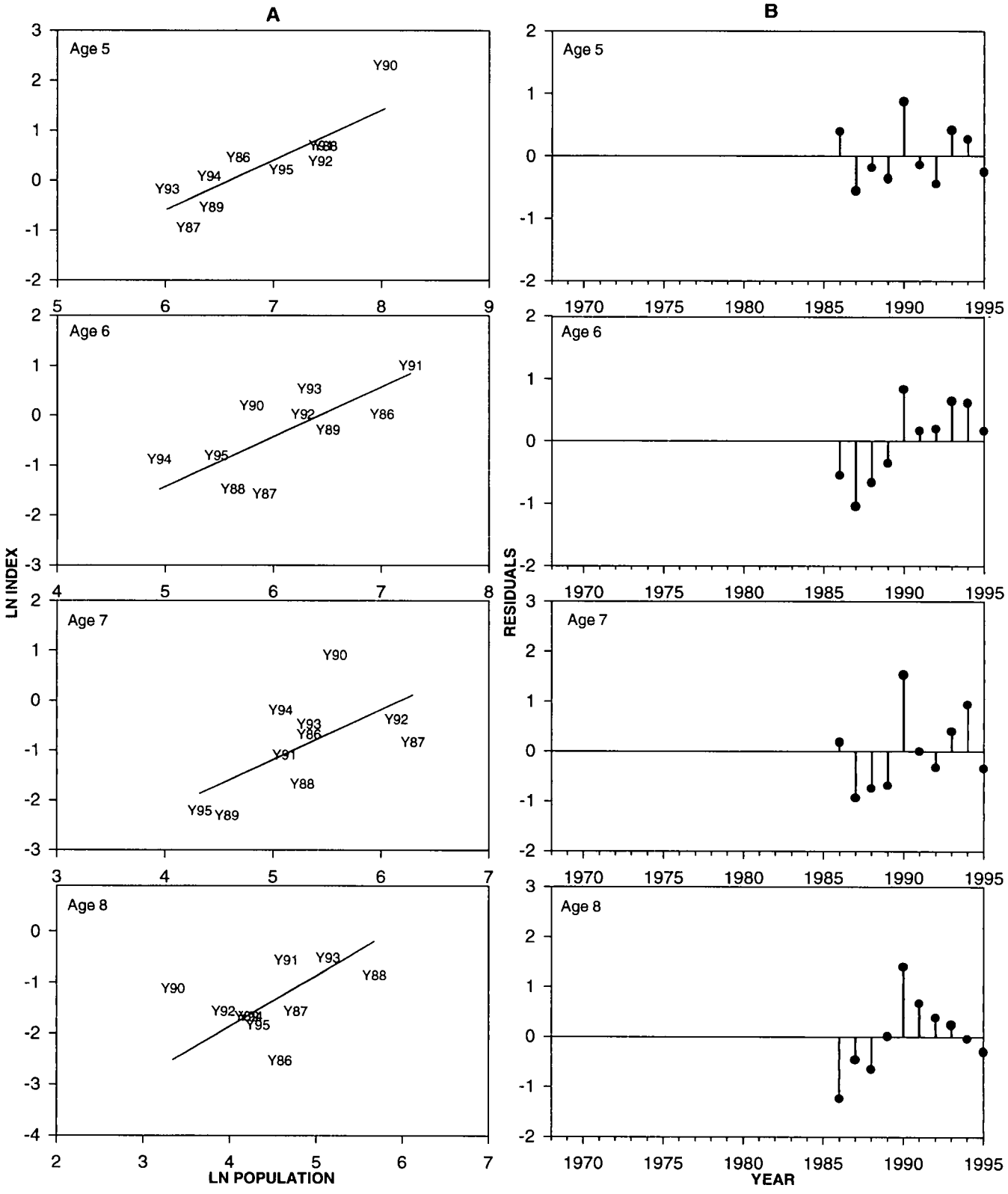


Figure 4c. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the Canadian spring survey for cod in unit areas 5Zj and 5Zm.

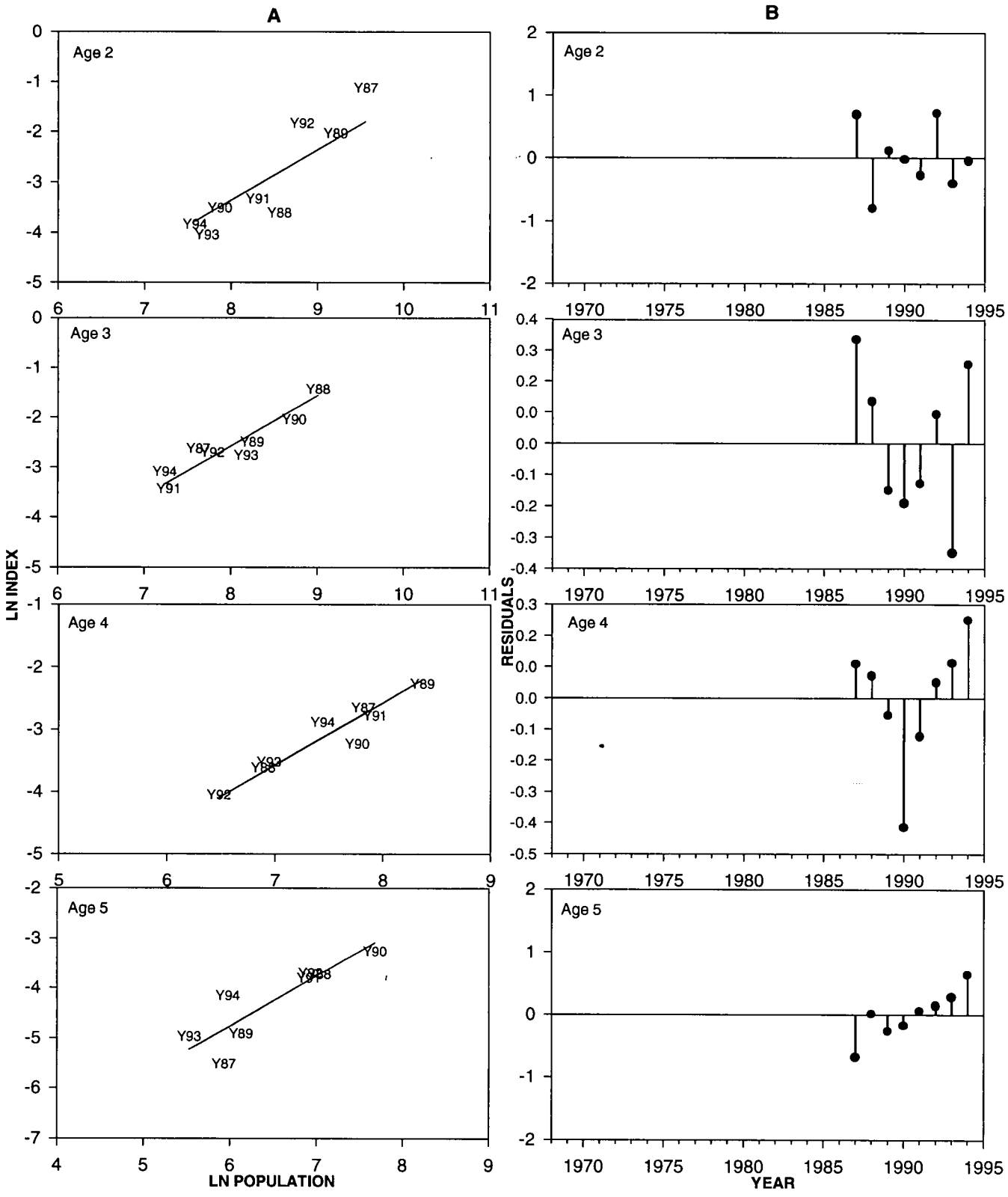


Figure 4d. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the Canadian commercial OTB for cod in unit areas 5Zj and 5Zm.

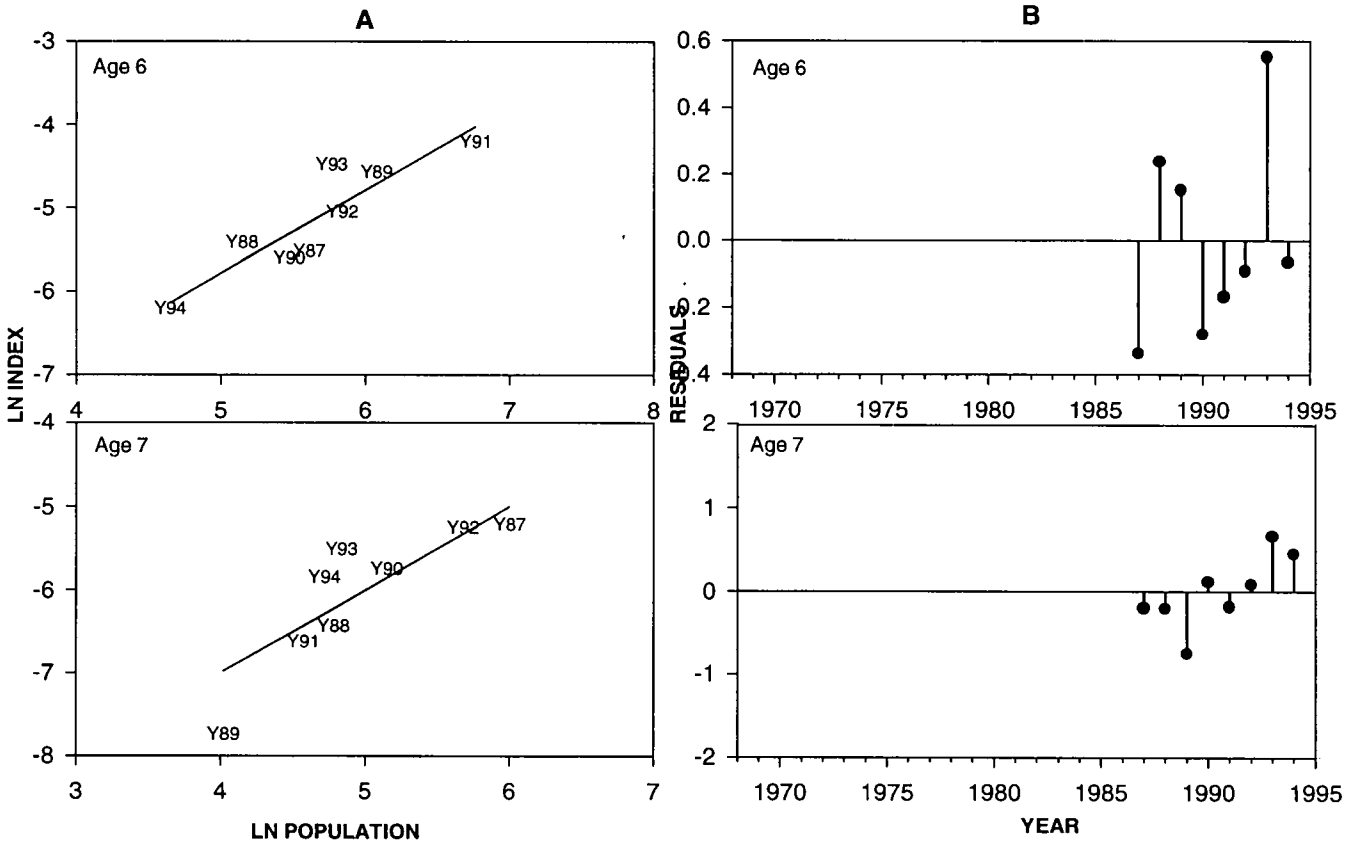


Figure 4d. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the Canadian commercial OTB for cod in unit areas 5Zj and 5Zm.

Figure 5. Residuals at ages 1-4 for research surveys and commercial catch rate.