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Assessment of Haddock on Eastern Georges Bank

by

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ABSTRACT

Landings in recent years have fluctuated around 5,000 tons. During 1993 landings declined to 3722t for Canada and to a record low of 421t for the USA. Both fisheries were largely supported by the 1987 yearclass which comprised over 40% of the landed weight. Survey trends indicate a decline of adult abundance in recent years to about the lowest levels observed. Indices for the 1992 yearclass are moderate, comparable in magnitude to those of 1983, 1985 and 1987.

The adaptive framework was used to calibrate the sequential population analysis with the research survey results. The 1992 yearclass was estimated to be comparable to the moderately strong 1983, 1985 and 1987 yearclasses. Adult biomass (ages 3+) has declined to below 10,000t approaching the historic low but shows some recovery in 1994. The fishing mortality rate for ages 4+ was the highest observed, corresponding to harvesting of roughly 60% of the population.

Yield projections showed that the expected catch of about 3,000t in 1994 will result in a fishing mortality of about 0.4, exceeding the $F_{0.1}$=0.25 value. The projected $F_{0.1}$ yield for 1995 would be about 4,000t with the 1992 yearclass accounting for roughly half the landed weight. Though haddock abundance is projected to increase, this is due primarily to the moderately strong 1992 yearclass. Restraint should be exercised in 1994 to allow these fish to grow and to contribute to spawning. It has been suggested by several fishermen that 140 mm square mesh is needed to conserve small haddock.

RESUME

Les débarquements des dernières années ont fluctué autour de 5 000 tonnes. Ils ont diminué en 1993, jusqu'à 3 722 t au Canada et à 421 t, seuil sans précédent, aux États-Unis. Dans les deux pays, la pêche a été largement alimentée par la classe d'âge de 1987, qui représentait plus de 40 % du poids des débarquements. Les tendances se dégageant des relevés de recherche dénotent une baisse de l'abondance des adultes, qui ces dernières années a atteint ses plus bas niveaux. D'après les indices, l'abondance de la classe de 1992 est modérée, et comparable à celles de 1983, 1985 et 1987.

On a utilisé la méthode Adapt pour étalonner l'analyse séquentielle de population à partir des résultats des relevés de recherche. On estimait que la classe d'âge de 1992 était comparable à celles de 1983, de 1985 et de 1987, qui étaient de force moyenne. La biomasse d'adultes (âges 3+) est tombée sous les 10 000 t, approchant du record le plus bas, mais présentait des signes de rétablissement en 1994. Le taux de mortalité due à la pêche des poissons d'âges 4+ était le plus élevé des taux observés, correspondant à une récolte d'environ 60 % de la population.

D'après les projections de rendement, les prises escomptées (environ 3 000 t) en 1994 se traduiront par une mortalité due à la pêche d'environ 0,4, ce qui est supérieur à la valeur $F_{0.1}$ = 0.25. Le rendement prévu à $F_{0.1}$ en 1995 serait d'environ 4 000 t, la classe d'âge de 1992 représentant environ la moitié du poids des débarquements. Quoique que l'on prévoie une hausse de l'abondance de l'aiglefin, en raison surtout de la classe d'âge de 1992, qui est modérément forte. Il convient de faire preuve de mesure en 1994 pour permettre à ces poissons de croître et de contribuer au frai. Selon plusieurs pêcheurs, il est nécessaire d'utiliser des filets à mailles carrées de 140 mm pour conserver le petit aiglefin.

DESCRIPTION OF THE FISHERY

The haddock on Georges Bank have supported a commercial fishery since the early 1920's (Clark et al 1982). Record landings were reported in the 1960s, reaching about 60,000t for eastern Georges Bank, unit areas 5Zjm (Fig. 1). Since 1969 landings have ranged between 2,500 and 25,000t (Table 1, Fig. 2) and in recent years have fluctuated around 5,000t. Since 1977, only Canada and the USA have conducted haddock fisheries on Georges Bank and following the establishment of a maritime boundary in 1984 by the International Court of Justice, each country's fishery has been restricted to their respective jurisdictions.

Bottom otter trawl and longline have been the predominant gears in the Canadian fishery (Table 2). During 1993 both the longline and otter trawl catches declined resulting in total landings of 3722t for Canada. In recent years the management plan regulated that 5Zj,m be closed to the otter trawl fishery not only during the Mar. 1 to May 31 spawning closure but also during January and February and consequently, landings have generally peaked during June or July (Table 3). Subsequent to the introduction of ITQs in 1992, the otter trawl fishery was permitted to operate during January and February of 1993 and a substantial quantity was landed in those months. That fishery reported good catches and the fish were generally larger and in spawning condition. However, catches during the second half of the year, following the end of the spawning closure, were lower than in previous years. The fishery was closed to all gears during January to May in 1994.

The USA fishery is almost exclusively an otter trawl fishery (Table 4). In recent years catches during the second half of the year have been minimal (Table 5). During 1993, USA landings decreased to a record low of 421t. During 1994 the USA extended the February to May spawning season closure into June and expanded the restricted area. A 500 lb. haddock trip limit was also imposed. Initial reports indicated a continuing decline in landings in 1994 with catches in the first quarter of about 60t.

Environmental conditions on Georges Bank do not appear to show any significant anomalous patterns in recent years. *There has been an increase of herring on Georges Bank and fishermen suggest that this is beneficial for haddock as they feed on herring roe.* Cod prey on juvenile haddock, as evidenced by increased reports from fishermen of stomach contents examined during the latter months of 1993, but the abundance of cod on Georges Bank appears to have declined substantially in recent years (Hunt and Buzeta 1993).

CATCH AND WEIGHT AT AGE

The 1993 Canadian commercial catch was well sampled for length and age composition with 43 samples taken while the reduced landings by the USA resulted in only 11 samples taken from that fishery. The catch and weight at age for 1969 to 1992 were taken from Gavaris and Van Eeckhaute (1993) and those for 1993 were calculated in a similar manner. The Canadian age length key for quarter 1 was used with the USA length frequency samples in quarter 1 due to insufficient samples from that portion of the fishery. Both fisheries were largely supported by the

1987 (average length of 62 cm) yearclass which comprised over % of the landed weight (Tables 6 - 11). *This observation was corroborated by reports from fishermen that the size of haddock caught in 1993 was generally larger than in recent years* (Fig. 3). There were no persistent long term trends in weight at age however the 1989 yearclass appears larger. The 1987 yearclass contributed to the landings to a greater extent than had been forecast from the previous assessment (Fig. 4), in part due to the otter trawl fishery in January and February which concentrated on spawning aggregations. Considerably fewer age 2 haddock were caught than was forecast and this may be due in part to increased use of larger mesh size and/or square mesh by the otter trawl fleets. The partial recruitment value used for the projections made last year assumed traditional gear selectivity. Examination of comparative interpretation of ages from otolith samples did not reveal any problematic inconsistencies (see Appendix 1).

ABUNDANCE INDICES

Research Surveys

Annual stratified random surveys have been conducted by the USA in the spring since 1968 and in the fall since 1963 and by Canada in the spring since 1986. Conversion factors to account for vessel and door changes (Tables 12 and 13) were applied to the USA surveys as suggested in Hayes and Buxton (1992). The trends indicate a decline in adult abundance to about the lowest levels observed (Tables 14-16) though there is indication of an increase in the most recent year. The abundance of ages 3 to 8 from the Canadian spring survey increased by about 180% between 1993 and 1994. The abundance of ages 2 to 7 from the USA fall survey increased by an order of magnitude between 1992 and 1993. The USA spring survey results for 1994 were not available. Survey results on incoming recruitment (ages 1 and 2) identified the strong 1975 and 1978 year-classes and the moderate 1983, 1985 and 1987 year-classes. Recruitment since then has been low though the 1992 year-class appears comparable, and perhaps stronger than those of 1983, 1985 and 1987. Although not well estimated, early indications suggest the 1993 yearclass may be of moderate strength. *Reports from fishermen indicated that small haddock, of a length corresponding to the 1993 yearclass, were seen in abundance in cod stomachs during the fishery at the end of 1993.*

Commercial Catch Rate

The 1987 to 1993 catch and effort data from tonnage classes 2 and 3 otter trawls were analyzed using a multiplicative model (Gavaris 1980) to standardize for vessel, area and month effect. Eighty-one vessels were selected for inclusion in the analysis based on having a history of activity in at least 4 years and more than 13 trips during the time series. Since most of the fishery occurs from June to Sept., records for those months only were used. Records where the effort was less than 3 hours were removed. The resulting trend showed an increase in 1989 followed by a sharp decline in 1990 and a further declined from 1992 to 1993 (Fig. 5). *Fishermen reported that "there appeared to be less haddock in the summer of '93 compared to the summer of '92" corroborating the results from the analysis for those two years but suggested that the change from diamond mesh to square mesh was the principal factor in the decline from the late 1980s to the early 1990s. They also indicated that the introduction of ITQs resulted in a change to their fishing patterns which impacted catch rates. The high value in 1989 was attributed to*

the closure of the fishery after only 2 weeks of fishing in June. Fishermen noted that interpretation of longline catch per trip would be confounded by behavioral differences associated with the availability of feed and by management measures such as trip limits. Recognizing these limitations in the interpretation of commercial catch rates as an index of trends in abundance, they were not used in subsequent analyses.

ESTIMATION OF STOCK PARAMETERS

The adaptive framework, ADAPT, (Gavaris 1988) was used to calibrate the sequential population analysis with the research survey results using the following data :

$C_{a,y}$ = catch	a=1 to 8, y=1969 to 1993
$I_{1,a,y}$ = USA fall survey	a=0 to 5, y=1968 to 1993
$I_{2,a,y}$ = USA spring survey	a=1 to 8, y=1969 to 1993
$I_{3,a,y}$ = Canadian spring survey	a=1 to 8, y=1986 to 1994

where a indexes age and y indexes year. The spring survey results were compared to beginning of year population abundance in the same year while the fall survey results were compared to beginning of year population abundance in the following year for the respective cohort. A preliminary analysis showed that there was a lot of variation in the relationship between population abundance and USA fall survey indices at ages 6 and 7 and led to the exclusion of those ages. The 1979 observation at age 2 and the 1987 observation at age 1 from the USA fall survey and the 1975 observations at ages 7 and 8 from the USA spring survey which had extreme residuals were removed. These observations were not influential with respect to the estimates of population abundance but their exclusion along with exclusion of the USA fall survey indices at ages 6 and 7 resulted in a 20% reduction of the mean square residual, thereby impacting our perception of the precision of estimates. All other available data since 1968 were used except when the indices were 0 (logarithm not defined) or when discarding was high and survey independent estimates of the catch were not available. The model formulation employed assumed that the error in the catch at age was negligible. The error in the survey abundance indices was assumed to be independent and identically distributed after taking natural logarithms of the values. Natural mortality, M, was assumed constant and equal to 0.2 and fishing mortality, F, for age 8 was assumed equal to the arithmetic average for ages 4 to 7.

Following the recommendation by Gavaris (1993) a model formulation using ln population abundances at the end of the terminal year (beginning of year y = t+1) as parameters was considered. Define the model parameters

$\phi_{a,t+1}$ = ln population abundance

for a = 1 to 7 and

$\kappa_{s,a}$ = calibration constants

for each survey, indexed by s, and the relevant ages.

ADAPT was used to solve for the parameters by minimizing the objective function

$$Q(\phi,\kappa) = \sum_{s,a,y}(q_{a,y}(\phi,\kappa))^2 = \sum_{s,a,y}(\ln(I_{s,a,y}) - \ln(\kappa_{s,a}N_{a,y}(\phi)))^2$$

To avoid confusion, the beginning of year population abundance, $N_{a,y}(\phi)$ is abbreviated by $N_{a,y}$. For year y = t+1, the population abundance was obtained directly from the parameter estimates,

$$N_{a,t+1} = \exp[\phi_{a,t+1}]$$

The population abundance for age 8 was not estimated but calculated assuming a fishing mortality rate equal to the average fully recruited fishing mortality rate. For all other years, y = 1 to t, the population abundance was computed using the virtual population analysis algorithm which incorporates the exponential decay model

$$N_{a,y} = N_{a+1,y+1} \exp[F_{a,y}+M]$$

where the fishing mortality for ages 1 to 8 is obtained by solving the catch equation using a Newton-Raphson algorithm,

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

The fishing mortality rate for age 9 was assumed equal to the average for ages 4 to 7.

The variance and bias of population abundance estimates and corresponding projected yield were derived using analytical approximation (Gavaris 1993). The population abundance estimates show a large relative error and substantial bias (Table 17). The magnitude of the residuals is large but they do not indicate a lack of fit to the model (Fig. 6) except perhaps those for the Canadian survey which suggest that the relationship between the abundance index and population does not go through the origin. The survey indices, scaled by the calibration constants and converted to biomass, correspond well with the trends estimated by the sequential population analysis (Fig. 7).

ASSESSMENT RESULTS

For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias and used to construct the history of stock status (Tables 18-21). This approach for bias adjustment, in the absence of an unbiased point estimator with optimal statistical properties, was considered preferable to using the biased point estimates.

The 1983, 1985 and 1987 year-classes were estimated to be the most abundant since the strong 1975 and 1978 year-classes (Fig. 8) and the strength of the 1992 year class was estimated to be comparable to these while those between 1987 and 1992 were weak. There are indications that the 1993 yearclass may be of moderate strength as well but it is too early to estimate its strength reliably. Adult biomass (ages 3+) declined rapidly to below 10,000t since 1990 as the 1985 and 1987 year-classes were fished down approaching the historic low observed during the early 1970s but shows some recovery in 1994 (Fig. 9). The fishing mortality rate for ages 4+ in 1993 was the highest observed (Fig. 10), corresponding to harvesting of roughly 60% of the population and primarily exploiting the 1987 yearclass. The previous occasion when the fishing mortality exceeded 0.5 was during the early 1970s when abundance was at its lowest.

PROGNOSIS

Yield projections were done using the 1994 beginning of year population numbers as estimated from ADAPT, the average of 1991-93 for weight at age and a revised partial recruitment to the fishery with reduced relative exploitation at ages 2 and 3 to reflect the increased use of larger mesh size and square mesh by the otter trawl fleets (Table 22). As with the population abundance estimates, the adjustment for bias of the projected yield was considered more appropriate than using the biased point estimate. Projections were done assuming that the combined Canadian and USA catch in 1994 would be 3,000t. A catch of this magnitude would result in a reduction of the fishing mortality rate to about 0.4, somewhat higher than the $F_{0.1}$ = 0.25 value. The adult biomass is projected to increase to over 30,000 t at the beginning of 1996 (Fig. 11) primarily due to the recruitment of the 1992 yearclass. The projected yield at $F_{0.1}$ in 1995 would be about 4,000 t with the 1992 year-class accounting for roughly half of the landed weight. A tendency for successive estimates of population abundance to decrease as additional years of data are included, has been noted for several stocks and is referred to as a retrospective pattern. This stock does not display a persistent retrospective pattern (Fig. 12).

Though haddock abundance is projected to increase, it should be noted that this is due primarily to one moderately strong yearclass. Continuing conservation efforts are needed to rebuild the population biomass and to expand the age structure. The 1992 yearclass will be 2 years old in 1994 and restraint should be exercised to allow these fish to grow and to contribute to spawning. A greater proportion of small fish were landed by the regulation diamond mesh which was used by the EA trawlers in a pollock directed fishery during quarter 4 than by the 130mm square mesh used by the ITQ draggers in a cod/haddock directed fishery during quarter 3 (Fig. 13). Based on controlled selectivity experiments investigating the influence of mesh type and size on catch, the observed difference was greater than would have been expected. Factors other than net mesh which could affect partial recruitment include net rigging, location of fishery and seasonal growth differences. *Several ITQ representatives have suggested that 140 mm square mesh should be mandatory on Georges Bank as a measure to conserve the smaller fast growing haddock.* The longline fleet fishing Georges Bank use large hooks for the most part and the size composition of their catch is similar to that of the ITQ draggers.

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Table 1. Nominal catches (t) of haddock from unit areas 5Zj and 5Zm. For "others" it was assumed that 40% of the total 5Z catch was in 5Zj and 5Zm.

Year	Canada	USA	Others	Total
1969	3941	6622	695	11258
1970	1970	3153	357	5480
1971	1610	3534	770	5914
1972	609	1551	502	2662
1973	1565	1396	396	3357
1974	462	955	573	2750*
1975	1353	1705	29	3087
1976	1355	973	24	2352
1977	2871	2429	0	9174*
1978	9968	4724	0	16269*
1979	5080	5211	0	10291
1980	10017	5615	0	25036*
1981	5658	9077	0	14735
1982	4872	6280	0	11152
1983	3208	4454	0	7662
1984	1463	5121	0	6583
1985	3484	1683	0	5167
1986	3415	2200	0	5615
1987	4703	1418	0	6111
1988	4046**	1693	0	5739
1989	3059	787	0	3846
1990	3340	1189	0	4529
1991	5446	931	0	6377
1992	4061	1629	0	5690
1993	3722	421	0	4143

* Values augmented by 760t, 3874t, 1577t, and 9404t in 1974, 1977, 1978, and 1980, respectively, to account for USA discards.

** 1895t excluded because of suspected misreporting.

Table 2. Canadian catch (t) of haddock in unit areas 5Zj and 5Zm by gear category and otter trawl tonnage class.

	OTTER TRAWL SIDE				OTTER TRAWL STERN					LONGLINE	OTHER	TOTAL
Year	2	3	4	Total	2	3	4	5	Total			
1969	1	7	769	777	0	1	225	2902	3127	23	15	3941
1970	0	24	551	575	2	0	133	1179	1314	78	2	1970
1971	0	0	495	501	0	0	16	939	955	151	3	1610
1972	0	2	146	148	0	0	2	260	263	195	3	609
1973	0	25	608	633	0	0	60	766	826	105	0	1565
1974	0	0	27	27	0	6	8	332	346	88	1	462
1975	0	1	221	222	0	1	60	963	1024	107	0	1353
1976	0	2	193	217	0	2	59	905	967	156	15	1355
1977	5	46	319	370	92	243	18	2025	2378	94	28	2871
1978	70	134	2252	2456	237	812	351	5639	7039	169	305	9968
1979	13	190	1419	1622	136	858	627	1564	3185	271	2	5080
1980	9	15	1419	1444	354	359	950	6254	7917	587	69	10017
1981	4	87	387	478	448	629	737	2344	4159	1019	2	5658
1982	1	25	89	115	189	318	187	3341	4045	712	0	4872
1983	17	89	0	106	615	431	107	1130	2283	815	4	3208
1984	0	5	0	5	180	269	21	149	620	835	3	1463
1985	0	72	0	72	840	1401	155	348	2745	626	41	3484
1986	4	48	0	51	829	1378	95	432	2734	594	35	3415
1987	6	41	0	48	782	1448	49	1241	3521	1046	89	4703
1988*	0	41	31	72	1091	1456	186	398	3183	695	97	4046
1989	0	0	0	0	489	573	376	536	1976	977	106	3059
1990	0	0	0	0	928	890	116	471	2411	853	76	3340
1991	0	0	0	0	1610	1647	81	679	4018	1309	119	5446
1992	0	0	0	0	797	1084	56	645	2583	1384	90	4058
1993	0	0	0	0	534	1178	67	699	2488	1138	96	3722

* Catches of 26t, 776t, 1091t and 2t for side otter trawlers class 3 and stern otter trawlers classes 2, 3 and 5 respectively were exluded because of suspected misreporting.

Table 3. Monthly catch (t) of haddock by Canada in unit areas 5Zj and 5Zm.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
1969	105	74	6	291	588	691	559	580	551	360	102	34	3941
1970	2	105	0	1	574	345	103	456	242	103	26	12	1970
1971	0	9	1	0	400	132	283	278	97	246	141	21	1610
1972	0	119	2	0	2	111	84	116	98	68	7	2	609
1973	4	10	0	0	0	184	198	572	339	232	22	4	1565
1974	19	0	1	0	0	58	63	53	96	61	92	19	462
1975	4	14	0	0	0	166	256	482	100	166	118	45	1353
1976	0	7	62	68	60	587	152	190	186	26	9	7	1355
1977	102	177	7	0	23	519	1059	835	13	59	56	22	2871
1978	104	932	44	22	21	319	405	85	642	5433	1962	0	9968
1979	123	898	400	175	69	1393	885	396	406	261	53	22	5080
1980	38	134	14	29	223	2956	2300	965	1411	1668	104	176	10017
1981	38	481	568	4	254	1357	1241	726	292	82	378	239	5658
1982	129	309	1	11	46	1060	769	682	585	837	398	44	4872
1983	32	67	29	47	60	1288	387	483	526	195	88	6	3208
1984	3	5	81	88	73	433	219	254	211	71	25	0	1463
1985	1	11	33	99	26	354	392	1103	718	594	61	93	3484
1986	11	28	79	99	40	1339	1059	369	233	139	12	8	3415
1987	24	26	138	70	12	1762	1383	665	405	107	97	14	4703
1988*	39	123	67	79	15	1816	1360	315	130	65	13	24	4046
1989**	32	94	48	7	20	1398	356	566	141	272	108	18	3059
1990	35	14	50	0	7	1179	668	678	469	199	18	22	3340
1991	144	166	49	26	21	1928	1004	705	566	576	123	137	5446
1992	118	205	97	152	36	1381	619	414	398	401	209	28	4058
1993	468	690	96	76	25	722	506	329	202	198	227	183	3722

* Catches of 3t, 1846t and 46t for Jan., Feb., and Mar., respectively for otter trawlers were excluded because of suspected misreporting.

** Early closure of fishery for otter trawlers in June (per. comm. P. Partington).

Table 4. USA catch (t) of haddock in unit areas 5Zj and 5Zm by gear category and otter trawl class.

Year	Otter Trawl Class 3	Otter Trawl Class 4	Otter Trawl Total	LL	Misc.	Total
1969	3010	3610	6621	0	0	6621
1970	1602	1551	3154	0	0	3154
1971	1760	1768	3533	0	0	3533
1972	861	690	1551	0	0	1551
1973	637	759	1396	0	0	1396
1974	443	512	955	0	0	955
1975	993	675	1668	0	36	1705
1976	671	302	972	0	2	974
1977	1721	700	2423	0	5	2428
1978	3140	1573	4713	0	11	4725
1979	3281	1927	5208	0	4	5212
1980	3654	2955	5611	0	4	5615
1981	3591	5408	9031	0	45	9075
1982	2585	3657	6242	11	26	6279
1983	1162	3261	4423	11	18	4453
1984	1854	3260	5115	2	3	5120
1985	856	823	1679	0	4	1683
1986	985	1207	2192	0	9	2201
1987	778	639	1417	0	1	1418
1988	920	768	1688	0	6	1694
1989	359	419	780	0	6	785
1990	486	688	1178	0	4	1182
1991	400	517	918	0	13	931
1992	597	740	1337	0	292	1629
1993	142	191	333	0	88	421

Table 5. Monthly catch (t) of haddock by USA in unit areas 5Zj and 5Zm.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	525	559	976	1825	670	809	204	219	249	226	203	157	6622
1970	169	219	242	375	608	374	324	333	179	219	61	50	3153
1971	155	361	436	483	668	503	338	152	147	165	58	68	3534
1972	150	196	91	90	239	261	97	164	84	63	52	64	1551
1973	90	111	77	85	138	365	217	196	37	3	22	55	1396
1974	135	70	47	70	122	160	165	43	27	6	19	91	955
1975	152	123	32	116	388	489	138	95	57	24	52	39	1705
1976	116	147	83	106	323	162	7	6	5	2	3	13	973
1977	75	211	121	154	374	372	434	191	73	52	146	226	2429
1978	336	437	263	584	752	750	467	221	245	426	194	49	4724
1979	274	329	352	548	766	816	588	659	224	202	281	172	5211
1980	632	1063	742	784	711	461	324	254	221	91	110	222	5615
1981	550	1850	634	627	882	1326	1233	873	321	284	242	255	9077
1982	425	754	502	347	718	1801	757	145	201	216	276	138	6280
1983	492	931	272	181	310	1145	231	178	187	110	227	190	4454
1984	540	961	366	281	627	1047	370	302	250	196	92	89	5121
1985	165	190	254	300	352	206	60	47	1	24	41	43	1683
1986	184	396	334	479	496	221	31	6	12	6	6	29	2200
1987	225	52	43	307	233	342	67	30	24	4	23	68	1418
1988	196	152	207	245	366	316	30	19	6	1	45	110	1693
1989	114	56	47	164	161	145	15	8	1	5	25	46	787
1990	148	21	155	274	214	306	23	3	5	5	16	19	1189
1991	105	28	76	133	89	434	1	20	6	0	19	19	931
1992	253	81	51	149	353	669	20	20	17	3	2	12	1629
1993	15	12	16	55	84	209	6	3	3	7	2	8	421

Table 6. Canadian commercial catch-at-age (numbers 000's) of haddock from unit areas 5Zj and 5Zm.

Year	Age Groups 1	2	3	4	5	6	7	8	9+	Total
1969	0	7	558	101	105	963	275	28	89	2127
1970	4	35	3	129	57	46	410	131	60	875
1971	0	491	71	6	67	41	33	173	84	968
1972	90	0	88	19	5	16	6	3	85	312
1973	107	829	1	188	15	3	18	3	49	1213
1974	0	240	66	0	10	1	0	9	16	341
1975	0	117	620	91	2	16	0	1	14	863
1976	53	119	120	391	57	0	7	0	10	757
1977	0	2398	34	63	94	46	0	3	1	2639
1978	1	250	5865	97	55	98	35	1	2	6404
1979	0	14	99	2196	136	70	56	11	2	2585
1980	2	8608	305	130	668	58	15	11	5	9802
1981	0	243	2279	140	275	390	38	3	18	3386
1982	0	313	469	1400	93	106	195	9	5	2590
1983	0	161	359	258	679	76	34	89	4	1660
1984	0	12	38	63	52	172	61	33	104	535
1985	0	2022	305	114	89	55	87	22	62	2755
1986	6	38	1701	86	70	52	29	40	21	2042
1987	0	1986	90	1088	59	32	30	28	68	3381
1988	4	51	1878	81	390	53	7	16	86	2566
1989	0	1132	68	623	64	202	13	8	37	2146
1990	2	6	1070	55	501	14	122	29	34	1833
1991	6	429	62	1809	50	297	28	123	57	2861
1992	7	230	237	62	1020	14	212	3	86	1871
1993	9	242	306	248	70	548	7	146	71	1647

Table 7. Average weight-at-age (kg) of haddock from the Canadian commercial fishery in unit areas 5Zj and 5Zm.

Year	Age Groups 1	2	3	4	5	6	7	8
1969	-	0.766	1.324	1.513	1.679	1.887	2.364	2.807
1970	0.721	1.062	0.812	1.653	1.905	2.137	2.201	2.855
1971	-	0.950	1.147	1.284	2.141	2.346	2.274	2.684
1972	0.759	-	1.703	1.820	2.209	2.624	2.469	2.792
1973	0.683	1.054	1.367	1.789	2.296	1.760	3.003	3.097
1974	-	1.025	1.449	-	1.995	3.760	-	3.145
1975	-	0.868	1.544	2.096	1.997	2.425	4.114	3.557
1976	0.596	0.996	1.351	2.076	2.808	-	3.251	-
1977	-	0.964	1.466	1.871	2.500	3.035	-	3.502
1978	0.619	1.168	1.505	2.186	3.100	3.290	3.188	3.364
1979	-	1.024	1.364	1.891	2.387	2.920	3.353	3.383
1980	0.405	0.888	1.032	1.792	2.294	2.593	3.948	3.803
1981	-	0.915	1.391	1.721	2.383	2.822	3.698	5.013
1982	-	1.056	1.556	1.915	2.348	2.801	2.909	3.414
1983	-	1.031	1.401	1.822	2.200	2.543	2.821	3.007
1984	-	0.883	1.401	2.010	2.257	2.770	2.918	3.326
1985	-	0.948	1.264	2.068	2.169	2.942	3.289	3.238
1986	0.452	0.981	1.458	2.104	2.913	2.899	3.646	4.248
1987	-	0.832	1.391	2.073	2.253	2.598	2.906	3.623
1988	0.421	0.974	1.315	1.787	2.234	2.264	2.978	3.036
1989	-	0.861	1.449	1.789	2.215	2.604	2.795	3.014
1990	0.639	0.956	1.461	1.711	2.232	2.281	2.736	2.396
1991	0.581	1.204	1.220	1.838	2.023	2.630	2.341	2.891
1992	0.538	1.163	1.687	1.694	2.264	2.073	2.977	2.633
1993	0.648	1.121	1.762	2.246	2.130	2.690	3.025	3.130

Table 8. USA commercial catch-at-age (numbers 000's) of haddock from unit areas 5Zj and 5Zm.

Year	Age Groups 1	2	3	4	5	6	7	8	9+	Total
1969	0	10	818	145	207	1739	489	53	175	3636
1970	9	42	4	199	82	71	657	212	111	1387
1971	0	566	155	23	150	102	112	462	269	1837
1972	125	0	235	42	13	55	27	8	248	754
1973	42	662	5	155	20	6	17	5	104	1015
1974	0	552	133	0	20	2	0	18	33	757
1975	0	65	784	144	4	29	1	2	24	1053
1976	0	28	53	421	62	0	9	0	11	584
1977	0	1307	30	115	211	117	0	12	13	1806
1978	0	39	2770	63	115	201	46	9	7	3249
1979	0	8	103	2207	189	112	138	28	11	2795
1980	0	911	46	175	1722	134	113	41	7	3149
1981	0	419	4313	244	310	830	84	27	6	6234
1982	0	401	579	1409	103	273	529	53	60	3406
1983	0	44	223	254	973	146	74	324	28	2065
1984	0	67	214	285	204	890	135	127	227	2149
1985	0	41	70	62	101	68	284	30	52	708
1986	0	0	856	87	72	71	89	133	19	1327
1987	0	5	37	427	37	24	52	40	40	661
1988	0	0	267	40	487	56	29	30	12	921
1989	0	21	10	111	66	118	18	13	7	364
1990	0	1	195	71	241	54	41	13	8	624
1991	0	12	27	232	39	92	45	22	3	472
1992	0	0	74	65	426	75	103	22	3	768
1993	0	1	25	35	17	84	27	10	4	203

Table 9. Average weight-at-age (kg) of haddock from the USA commercial fishery in unit areas 5Zj and 5Zm.

Year	Age Groups 1	2	3	4	5	6	7	8
1969	-	0.760	1.253	1.543	1.633	1.807	2.261	2.918
1970	0.721	1.071	0.813	1.653	1.873	2.116	2.198	2.833
1971	-	0.909	1.018	1.269	1.952	2.218	2.258	2.586
1972	0.759	-	1.509	1.719	2.125	2.470	2.397	2.414
1973	0.683	0.937	1.367	1.823	2.133	1.573	2.758	3.398
1974	-	0.946	1.402	-	1.979	3.760	-	3.120
1975	-	0.878	1.508	2.041	1.997	2.420	4.114	3.557
1976	-	0.785	1.163	1.654	2.057	-	2.293	-
1977	-	0.981	1.414	1.776	2.264	2.720	-	3.007
1978	-	1.043	1.280	1.852	2.397	2.737	2.808	2.745
1979	-	0.920	1.235	1.719	2.076	2.735	3.164	3.233
1980	-	0.929	1.050	1.640	2.045	2.593	3.481	3.553
1981	-	0.876	1.194	1.518	2.170	2.511	3.418	3.882
1982	-	0.894	1.207	1.657	2.308	2.463	2.976	3.551
1983	-	1.001	1.245	1.678	2.061	2.491	2.906	3.130
1984	-	0.875	1.345	1.801	2.134	2.573	2.828	3.084
1985	-	1.049	1.081	1.635	2.278	2.509	2.745	3.138
1986	-	-	1.142	1.630	1.830	2.576	2.749	3.367
1987	-	1.118	1.529	1.758	1.978	2.588	2.980	3.661
1988	-	1.160	1.239	1.546	1.888	2.431	3.019	3.449
1989	-	1.246	1.455	1.706	2.152	2.381	3.170	3.650
1990	-	1.416	1.184	1.846	1.953	2.570	3.016	4.288
1991	-	0.939	1.288	1.515	2.169	2.485	3.276	3.687
1992	-	1.311	1.417	1.616	1.946	2.573	3.011	3.505
1993	-	1.036	1.394	1.787	1.769	2.274	2.209	2.843

Table 10. Total[1] commercial catch-at-age (numbers 000's) of haddock from unit areas 5Zj and 5Zm.

Year	Age Groups 1	2	3	4	5	6	7	8	9+	Total
1969	0	19	1449	262	333	2881	816	88	264	5763
1970	25	83	7	350	148	127	1140	366	171	2262
1971	0	1219	261	32	249	163	166	748	353	2805
1972	281	1	398	75	22	87	42	13	333	1066
1973	1015	1728	7	360	37	10	37	8	153	2228
1974	17	2080[2]	272	0	40	3	0	35	49	1098
1975	0	184	1418	237	6	46	1	3	38	1916
1976	67	148	175	818	121	0	16	0	21	1341
1977	0	7623[2]	65	178	305	163	0	15	14	4445
1978	1	289	9832[2]	160	169	299	81	10	9	9653
1979	0	22	202	4403	325	182	195	39	13	5380
1980	2	9519	351	305	2391	192	128	52	12	12951
1981	0	661	6593	384	585	1220	121	31	24	9620
1982	0	714	1048	2809	196	379	724	62	65	5996
1983	0	205	582	512	1652	221	108	413	32	3725
1984	0	79	252	348	256	1062	196	160	331	2684
1985	0	2063	374	176	189	123	371	53	114	3463
1986	6	38	2557	173	142	122	118	173	40	3369
1987	0	1990	127	1515	96	56	82	68	108	4042
1988	4	51	2145	121	877	109	36	46	98	3487
1989	0	1153	78	734	129	320	31	20	44	2510
1990	2	7	1265	126	743	68	163	42	42	2457
1991	6	441	89	2041	88	389	72	145	60	3333
1992	7	230	311	127	1446	89	315	26	89	2639
1993	9	243	331	282	86	632	34	156	75	1850

[1]Total catch includes small mesh foreign fishery.
[2]Includes discard estimates based on trip interviews.

Table 11. Average weight-at-age (kg) of haddock from the commercial fishery in unit areas 5Zj and 5Zm.

Year	Age Groups 1	2	3	4	5	6	7	8
1969	-	0.763	1.282	1.531	1.649	1.836	2.298	2.879
1970	0.721	1.067	0.812	1.653	1.886	2.124	2.199	2.841
1971	-	0.928	1.059	1.272	2.011	2.255	2.262	2.613
1972	0.759	-	1.562	1.750	2.147	2.505	2.411	2.514
1973	0.683	1.002	1.367	1.804	2.202	1.631	2.885	3.295
1974	-	0.970	1.418	-	1.984	3.760	-	3.128
1975	-	0.872	1.524	2.062	1.997	2.422	4.114	3.557
1976	0.596	0.956	1.293	1.857	2.417	-	2.702	-
1977	-	0.970	1.442	1.809	2.337	2.809	-	3.095
1978	0.619	1.151	1.433	2.055	2.623	2.919	2.972	2.829
1979	-	0.987	1.298	1.805	2.206	2.806	3.219	3.277
1980	0.405	0.892	1.034	1.705	2.115	2.593	3.535	3.608
1981	-	0.890	1.262	1.592	2.270	2.611	3.505	4.009
1982	-	0.965	1.363	1.786	2.327	2.557	2.958	3.531
1983	-	1.024	1.341	1.750	2.118	2.509	2.879	3.104
1984	-	0.876	1.354	1.838	2.159	2.605	2.856	3.134
1985	-	0.950	1.230	1.915	2.227	2.702	2.872	3.180
1986	0.452	0.981	1.352	1.866	2.367	2.712	2.969	3.570
1987	-	0.833	1.431	1.984	2.148	2.594	2.953	3.646
1988	0.421	0.974	1.305	1.708	2.042	2.350	3.011	3.305
1989	-	0.868	1.450	1.777	2.183	2.522	3.012	3.411
1990	0.639	0.999	1.419	1.787	2.141	2.509	2.807	3.002
1991	0.581	1.197	1.241	1.802	2.087	2.596	2.918	3.012
1992	0.538	1.163	1.622	1.654	2.171	2.491	2.988	3.388
1993	0.648	1.121	1.734	2.190	2.059	2.635	2.385	3.112

Table 12. Vessel and door used in the spring survey on Georges Bank, and conversion coefficients (from Hayes and Buxton 1992).

Year(s)	Vessel	Door	Conversion coefficient
1968-80	ALBATROSS IV	BMV	1.633
1981-82	DELAWARE II	BMV	1.391
1983-84	ALBATROSS IV	BMV	1.633
1985-88	ALBATROSS IV	POLY	1.000
1989-91	DELAWARE II	POLY	0.852
1992-93	ALBATROSS IV	POLY	1.000

Table 13. Vessel and door used in the fall survey on Georges Bank, and conversion coefficients (from Hayes and Buxton 1992).

Year(s)	Vessel	Door	Conversion coefficient
1963-76	ALBATROSS IV	BMV	1.633
1977-81	DELAWARE II	BMV	1.391
1982-84	ALBATROSS IV	BMV	1.633
1985-88	ALBATROSS IV	POLY	1.000
1989-91	DELAWARE II	POLY	0.852
1992	ALBATROSS IV	POLY	1.000
1993	DELAWARE II	POLY	0.852

Table 14. Total estimated abundance-at-age (numbers in 000's) of haddock from unit areas 5Zj and 5Zm from the Canadian spring surveys.

Year	Age Group 1	2	3	4	5	6	7	8	9+	Total
1986	5057	306	8175	997	189	348	305	425	401	16205
1987	46	4286	929	3450	653	81	387	135	1132	11099
1988	971	49	12714	257	4345	274	244	130	686	19670
1989	47	6473	959	2814	241	523	40	36	259	11391
1990	726	108	12302	166	4465	299	1370	144	389	19968
1991	400	2175	137	10776	115	1868	117	497	220	16306
1992	1914	3879	1423	221	4810	18	1277	52	655	14249
1993	3448	1759	545	431	34	1186	19	281	15	7849
1994	4197	15163	5332	549	314	20	915	18	356	26864

Table 15. Total estimated abundance-at-age (numbers in 000's) of haddock in unit areas 5Zj and 5Zm from the spring USA surveys. From 1973-81 a 41 Yankee trawl was used while a 36 Yankee was used in other years. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group 1	2	3	4	5	6	7	8	9+	Total
1969	19	38	673	257	573	3543	1337	392	536	7369
1970	524	209	0	614	1094	484	3473	2748	843	9965
1971	0	718	286	0	158	111	63	1270	297	2904
1972	2843	0	845	144	28	52	231	29	1330	5501
1973	2691	6180	0	1131	169	0	302	0	1324	11796
1974	1450	22573	4476	0	388	0	47	79	353	29366
1975	579	621	6593	1165	0	239	139	50	228	9615
1976	9073	441	475	1347	638	0	0	0	24	11765
1977	151	28410	323	937	894	642	0	24	107	31488
1978	0	815	22861	703	965	1275	98	26	127	26869
1979	11503	483	1439	10701	521	78	488	46	10	25269
1980	4782	74483	1237	1224	6381	688	418	773	394	88552
1981	4093	3462	31529	3287	819	2720	382	65	24	46380
1982	665	4208	1877	8816	848	509	761	0	0	17685
1983	260	844	752	394	2840	32	0	875	63	6060
1984	1497	1551	1092	1097	1026	1365	151	97	515	8391
1985	40	8911	1396	674	1496	588	1995	127	483	15709
1986	3334	280	3597	246	210	333	235	560	159	8953
1987	122	5480	144	1394	157	231	116	370	0	8013
1988	305	61	1868	235	611	203	218	178	0	3678
1989	87	6925	643	1395	278	822	61	95	49	10355
1990	1719	73	10742	621	1083	114	190	0	0	14541
1991	769	2152	449	3513	199	211	68	91	26	7479
1992	530	287	214	141	609	32	46	46	0	1905
1993	1870	1116	197	232	195	717	77	35	43	4480

Table 16. Total estimated abundance-at-age (numbers in 000's) of haddock in unit areas 5Zj and 5Zm from the fall USA survey. Conversion factors to adjust for changes in door type and survey vessel were applied.

	Age Groups									
Year	0	1	2	3	4	5	6	7	8+	Total
1968	60	124	877	30	41	2437	599	194	343	4705
1969	420	0	0	569	69	33	825	502	126	2545
1970	0	7014	368	18	454	369	548	989	633	10394
1971	2878	0	864	107	0	290	30	80	651	4900
1972	5202	2626	0	254	0	0	58	0	302	8442
1973	1474	18409	1760	0	197	1	0	18	18	21711
1974	166	256	1053	185	0	6	0	0	76	1742
1975	33279	728	211	1116	243	0	0	0	28	35604
1976	859	145350	500	28	531	78	0	19	40	147404
1977	53	271	29969	506	142	240	96	4	4	31285
1978	16670	623	603	8774	64	48	107	0	0	26888
1979	1791	24041	16	373	1663	50	13	0	0	27948
1980	4077	3207	6691	0	115	1235	124	29	4	15482
1981	701	5256	2942	3133	120	155	338	0	17	12663
1982	68	0	733	504	2823	174	100	514	46	4961
1983	3956	487	355	476	311	434	21	10	87	6135
1984	50	4219	856	242	230	47	278	0	52	5974
1985	12148	381	1646	199	70	68	46	30	21	14611
1986	30	7471	109	961	52	50	72	24	23	8793
1987	508	4	839	28	152	38	22	0	0	1592
1988	122	3983	206	2326	155	400	142	140	38	7513
1989	174	86	2748	117	529	70	76	0	0	3799
1990	1265	1076	25	1532	94	179	22	5	0	4198
1991	733	344	285	71	277	26	10	0	0	1745
1992	3484	1052	172	110	0	95	0	18	18	4948
1993	714	6914	3742	607	0	90	100	31	0	12200

Table 17. Statistical properties of population abundance and survey calibration constants as estimated with ADAPT.

Population abundance

	Par. Est.	Std. Err.	Rel. Err.	Bias	Rel. Bias
Age 1	11318	7667	0.68	2674	0.24
2	18388	7877	0.43	1800	0.10
3	3959	1396	0.35	260	0.07
4	841	326	0.39	55	0.07
5	286	165	0.58	36	0.13
6	43	25	0.58	7	0.16
7	322	243	0.75	77	0.24
8	21	8	0.38	0	-0.01
9	95	36	0.38	-1	-0.01

Survey Calibration Constants

USA Fall Survey

Age 1	0.1460	0.0280	0.1920	0.0021	0.0146
2	0.4239	0.0860	0.2029	0.0070	0.0165
3	0.2985	0.0576	0.1930	0.0046	0.0153
4	0.2294	0.0433	0.1889	0.0035	0.0154
5	0.1813	0.0364	0.2006	0.0034	0.0185
6	0.1910	0.0364	0.1904	0.0031	0.0163

USA Spring Survey

Age 1	0.1532	0.0304	0.1982	0.0024	0.0158
2	0.3790	0.0730	0.1926	0.0057	0.0151
3	0.5091	0.0979	0.1922	0.0078	0.0153
4	0.5737	0.1102	0.1921	0.0089	0.0155
5	0.6715	0.1262	0.1879	0.0099	0.0147
6	0.4807	0.0946	0.1967	0.0082	0.0170
7	0.6966	0.1400	0.2010	0.0144	0.0207
8	0.6990	0.1439	0.2059	0.0148	0.0212

Canadian Spring Survey

Age 1	0.1579	0.0514	0.3257	0.0068	0.0432
2	0.4107	0.1296	0.3154	0.0166	0.0405
3	0.9427	0.2945	0.3124	0.0382	0.0405
4	0.6992	0.2185	0.3126	0.0297	0.0425
5	0.7955	0.2514	0.3160	0.0373	0.0469
6	0.5713	0.1822	0.3189	0.0263	0.0460
7	0.9517	0.3118	0.3276	0.0570	0.0599
8	0.7670	0.2431	0.3169	0.0457	0.0595

Table 18. Estimated bias adjusted population numbers (000's) at the beginning of the year for haddock in unit areas 5Zj and 5Zm.

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	797	3663	191	5120	11018	2840	3423	54226	6297	4148
2	169	653	2976	157	3937	8102	2310	2803	44336	5156
3	3167	122	459	1334	128	1660	4752	1725	2161	29402
4	875	1282	93	140	732	99	1113	2607	1254	1711
5	863	480	733	47	47	273	81	697	1394	865
6	6647	405	258	375	19	5	188	60	461	865
7	2260	2835	216	64	229	7	2	112	49	230
8	235	1112	1290	27	14	153	6	0	77	41
9	0	113	579	379	10	4	94	2	0	50
1+	15014	10664	6797	7643	16135	13145	11967	62231	56028	42466
2+	14217	7001	6606	2523	5116	10305	8543	8005	49731	38319
3+	14047	6348	3629	2366	1179	2202	6234	5203	5395	33163
4+	10880	6227	3170	1032	1051	542	1482	3478	3235	3761

Year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	40746	6174	4440	2060	2382	15368	1511	13035	1148	14022
2	3395	33360	5053	3635	1687	1950	12583	1237	10667	940
3	3960	2760	18699	3539	2330	1196	1525	8435	979	6933
4	15176	3059	1942	9345	1949	1381	751	910	4592	687
5	1256	8441	2229	1242	5109	1133	816	456	589	2389
6	555	734	4748	1296	839	2688	696	497	245	395
7	438	290	427	2783	718	487	1240	458	296	150
8	115	182	121	240	1624	490	221	680	269	168
9	24	59	102	72	141	956	257	133	400	158
1+	65664	55060	37763	24212	16780	25650	19600	25842	19185	25843
2+	24918	48885	33322	22152	14397	10282	18089	12807	18037	11821
3+	21524	15525	28269	18516	12710	8331	5506	11570	7370	10880
4+	17564	12766	9570	14978	10380	7135	3981	3134	6391	3948

Year	1989	1990	1991	1992	1993	1994
1	723	2234	2295	5854	20271	8644
2	11477	592	1828	1874	4787	16588
3	724	8353	478	1097	1326	3699
4	3735	522	5695	311	617	786
5	453	2393	314	2816	139	250
6	1162	254	1287	177	997	36
7	225	662	146	702	64	245
8	90	156	394	54	290	21
9	97	55	90	191	21	96
1+	18685	15222	12526	13075	28512	30365
2+	17962	12988	10232	7221	8241	21721
3+	6486	12396	8404	5348	3454	5133
4+	5762	4043	7926	4251	2129	1434

Table 19. Estimated bias adjusted population biomass (000's t) at the beginning of the year for haddock in unit areas 5Zj and 5Zm.

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	359	2328	89	3381	6321	1414	1627	25357	2728	2032
2	115	522	2435	121	3433	6596	1670	2123	33729	4285
3	3132	96	488	1606	149	1979	5776	1831	2537	34670
4	1226	1867	94	191	1229	155	1903	4385	1917	2944
5	1370	815	1337	78	93	517	153	1555	2904	1885
6	11564	757	533	841	36	15	411	140	1200	2259
7	4641	5697	474	149	614	14	7	287	134	664
8	605	2841	3092	63	41	461	17	0	222	112
9	0	363	1828	1081	26	17	305	8	0	164
1+	23011	15286	10372	7512	11942	11168	11869	35687	45372	49016
2+	22653	12958	10283	4131	5621	9754	10242	10330	42644	46983
3+	22538	12436	7848	4010	2188	3159	8572	8207	8915	42699
4+	19406	12340	7359	2403	2038	1180	2796	6376	6378	8029

Year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	20049	1687	2100	946	1183	7329	709	4347	541	4114
2	2654	24407	3035	2767	1323	1414	9499	949	6549	719
3	4841	2789	19843	3899	2651	1408	1584	9559	1160	7229
4	24405	4551	2492	14028	3011	2168	1209	1379	7522	1074
5	2673	16491	4385	2391	9936	2202	1651	970	1178	4809
6	1506	1755	11156	3122	2028	6314	1681	1221	606	887
7	1342	913	1289	7734	1948	1304	3392	1298	838	419
8	360	622	457	846	4920	1473	667	2177	884	526
9	69	204	391	306	500	3038	839	448	1593	640
1+	57899	53418	45147	36038	27499	26651	21231	22349	20872	20416
2+	37850	51732	43046	35092	26316	19323	20522	18001	20332	16302
3+	35196	27325	40011	32325	24994	17908	11023	17052	13782	15584
4+	30355	24536	20169	28427	22343	16500	9440	7493	12622	8355

Year	1989	1990	1991	1992	1993	1994
1	336	1043	942	2183	7560	3332
2	6939	458	1598	1540	3718	13676
3	860	9271	533	1529	1882	4843
4	5688	841	9106	445	1163	1288
5	875	4668	606	5569	257	479
6	2638	594	3035	403	2385	84
7	598	1761	395	1955	156	647
8	288	470	1146	170	883	65
9	338	200	269	596	78	313
1+	18560	19306	17631	14391	18083	24726
2+	18224	18263	16689	12208	10523	21394
3+	11285	17805	15091	10668	6805	7718
4+	10424	8535	14558	9139	4923	2875

Table 20. Estimated bias adjusted population biomass (000's mt) at mid-year for haddock in unit areas 5Zj and 5Zm.

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	434	2385	104	3417	6482	1539	1862	29294	3425	2326
2	110	587	1900	142	2642	6088	1746	2360	35281	5216
3	2672	87	285	1567	154	1940	5443	1909	2778	30823
4	1007	1624	86	149	840	161	1833	3599	1895	3023
5	998	675	1074	67	42	452	140	1379	2590	1833
6	8212	639	314	741	19	12	355	148	933	1831
7	3719	4315	204	80	544	17	2	252	121	494
8	480	2320	1945	42	28	379	12	0	193	89
1+	17631	12632	5912	6205	10752	10588	11393	38941	47216	45635
2+	17197	10247	5808	2788	4270	9049	9532	9647	43791	43309
3+	17087	9659	3908	2646	1628	2960	7786	7287	8510	38093
4+	14415	9573	3623	1079	1474	1020	2342	5378	5732	7270

Year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	22158	2266	2415	1120	1296	8357	822	5345	624	5352
2	3028	22594	3785	2833	1462	1515	9851	1082	7220	806
3	4531	2407	17021	3634	2433	1294	1466	8545	1180	6747
4	20721	4470	2493	12526	2633	1974	1132	1376	6691	960
5	2143	13574	3906	2391	7985	1936	1433	803	1043	3477
6	1146	1470	9603	2502	1624	4876	1537	1052	502	709
7	939	684	1139	6365	1719	962	2677	1054	668	353
8	276	500	378	658	3912	1132	553	1884	761	427
1+	54941	47965	40740	32029	23064	22046	19470	21142	18688	18831
2+	32783	45699	38325	30908	21768	13689	18648	15797	18064	13479
3+	29755	23105	34540	28076	20306	12174	8797	14715	10844	12673
4+	25224	20698	17519	24442	17873	10880	7331	6170	9664	5926

Year	1989	1990	1991	1992	1993
1	393	1293	1207	2854	11903
2	8535	532	1713	1842	4730
3	895	9847	482	1353	1790
4	5357	731	7366	354	889
5	751	3819	498	3803	157
6	2242	490	2506	277	1411
7	568	1450	270	1392	93
8	242	360	845	119	546
1+	18983	18522	14888	11993	21519
2+	18590	17229	13681	9139	9617
3+	10055	16697	11968	7298	4886
4+	9160	6850	11485	5944	3096

Table 21. Estimated bias adjusted fishing mortality for haddock in unit areas 5Zj and 5Zm.

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.00	0.01	0.00	0.06	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.13	0.15	0.60	0.01	0.66	0.33	0.09	0.06	0.21	0.06	0.01	0.38	0.16
3	0.70	0.07	0.99	0.40	0.06	0.20	0.40	0.12	0.03	0.46	0.06	0.15	0.49
4	0.40	0.36	0.47	0.89	0.79	0.00	0.27	0.43	0.17	0.11	0.39	0.12	0.25
5	0.56	0.42	0.47	0.71	1.98	0.18	0.09	0.21	0.28	0.24	0.34	0.38	0.34
6	0.65	0.43	1.20	0.29	0.84	0.97	0.31	0.00	0.49	0.48	0.45	0.34	0.33
7	0.51	0.59	1.90	1.29	0.20	0.01	2.41	0.18	0.00	0.49	0.68	0.67	0.38
8	0.54	0.45	1.02	0.81	0.96	0.29	0.82	0.00	0.24	0.33	0.47	0.38	0.33

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.24	0.14	0.05	0.20	0.03	0.23	0.06	0.12	0.01	0.31	0.15	0.06
3	0.40	0.32	0.27	0.32	0.41	0.15	0.42	0.13	0.18	0.23	0.38	0.32
4	0.40	0.34	0.33	0.30	0.24	0.45	0.22	0.25	0.31	0.50	0.60	0.70
5	0.19	0.44	0.29	0.30	0.42	0.20	0.52	0.38	0.42	0.37	0.84	1.15
6	0.39	0.34	0.57	0.22	0.32	0.29	0.36	0.36	0.35	0.41	0.81	1.21
7	0.34	0.18	0.59	0.40	0.33	0.36	0.31	0.16	0.32	0.79	0.69	0.90
8	0.33	0.33	0.45	0.31	0.33	0.33	0.36	0.29	0.35	0.52	0.74	0.90

Table 22. Projections for haddock in unit areas 5Zj and 5Zm.

Weight at age (Mid-Year)

	1994	1995
1	0.59	0.59
2	1.16	1.16
3	1.53	1.53
4	1.88	1.88
5	2.11	2.11
6	2.57	2.57
7	2.76	2.76
8	3.17	3.17

Weight at age (Beginning Year)

	1994	1995	1996
1	0.38	0.38	0.38
2	0.81	0.81	0.81
3	1.37	1.37	1.37
4	1.65	1.65	1.65
5	1.91	1.91	1.91
6	2.34	2.34	2.34
7	2.62	2.62	2.62
8	3.08	3.08	3.08
9	3.34	3.34	3.34

Beginning of Year

Population Numbers

	1994	1995	1996
1	8644	10000	10000
2	16588	7077	8187
3	3699	12584	5512
4	786	2503	9092
5	250	439	1596
6	36	140	280
7	245	20	89
8	21	137	13
9	96	12	87
1+	30365	32911	34856
2+	21721	22911	24856
3+	5133	15834	16669
4+	1434	3251	11157

Population Biomass

	1994	1995	1996
1	3260	3771	3771
2	13399	5716	6613
3	5084	17293	7574
4	1298	4135	15022
5	478	841	3054
6	84	326	655
7	641	53	233
8	66	421	39
9	321	40	292
1+	24631	32596	37254
2+	21371	28825	33483
3+	7972	23108	26870
4+	2888	5816	19296

Mid-Year

Population Numbers

	1994	1995
1	7834	9063
2	14494	6262
3	3062	10743
4	596	2015
5	189	354
6	27	112
7	186	16
8	16	110
1+	26405	28677
2+	18570	19613
3+	4076	13352
4+	1014	2608

Population Biomass

	1994	1995
1	4615	5339
2	16817	7265
3	4693	16464
4	1122	3793
5	399	745
6	70	289
7	513	45
8	51	349
1+	28279	34290
2+	23664	28951
3+	6847	21686
4+	2154	5221

Table 22. (continued)

Fishing Mortality			Catch Numbers			Catch Biomass		
	1994	1995		1994	1995		1994	1995
1	0.00	0.00	1	0	0	1	0	0
2	0.08	0.05	2	1106	313	2	1283	363
3	0.19	0.13	3	584	1343	3	895	2058
4	0.38	0.25	4	227	504	4	428	948
5	0.38	0.25	5	72	88	5	152	186
6	0.38	0.25	6	10	28	6	27	72
7	0.38	0.25	7	71	4	7	196	11
8	0.38	0.25	8	6	28	8	20	87
			1+	2077	2308	1+	3000	3727
			2+	2077	2308	2+	3000	3727
			3+	971	1995	3+	1717	3363
			4+	387	652	4+	822	1305

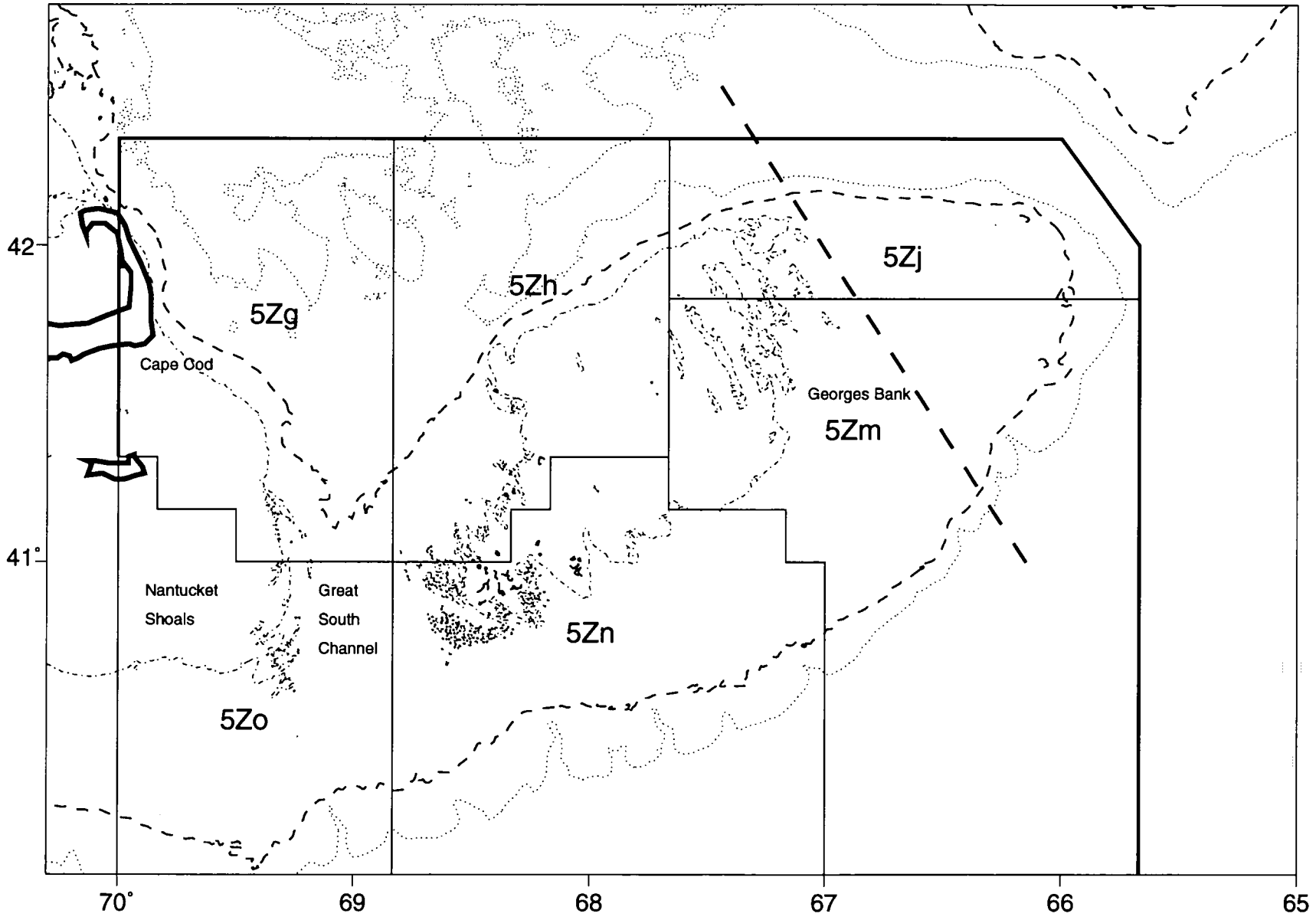

Fig. 1. Canadian fisheries statistical unit areas in NAFO Division 5Z.

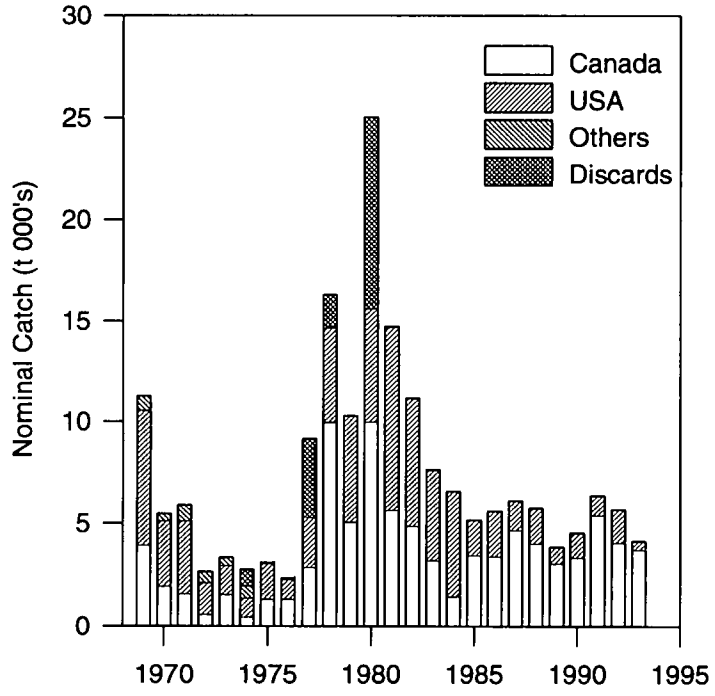

Fig. 2. Nominal catch of haddock in unit areas 5Zj and 5Zm.

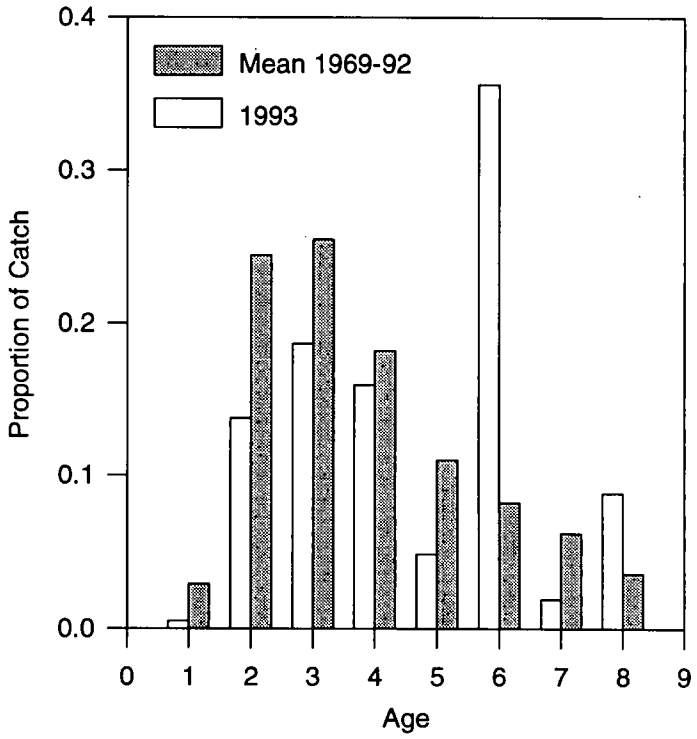

Fig. 3. Catch proportioned by age in 1993 compared to mean for 1969-92.

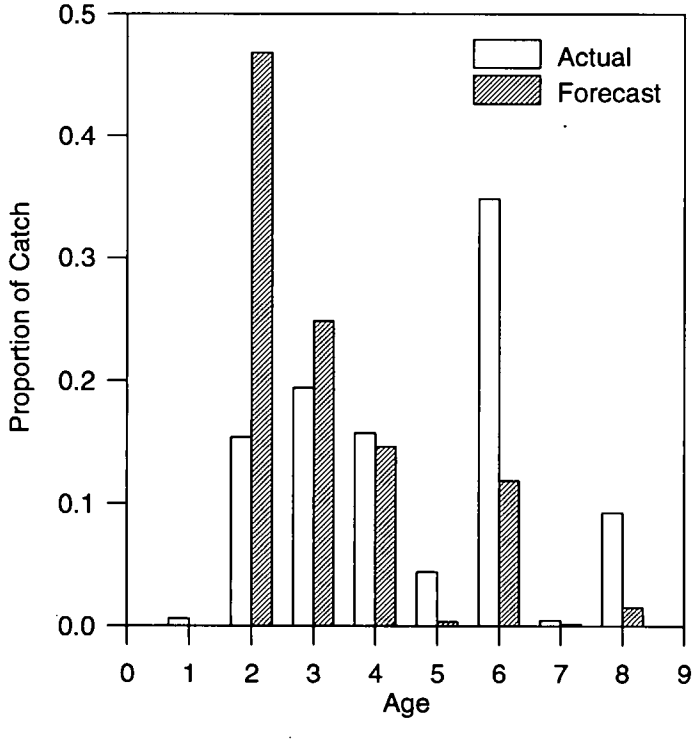

Fig.4. Haddock catch from 5Zj and 5Zm in 1993, actual and forecast.

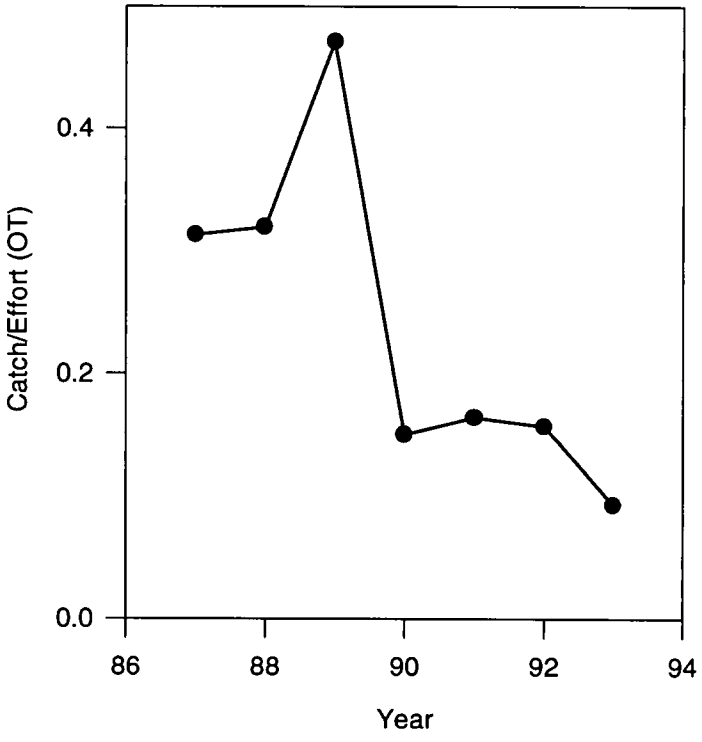

Fig. 5. Catch per unit effort for haddock in 5Zj and 5Zm for the otter trawl fishery.

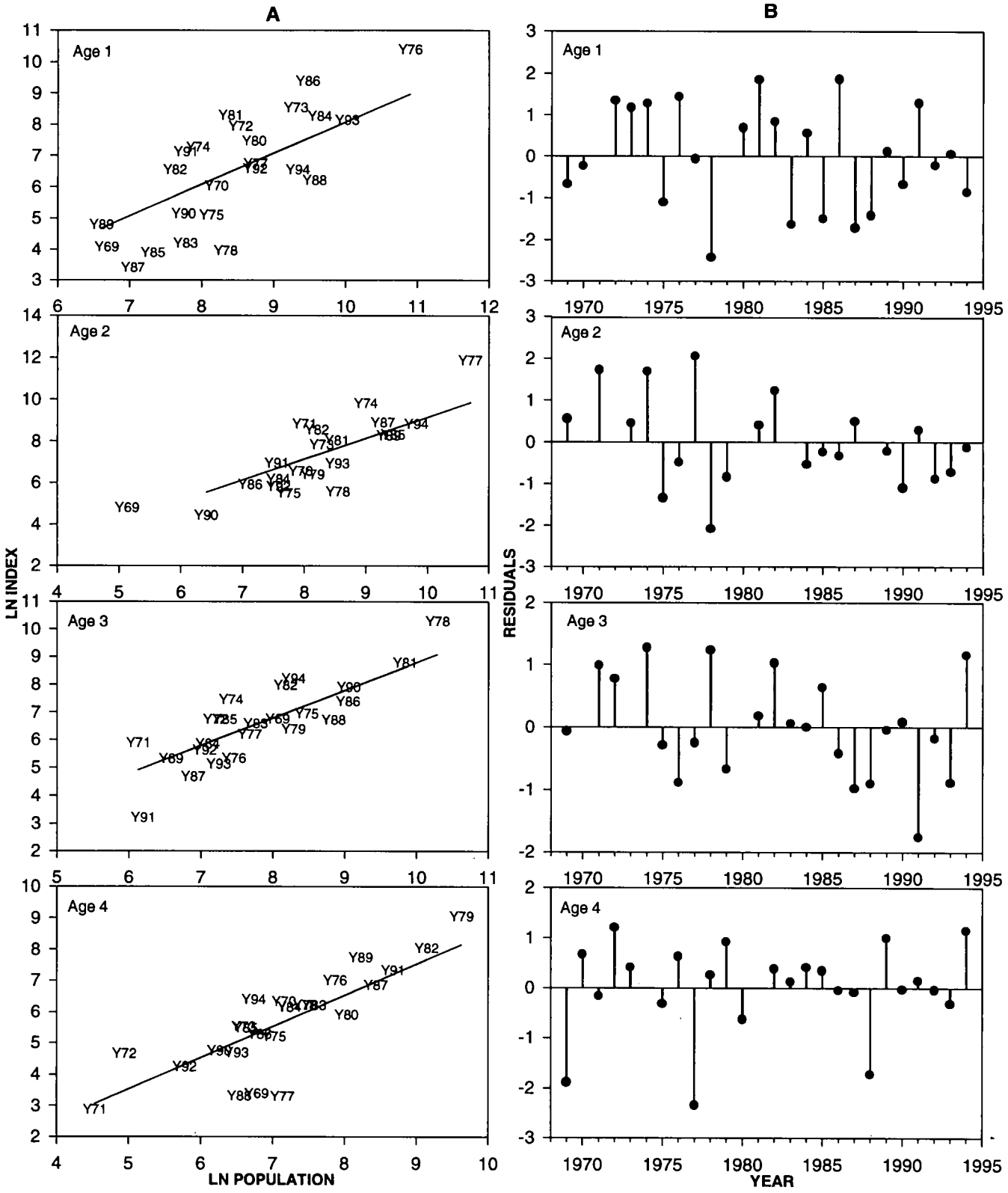

Fig. 6a. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the USA fall survey for haddock in unit areas 5Zj and 5Zm.

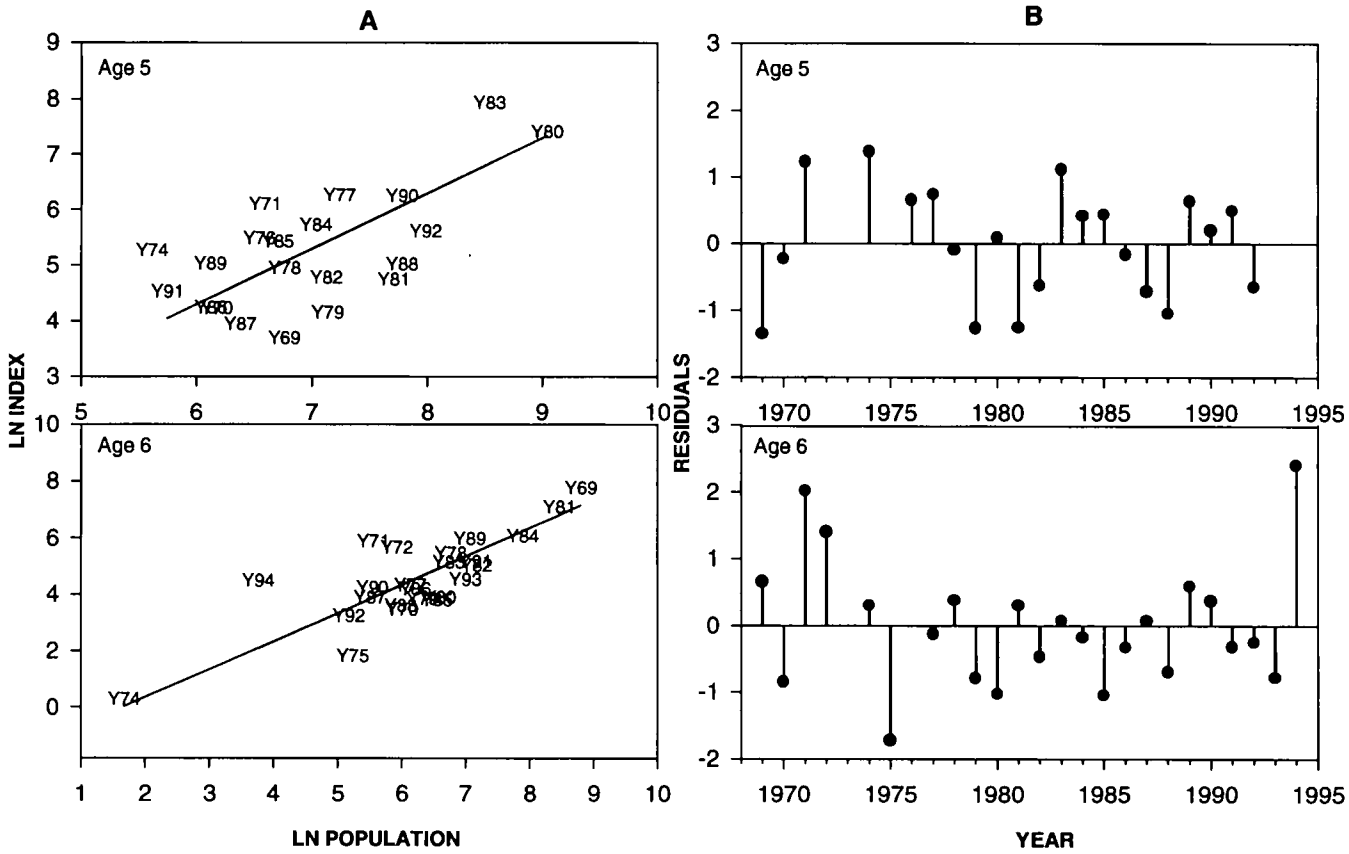

Fig. 6a (continued). Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the USA fall survey for haddock in unit areas 5Zj and 5Zm.

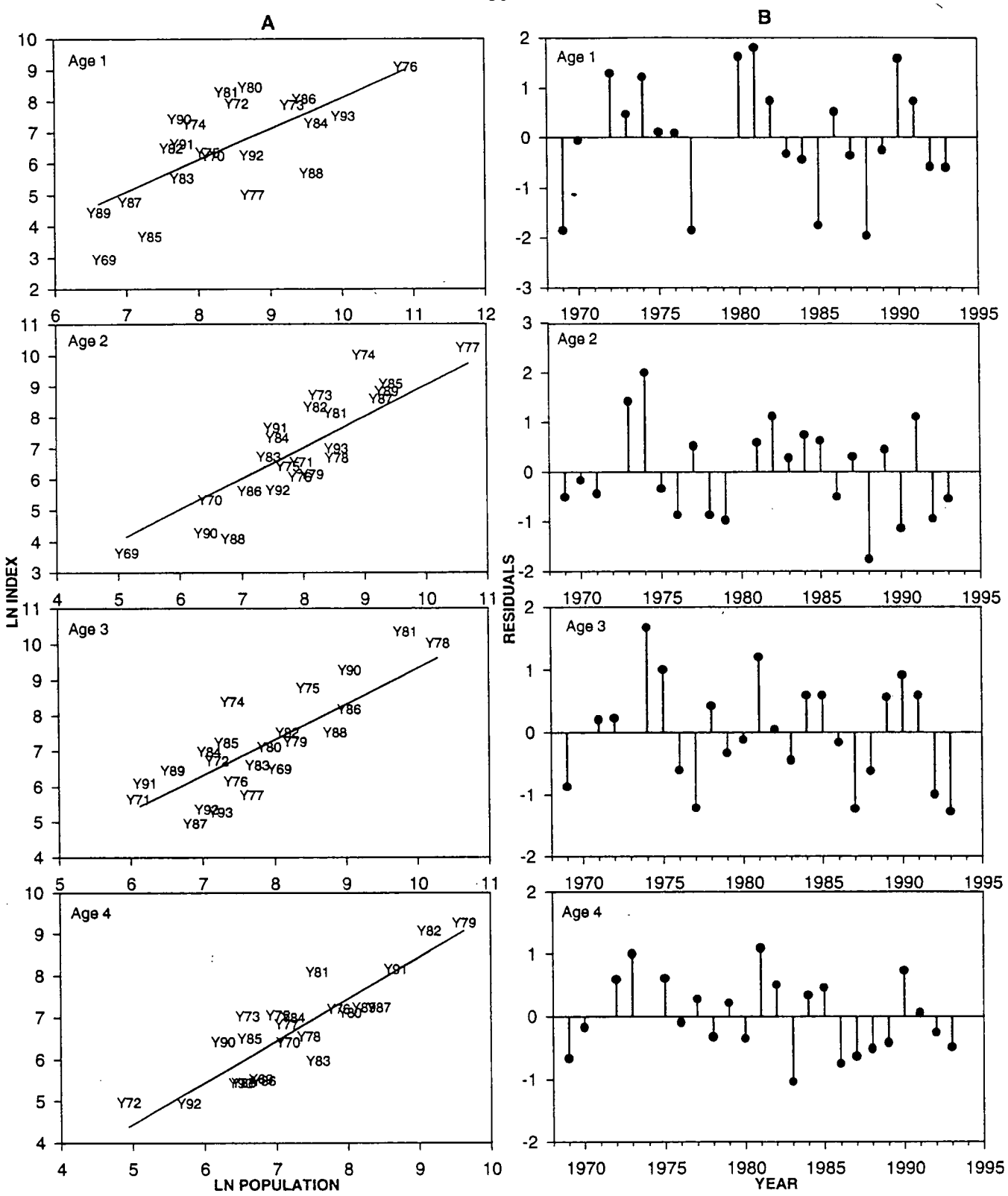

Fig. 6b. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the USA spring survey for haddock in unit areas 5Zj and 5Zm.

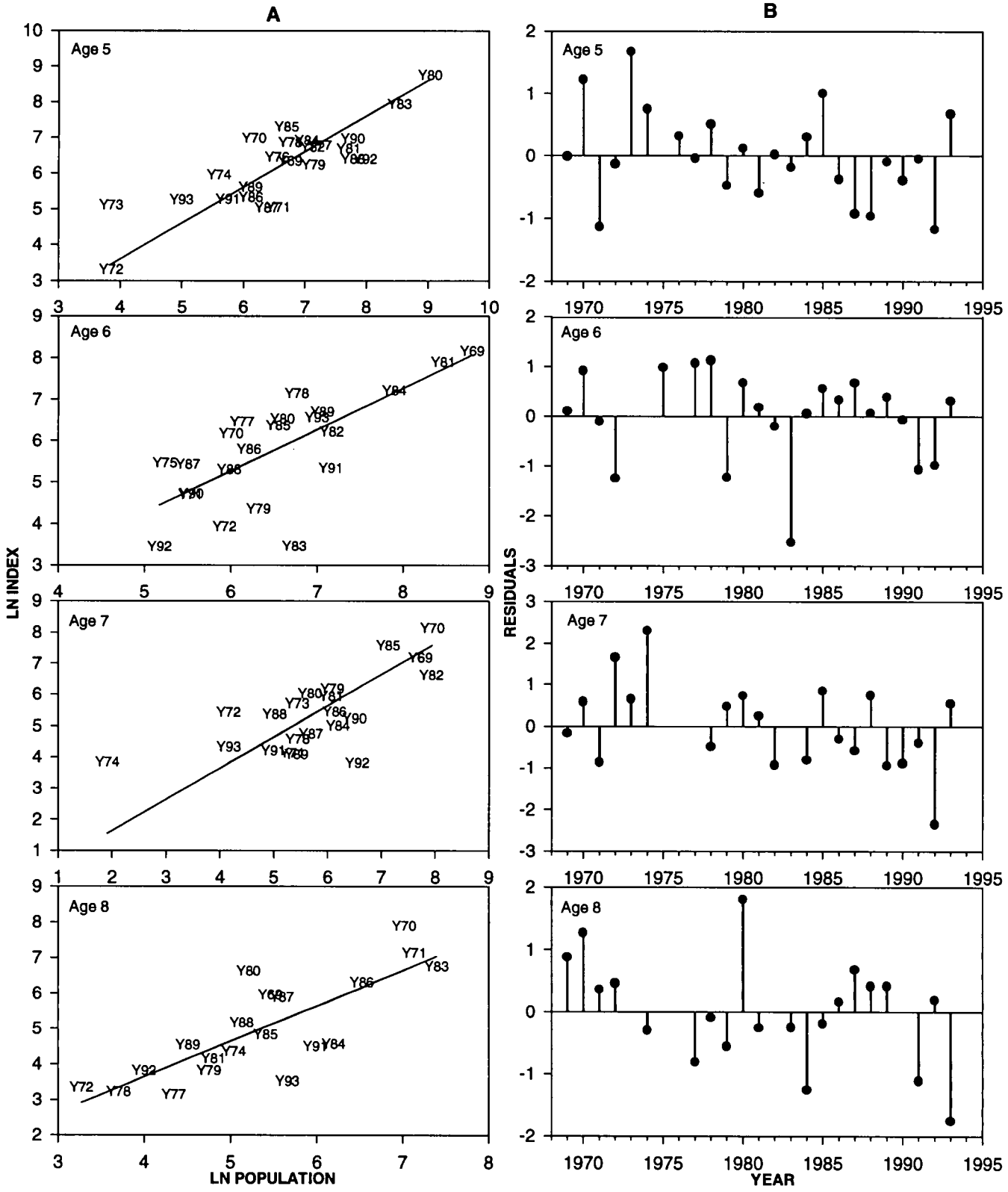

Fig. 6b (continued). Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the USA spring survey for haddock in unit areas 5Zj and 5Zm.

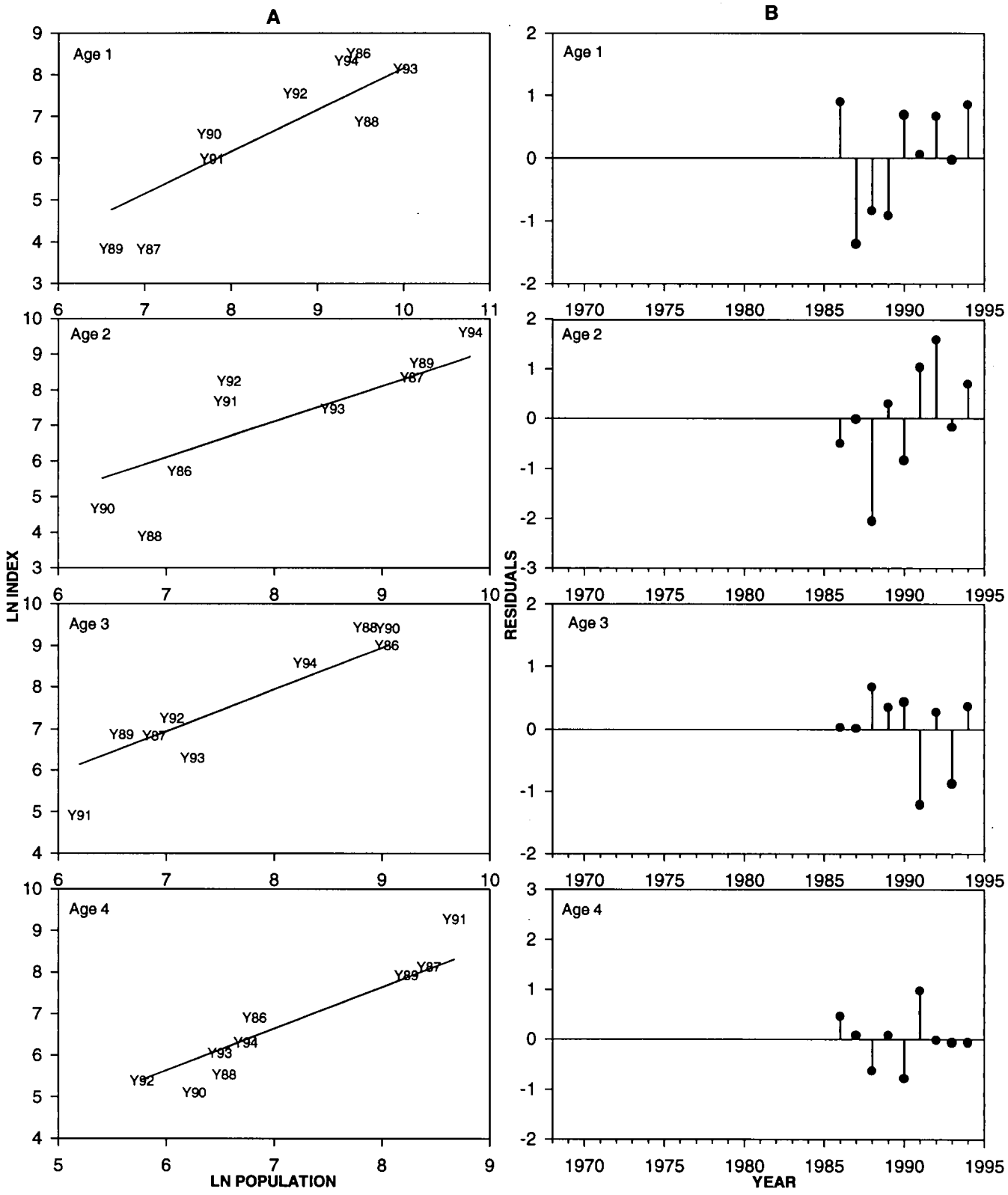

Fig. 6c. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the Canadian spring survey for haddock in unit areas 5Zj and 5Zm.

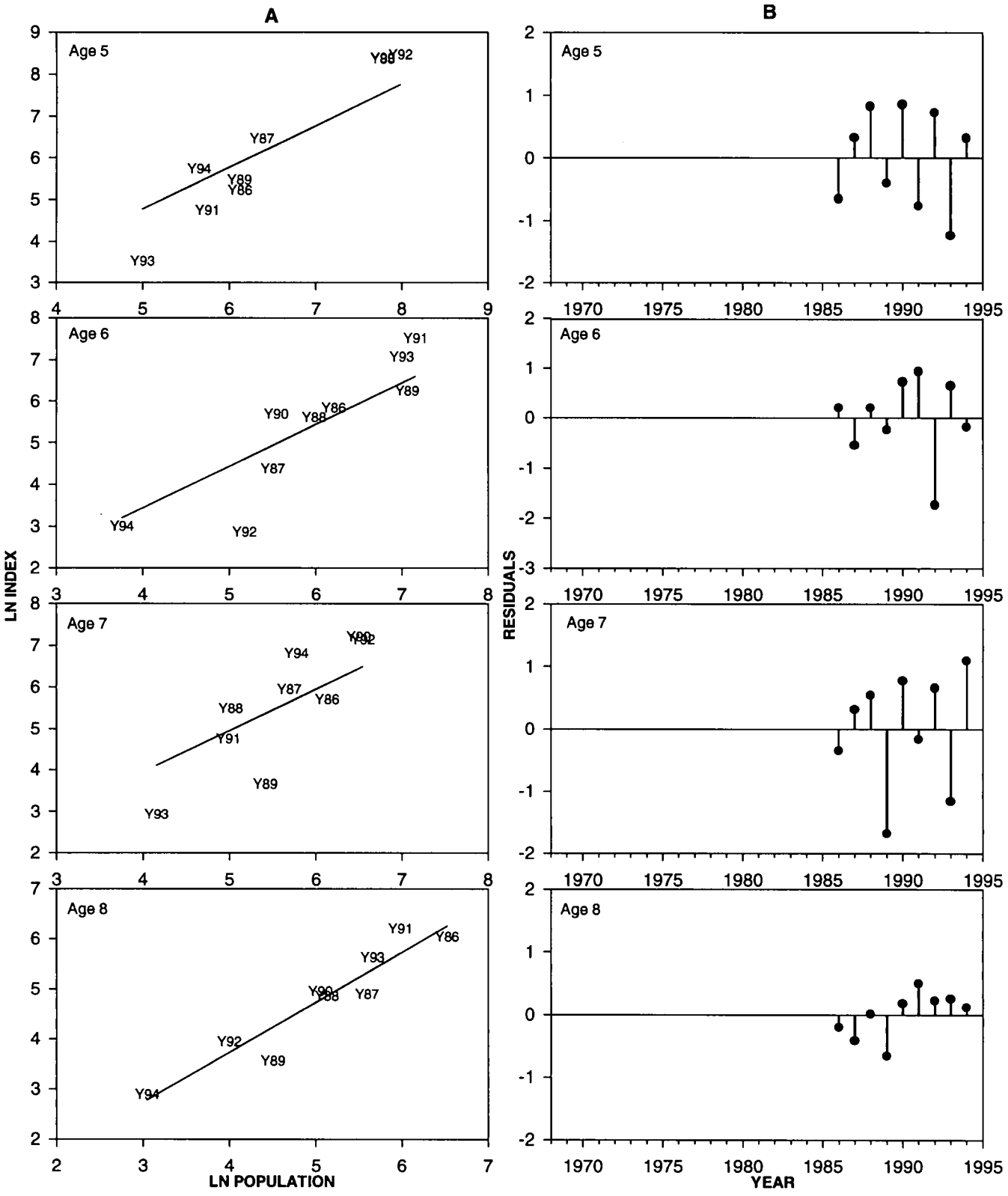

Fig. 6c (continued). Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers and B) residuals plotted against year for the Canadian spring survey for haddock in unit areas 5Zj and 5Zm.

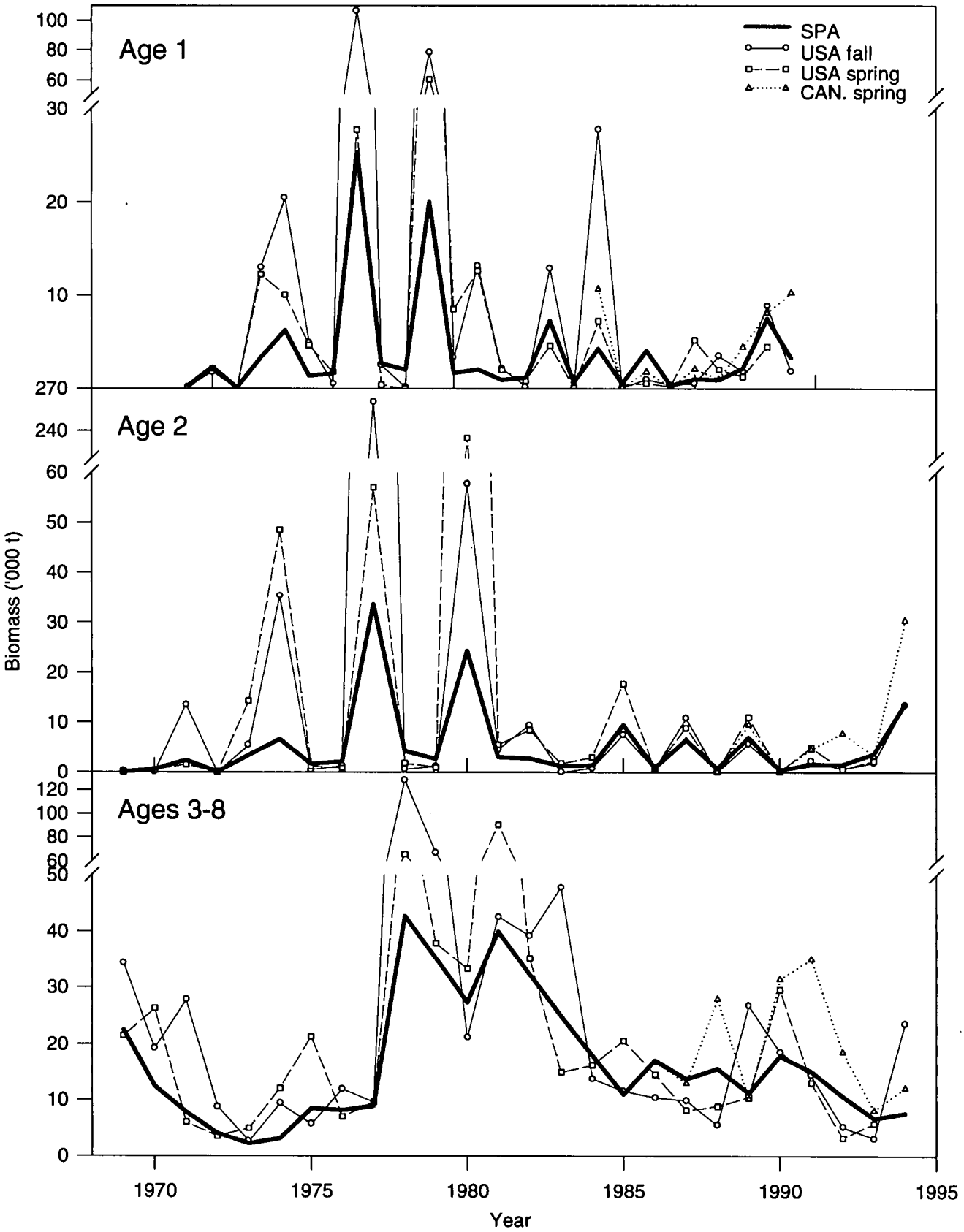

Fig. 7. Beginning of year biomass from sequential population analysis (bias adjusted SPA) and research survey indices (adjusted by calibration constants) for 5Zj,m haddock.

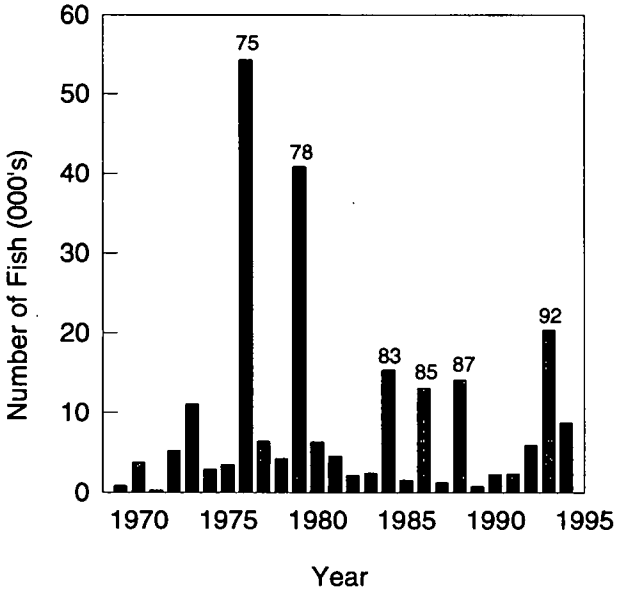

Fig. 8. Recruitment (age 1) for haddock in unit areas 5Zj and 5Zm. Numbers above bars indicate the yearclass.

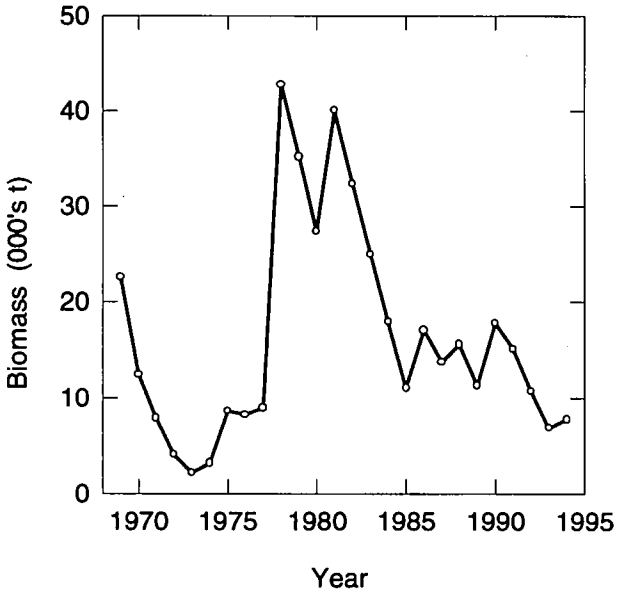

Fig. 9. Beginning of year biomass (3+) for haddock in unit areas 5Zj and 5Zm.

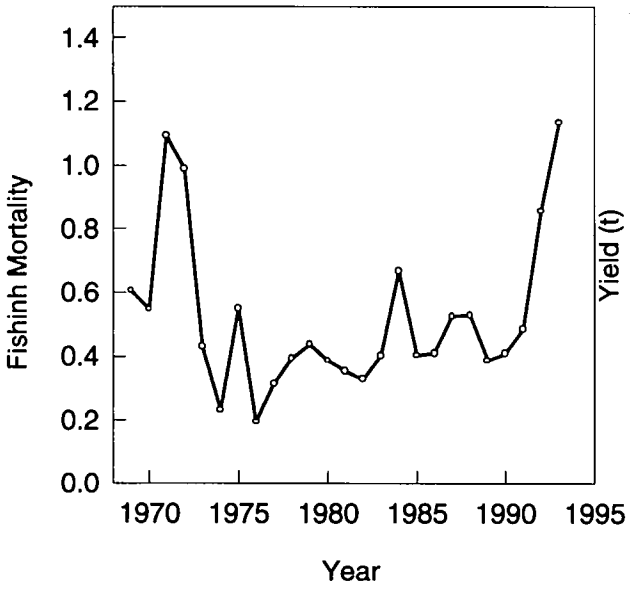

Fig. 10. Fishing mortality (4+) for haddock in unit areas 5Zj and 5Zm.

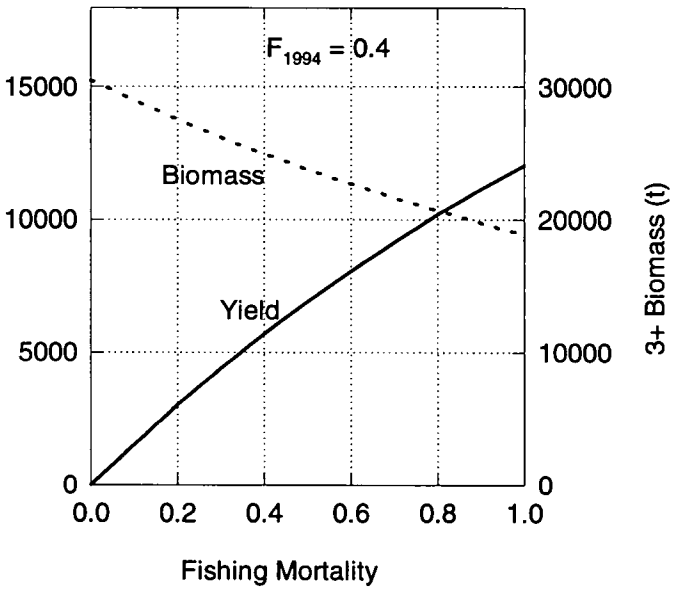

Fig. 11. Projected 5Zjm haddock yield for 1995 and beginning of year biomass in 1996.

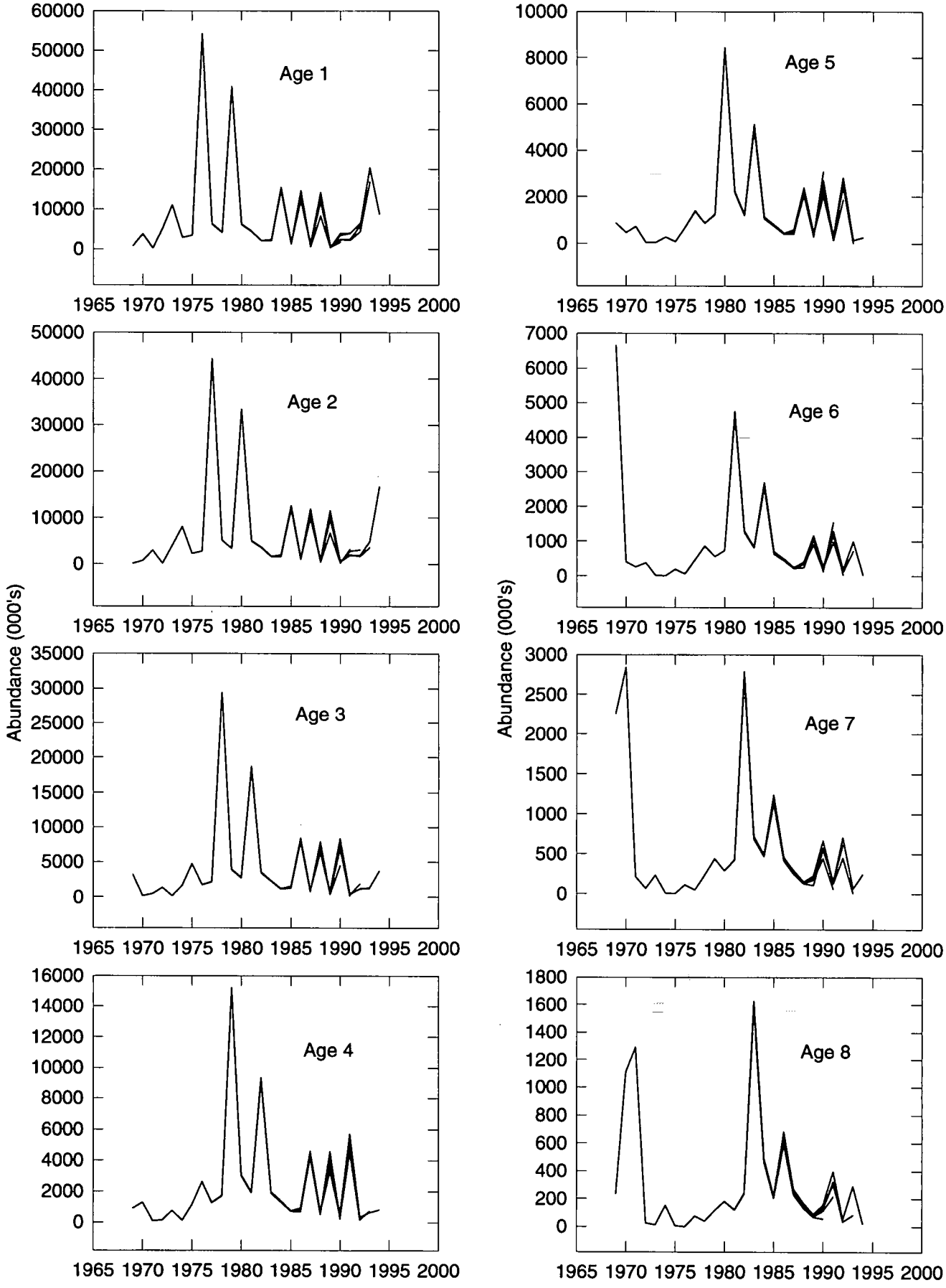

Fig. 11. Retrospective analysis of population abundance for haddock in unit areas 5Zj and 5Zm.

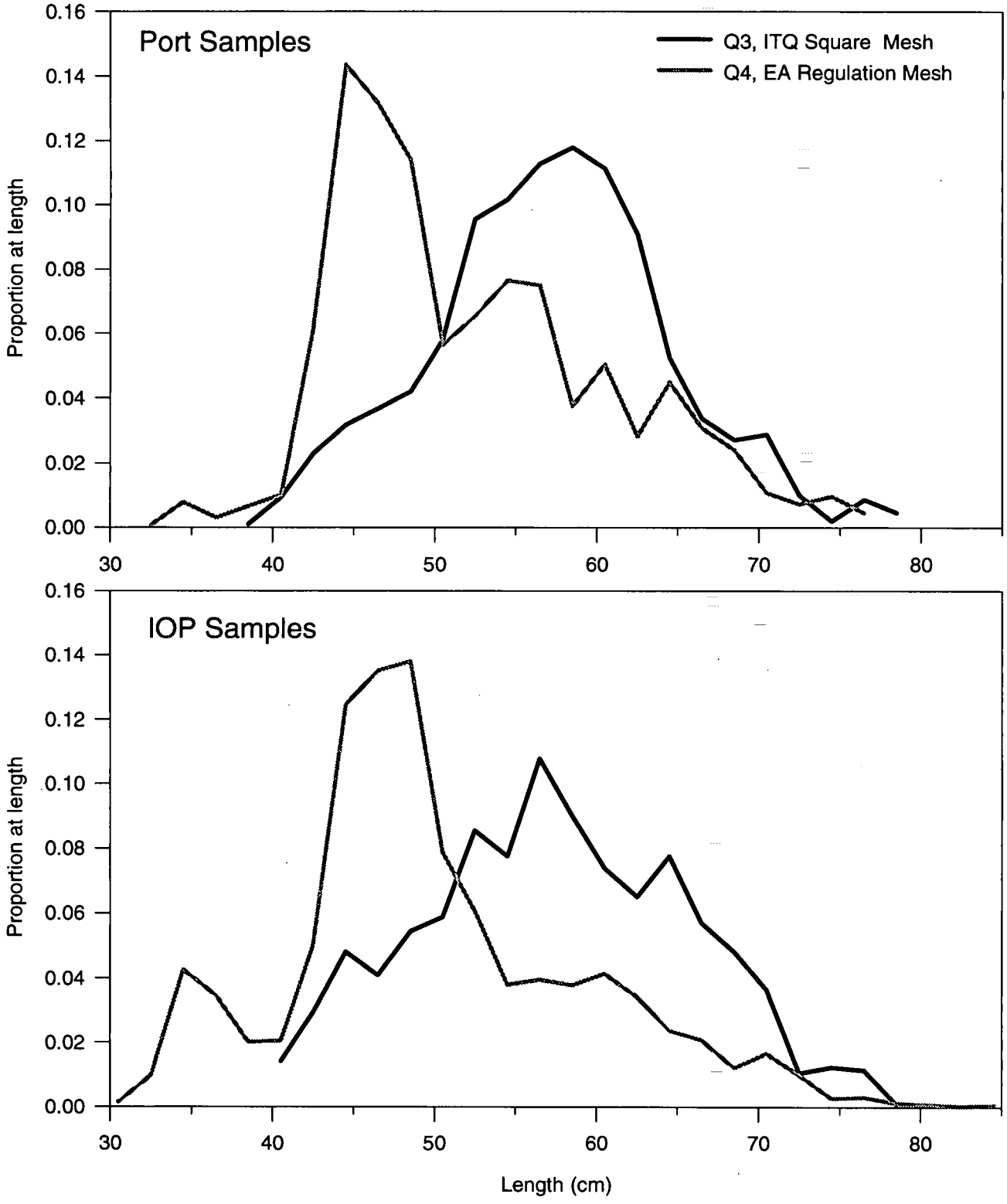

Fig. 13. Quarter 3 and 4 length frequencies of 5Zj,m haddock from IOP and port samples in 1993.

Appendix A

Table A1. Comparison of ages derived from otoliths from 2 independent readings by L. Van Eeckhaute of first quarter Canadian commercial fishery 5Zj,m haddock samples.

First Reading

Second Reading	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Omit	Tot
1	14															14
2		11														11
3			13													13
4				9												9
5					27											27
6						19										19
7							12									12
8								3								3
9								1	3	1	1					6
10									1	3						4
11											0					0
12												0				0
13													1			1
14													1	0		1
Omit																0
Tot	14	11	13	9	27	19	12	4	4	4	1	0	2	0	0	120
Agreement =								96								120

Table A2. Comparison of ages derived from otoliths by L. Van Eeckhaute (Canadian ian ager) and N. Munroe (USA ager) for 5Z haddock Canadian commercial fishery samples, Nos. 920336, 920434 and 920351.

Reader = Nancy Munroe (USA)

Reader= L. Van Eeckhaute (Can.)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Omit	Tot
1																0
2		1														1
3			1												1	1
4			1													1
5					60	2										62
6																0
7					1	6	17								1	25
8																0
9						1			4						2	7
10									1							1
11												1				1
12																0
13												1				1
14														2		2
Omit					1										1	2
Tot	0	1	1	0	62	9	17	0	5	0	0	2	0	2	5	104
Agreement between readers =								86								104