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Assessment of Haddock on Eastern Georges Bank

by

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ABSTRACT

Landings of haddock from eastern Georges Bank in recent years have fluctuated around 5,000 tons. Under management restrictions, 1994 landings declined to 2411t for Canada and to a record estimated low of 300t for the USA. Both fisheries were largely supported by the 1991 year-class which comprised about 50% of the landed weight. Survey trends indicate a decline of adult abundance in recent years to about the lowest levels observed but suggest some recovery since 1993. Indices for the 1992 year-class 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. Biomass for ages 3 and older increased to about 20,000t at the beginning of 1995 after declining to below 10,000t, approaching the historic low. The 1992 year-class was estimated to be comparable to the moderately strong 1983, 1985 and 1987 year-classes. The fishing mortality rate for ages 4 and older decreased to about 0.5 in 1994 from about 0.8 in 1993, amongst the highest observed, but remained above the $F_{0.1} = 0.25$ reference level.

Yield projections showed that a catch of about 3,000t in 1995 will result in a fishing mortality approximating the $F_{0.1} = 0.25$ value. Roughly half the landed weight though, will be contributed by the 1992 year-class. The projected increase in biomass is due primarily to recruitment of the moderately strong 1992 year-class. Continuing conservation efforts are needed to rebuild the biomass and expand the age range.

RÉSUMÉ

Les débarquements d'aiglefin de l'est du banc Georges ont fluctué ces dernières années autour de 5 000 tonnes. Sous l'effet des mesures de gestion, ils ont diminué en 1994 à 2 411 t pour le Canada et à un seuil sans précédent, estimé à 300 t, pour les États-Unis. Dans les deux pays, la pêche a été largement alimentée par la classe d'âge de 1991, qui représentait plus de 50 % 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; elles semblent toutefois indiquer une certaine remontée depuis 1993. D'après les indices, l'abondance de la classe d'âge de 1992 est modérée, et comparable à celle des classes d'âge 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. La biomasse des poissons de trois ans et plus a augmenté pour atteindre environ 20 000 t au début de 1995, après avoir été inférieure à 10 000 t, niveau proche du seuil historique. On a estimé que la classe d'âge de 1992 était comparable à celles de 1983, de 1985 et de 1987, qui étaient de force moyenne. Le taux de mortalité par pêche des poissons d'âge 4+, qui à environ 0,8 en 1993 était le plus élevé des taux observés, est tombé à environ 0,5 en 1994, mais est demeuré supérieur au niveau de référence $F_{0,1} = 0,25$.

D'après les projections de rendement, des prises d'environ 3 000 t en 1995 se traduiront par une mortalité par pêche correspondant approximativement à la valeur $F_{0,1} = 0,25$. Toutefois, à peu près la moitié du poids des débarquements proviendra de la classe d'âge de 1992. La hausse prévue de la biomasse est due essentiellement au recrutement de la classe d'âge de 1992, qui est modérément forte. Il convient de poursuivre les efforts de conservation pour reconstituer la biomasse et étendre la fourchette d'âges.

DESCRIPTION OF THE FISHERY

The haddock on Georges Bank have supported a commercial fishery since the early 1920's (Clark et al 1982). Record high 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. It was determined that substantial discarding of small haddock from the 1972, 1975 and 1978 year-classes occurred and catches were augmented to account for this (Overholtz et al. 1983). Since 1977, with the extension of jurisdiction by coastal states, only Canada and the USA have conducted haddock fisheries on Georges Bank. A Total Allowable Catch was introduced in 1970 by the International Commission for the Northwest Atlantic Fisheries. Seasonal closures of haddock spawning areas were also instituted in that year as an adjunct and have been retained by Canada and USA (Halliday 1988). Following the establishment of a maritime boundary in 1984 by the International Court of Justice, the Canadian and USA fisheries have been restricted to their respective jurisdictions.

Under increasingly restrictive management, total Canadian landings decreased to 2,411t in 1994. Bottom otter trawl and longline have been the predominant gears in the Canadian fishery and landings by both declined in each of the last 3 years (Table 2). The quota of 3,000t was not reached due primarily to a shortfall by otter trawlers, tonnage classes 4 and greater, in catching their allocation. In recent years prior to 1994, allocations to fishery sectors have either been exceeded or have not been restrictive.

Fishery Sector	1991		1992		1993		1994	
	Quota	Catch	Quota	Catch	Quota	Catch	Quota	Catch
Fixed gear <65'	1185	1456	1185	1377	1508	1216	791	784
Mobile gear <65'	2535	3095	2535	1704	2212	1646	1439	1206
Fixed gear 65'-100'	52	45	50	5	50	8	30	8
Mobile gear 65'-100'	48	48	50	55	32	32	30	33
Vessels >100'	1180	853	1180	853	1198	826	710	290
Totals	5000	5497	5000	3994	5000	3728	3000	2411

Fewer vessels participated in the fishery during 1994. Only about 85 otter trawlers in tonnage classes 2 and 3 fished Georges Bank in 1994 compared to about 105 vessels in 1993. *Industry comments indicated that the reduction in the quota stimulated quota transfers amongst the vessels fishing Individual Transferable Quotas.* As a new regulation for 1994, fixed gear vessels were required to choose between and designate either Georges Bank or Division 4X for their fishery during June to October but could not fish both stock areas. *Industry reported that this resulted in fewer longliners participating in the Georges Bank fishery. It was noted though, that the number of vessels participating during 1993 was inflated and up to 1/3 of the landings*

reported for Georges Bank in 1993 may have actually been caught in Division 4X. Though adjustments have been made for known discards and misreporting, there continue to be unquantified reports, such as this, of further discrepancies in landings which merit investigation. The quality of information however, was reported to be much improved since 1992, after the introduction of dockside monitoring. About 75 longline vessels fished Georges Bank in 1994 compared to about 130 in 1993. A small fish protocol (fisheries would be closed if an unacceptably high proportion of the catch was comprised of small fish) with increased at-sea monitoring was also implemented during 1994 to protect incoming recruitment. The traditional spawning closure during Mar. 1 to May 31 was extended in 1994 to include January and February and, additionally, otter trawlers greater than 65 feet could not begin fishing until July 1. Landings in recent years have generally peaked during June or July (Table 3) though substantial landings have also occurred in the past during the early months of the year.

The USA fishery is almost exclusively an otter trawl fishery (Table 4). In recent years catches have generally been concentrated during the first half of the year, peaking in June (Table 5). 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. Best catches of haddock in the USA fishery on eastern Georges Bank were observed immediately following the spawning closure in the vicinity of the maritime boundary on the northern edge. Mandatory log books were introduced in 1994, replacing the existing interview system for obtaining catch and effort information. Statistics for the 1994 fishery were not available but it is estimated that about 300t of haddock were landed (pers. comm. R.K. Mayo, NMFS Woods Hole).

CATCH AND WEIGHT AT AGE

The catch and weight at age for the commercial fishery from 1969 to 1992 were taken from Gavaris and Van Eeckhaute (1994). Catch and weight at age for 1993 and 1994 were calculated by applying age length keys to length frequencies using the methods described by Gavaris and Gavaris (1983). Growth patterns of haddock do not appear to differ between the two unit areas 5Zj and 5Zm or between catches by gears participating in the fishery. Accordingly, age length samples are typically pooled to construct keys by quarter for each country where information is available. Length compositions of catches can vary between gears therefore, length frequency samples are pooled within gears and applied to the respective landings before being aggregated to the level of age length leys. When landings occurred in a month-gear category for which samples were not available, suitable adjacent samples were used.

The Canadian otter trawl fishery has undergone considerable evolution in recent years with a greater prevalence of square mesh in the codend. During 1993, about 65% of the landings by tonnage classes 2 and 3 vessels were made with square mesh, while virtually all of the landings by vessels of larger tonnage class were made with diamond mesh. During 1994, almost all vessels of tonnage classes 2 and 3 used square mesh while vessels of larger tonnage class used predominantly diamond mesh prior to mid-October and subsequently changed to square mesh. The 1993 and 1994 Canadian commercial fishery was sampled sufficiently to permit computation of length and age composition for each mesh type as well as for longline and gillnet catches

(Appendix A). The results for 1993, which were re-calculated to take into consideration mesh type, did not differ much from those in Gavaris and Van Eeckhaute (1994). The length frequency samples for 1994 were augmented with samples collected by at sea observers as examinations revealed that port and sea samples were comparable. The observer samples were obtained on a set by set basis and these were pooled to the trip level to make them compatible with port samples before being combined with them. Observer information for earlier years should be examined to determine if it can be used to augment port sampling. During 1994, the otter trawl and longline catches peaked between 50 and 55 cm while the gillnet catches peaked at about 65 cm (Fig. 3). There is evidence of a second mode at about 45 cm in the otter trawl catches, particularly for the tonnage classes 4 and greater.

The catch and weight at age for the 1993 USA fishery was re-calculated to account for minor adjustments to the landings from those used by Gavaris and Van Eeckhaute (1994), resulting in nominal modification. Processing of USA sample information is linked to the landings database. As noted earlier, the mandatory logbook system introduced in 1994 for USA landings data has resulted in delays. Consequently, samples from the 1994 USA fishery were not available. In the absence of samples for the USA fishery, the Canadian age composition for the June otter trawl fishery was applied to the estimated landings as most USA landings in recent years have occurred in the first half of the year.

The fishery in 1994 was largely supported by the 1991 (average length of 53 cm) year-class which comprised about 50% of the landed weight. The 1987 (average length of 65 cm) year-class continued to contribute substantially accounting for about 15% of the landed weight (Fig. 4, Tables 6 - 11). *This observation was corroborated by reports from fishermen that the size of haddock caught in 1994 was generally larger than in recent years.* There were no marked, persistent, long term trends in weight at age however the year-classes after 1988 appear larger at age. It is recommended that this feature be examined further using research survey information as well. Considerably fewer age 2 haddock were caught than had been forecast, attesting to the effectiveness of the small fish protocol, and may be due in part to increased use of larger mesh size and/or square mesh by the otter trawl fleets. Examination of comparative interpretation of ages from otolith samples did not reveal any problematic inconsistencies (see Appendix B).

ABUNDANCE INDICES

Commercial Catch Rate

The 1993 and 1994 catch and effort data from tonnage classes 2 and 3 otter trawlers and longliners were summarized (Fig. 5). Only those vessels which fished during 1994 and reported more than 1t of landings for the year were selected for inclusion in the comparison with 1993. For otter trawlers, the catch rate was computed as the catch per hour aggregated by month and tonnage class, while for longliners, the aggregate catch per trip was used since days fished were not available for 1994. The trends suggest that otter trawl catch rates were somewhat higher during 1994. *Otter trawler fishermen reported that the abundance of haddock during 1994 was*

generally comparable to 1993 and the large increase in the latter months was due to a good run of large fish on the peak of the bank in areas of greater bottom depth. The longline catch rates were of similar magnitude in 1993 and 1994. *Several fishermen noted that fishing seemed better in 1994 and that they had shorter trips in that year. Generally, most fishermen are sceptical about the representativeness of catch rates as indicators of abundance, since in a mixed fishery their effort is not directed at haddock.* Accordingly, catch rates from the commercial fishery were considered only for qualitative corroboration of results.

Research Surveys

Annual depth 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 by Hayes and Buxton (1992). Fall survey results were compared to the beginning of year indices from the Canadian and USA spring surveys for the respective cohorts. Results for the 1989 and 1991 Canadian survey were revised to correct for errors in strata designation of one set in each survey. The change in results from those reported by Gavaris and Van Eeckhaute (1994) were minor. Abundance trends for ages 3-8 increased during the late 1970s after having declined to their lowest in the early 1970s. Following a rapid decline in the early 1980s, abundance remained stable at relatively low levels through the mid to late 1980s before declining again in the early 1990s, approaching the lowest levels observed. There are indications of an increase in the most recent years (Tables 14-16, see also Fig. 7 but note that the fall surveys are compared to the beginning of the subsequent year). Survey results for 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 but the 1992 year-class appears comparable to those of 1983, 1985 and 1987. Although not well estimated, early indications suggest that the 1993 and 1994 year-classes may not be as strong as the 1992 year-class.

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 1994
$I_{1,a,y}$ = USA fall survey	a=0 to 5, y=1968 to 1994
$I_{2,a,y}$ = USA spring survey	a=1 to 8, y=1969 to 1994
$I_{3,a,y}$ = Canadian spring survey	a=1 to 8, y=1986 to 1995

where a indicates age and y indicates 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. The frequent occurrence of zero catches and the large variation in the relationship between population abundance and USA fall survey indices at ages 6 and 7 led to the exclusion

of those ages. All available data since 1968 were used except when the indices were 0 (logarithm not defined). During years when discarding was high, survey information was used along with interviews to obtain estimates of the USA catch. This lack of complete independence between catch and survey data does not influence population estimates but may deflate variance estimates marginally. 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 6, 8 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,

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

Due to the low estimate of survivors and high variability, the population abundance for age 7 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 7 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 8 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 an 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 may not pass exactly 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). Gavaris and Van Eeckhaute (1994) considered that this approach for bias adjustment, in the absence of an unbiased point estimator with optimal statistical properties, was preferable to using the biased point estimates.

The stock biomass declined rapidly in the early 1980s when the strong 1975 and 1978 year-classes were fished down and subsequently decreased steadily but more gradually to a low of about 15,000t in 1992 before increasing to about 25,000t in 1995. Biomass for ages 3 and older showed a similar pattern but declined more rapidly to below 10,000t since 1990 as the 1985 and 1987 year-classes were fished down, and approached the historic low observed during the early 1970s (Fig. 8). The recent increase, due principally to the 1992 year-class, but also supported by the 1991 year-class, was enhanced by increased weight at age of haddock from these and adjacent year-classes as well as increased survivorship of young haddock from reduced capture of small fish in the commercial fisheries. Recruitment during the 1980s was poor and the 1983, 1985 and 1987 year-classes were estimated to be the most abundant since the strong 1975 and 1978 year-classes (Fig. 9). The strength of the 1992 year class was estimated to be comparable to the 1983, 1985 and 1987 year-classes while those between 1987 and 1991 were weak. The 1991 and 1993 year-classes were estimated at about a third of the magnitude of the 1992 yeaclass. The 1994 year-class was not well estimated but early indications suggest it is weaker than the 1993 year-class. The fishing mortality rate for ages 4 and older has generally exceeded $F_{0.1} = 0.25$ and increased markedly in 1993 to about 0.8, amongst the highest observed (Fig. 10). The previous occasion when the fishing mortality exceeded 0.5 was during the early 1970s when abundance was at its lowest. The fishing mortality rate declined in 1994 to about 0.5 still remaining above the $F_{0.1}$ target.

Results from assessments for several other stocks have revealed a discrepancy between past estimates of stock status and current estimates using additional data. Generally, the current estimates are more optimistic but as additional data becomes available, the current view of the past is more pessimistic. This characteristic has been referred to as a retrospective pattern. Examination of year-class estimates at age 1 from assessments done using a comparable

formulation with years 1990 through 1995 considered the terminal year for the assessment show remarkable consistency (Fig. 11). It was concluded that this stock assessment does not suffer from a retrospective pattern.

The Georges Bank ecosystem is complex with numerous species interactions. Further, species adapt to fluctuations in abundance of both their prey and predators. These interactions were modelled by a constant natural mortality and there were no indications that this assumption was severely violated. Currently available information does not permit more complex models to be employed.

Environmental conditions on Georges Bank have varied but have not displayed extreme deviations in recent years. Though environmental conditions are thought to influence fisheries processes, convincing relationships with quantities such as recruitment, survival rates and fish catchability have not been established.

PROGNOSIS

Yield projections were done using the 1995 beginning of year population numbers as estimated from ADAPT and the average weight at age for 1992-94. With the changing fishing practices and the increased use of larger mesh size and square mesh by the otter trawl fleets, there appears to be a trend towards lower exploitation of age 2 haddock:

Age	1991		1992		1993		1994	
	F	PR	F	PR	F	PR	F	PR
2	0.34	0.84	0.18	0.26	0.06	0.07	0.02	0.04
3	0.17	0.41	0.43	0.59	0.46	0.58	0.26	0.54
4+	0.40		0.72		0.79		0.47	

For projections, it was assumed that the partial recruitment to the fishery for ages 1, 2 and 3 was 0, 0.05 and 0.5 respectively. The abundance of year-classes after 1994 were assumed to be 10 million, but this assumption is of no consequence to the short term forecasts. As with the population abundance estimates, the adjustment for bias of the projected yield was considered more appropriate than using the biased point estimate. The projected yield at $F_{0.1} = 0.25$ in 1995 would be about 3,000 t with the 1992 year-class accounting for roughly half of the landed weight (Table 22). The biomass for ages 3 and older is projected to increase to about 23,000 t at the beginning of 1996 (Fig. 12) primarily due to the recruitment of the 1992 year-class.

With the current state of the stock, younger aged haddock make a relatively large contribution to the projected yield. The precision of the abundance estimates is poorest at the youngest ages. This uncertainty gets translated to the projected yield and its relative error is roughly 25%. Increasing the number of age groups contributing to the catch should lead to greater precision in the advice. Increased abundance over a broader age span would also moderate fluctuations in biomass and result in more stable yield between years. A larger

spawning biomass could enhance recruitment by capitalizing on the opportunities for greater egg and larval survival when environmental conditions are favourable.

The projected increase in haddock abundance is due primarily to recruitment of one year-class, the moderately strong 1992 year-class. Continuing conservation efforts such as low exploitation and fishing practices which permit recruits to realize their growth and reproductive potential are needed to rebuild the population biomass and to expand the age structure.

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

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 [1]
1975	1353	1705	29	3087
1976	1355	973	24	2352
1977	2871	2429	0	9174 [1]
1978	9968	4724	0	16269 [1]
1979	5080	5211	0	10291
1980	10017	5615	0	25036 [1]
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 [2]	1693	0	5739
1989	3059	787	0	3846
1990	3340	1189	0	4529
1991	5446	931	0	6377
1992	4061	1629	0	5690
1993	3727	421	0	4148
1994	2411	300 [3]	0	2711

[1] values augmented by 760t, 3874t, 1577t, and 9404t in 1974, 1977, 1978, and 1980, respectively, to account for USA discards

[2] 1895t excluded because of suspected area misreporting

[3] estimated

Table 2. Canadian catch (t) of haddock in unit areas 5Zjm by gear category and tonnage class for principle gears.

Year	Otter Trawl									
	Side	Stern					Longline			Other	Total
		2	3	4	5	Total	2	3	Total		
1969	777	0	1	225	2902	3127	2	21	23	15	3941
1970	575	2	0	133	1179	1314	6	72	78	2	1970
1971	501	0	0	16	939	955	18	129	151	3	1610
1972	148	0	0	2	260	263	23	169	195	3	609
1973	633	0	0	60	766	826	23	80	105	0	1565
1974	27	0	6	8	332	346	29	59	88	1	462
1975	222	0	1	60	963	1024	25	81	107	0	1353
1976	217	0	2	59	905	967	48	108	156	15	1355
1977	370	92	243	18	2025	2378	43	51	94	28	2871
1978	2456	237	812	351	5639	7039	121	47	169	305	9968
1979	1622	136	858	627	1564	3185	190	80	271	2	5080
1980	1444	354	359	950	6254	7917	129	51	587	69	10017
1981	478	448	629	737	2344	4159	331	99	1019	2	5658
1982	115	189	318	187	3341	4045	497	187	712	0	4872
1983	106	615	431	107	1130	2283	593	195	815	4	3208
1984	5	180	269	21	149	620	614	192	835	3	1463
1985	72	840	1401	155	348	2745	562	33	626	41	3484
1986	51	829	1378	95	432	2734	475	98	594	35	3415
1987	48	782	1448	49	1241	3521	854	113	1046	89	4703
1988 [1]	72	1091	1456	186	398	3183	428	200	695	97	4046
1989	0	489	573	376	536	1976	713	175	977	106	3059
1990	0	928	890	116	471	2411	623	173	853	76	3340
1991	0	1610	1647	81	679	4018	900	271	1309	119	5446
1992	0	797	1084	56	645	2583	984	245	1384	90	4061
1993	0	535	1179	67	699	2490	794	156	1144	94	3727
1994	0	495	911	79	112	1597	498	47	714	100	2411

[1] Catches of 26t, 776t, 1091t and 2t for side otter trawlers and stern otter trawlers tonnage classes 2, 3 and 5 respectively were excluded because of suspected area misreporting.

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

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
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 [1]	39	123	67	79	15	1816	1360	315	130	65	13	24	4046
1989 [2]	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	4061
1993	466	690	96	78	25	723	505	329	202	198	230	185	3727
1994	1	3	1	2	0	398	693	373	375	220	211	134	2411

[1] catches of 3t, 1846t and 46t for Jan., Feb., and Mar., respectively for otter trawlers were excluded because of suspected area misreporting

[2] early closure of fishery for otter trawlers in June (per. comm. P. Partington)

Table 4. USA catch (t) of haddock in unit areas 5Zjm by gear category and tonnage class.

Year	Otter Trawl			Other	Total
	3	4	Total		
1969	3010	3610	6621	0	6622
1970	1602	1551	3154	0	3153
1971	1760	1768	3533	0	3534
1972	861	690	1551	0	1551
1973	637	759	1396	0	1396
1974	443	512	955	0	955
1975	993	675	1668	36	1705
1976	671	302	972	2	973
1977	1721	700	2423	5	2429
1978	3140	1573	4713	11	4724
1979	3281	1927	5208	4	5211
1980	3654	2955	5611	4	5615
1981	3591	5408	9031	45	9077
1982	2585	3657	6242	37	6280
1983	1162	3261	4423	29	4454
1984	1854	3260	5115	5	5121
1985	856	823	1679	4	1683
1986	985	1207	2192	9	2200
1987	778	639	1417	1	1418
1988	920	768	1688	6	1693
1989	359	419	780	6	787
1990	486	688	1178	4	1189
1991	400	517	918	13	931
1992	597	740	1337	292	1629
1993	142	191	333	88	421
1994			n/a		300 [1]

[1] estimated

Table 5. Monthly catch (t) of haddock by USA in unit areas 5Zjm.

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
1994							n/a						300 [1]

[1] estimated

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

	Age Group									
Year	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	7	246	319	245	69	551	7	143	69	1656
1994	0	210	703	137	49	33	107	13	37	1289

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

	Age Group							
Year	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	0.659	1.160	1.750	2.236	2.113	2.677	2.987	3.133
1994	0.405	1.141	1.669	2.246	2.664	2.439	2.835	3.240

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

	Age Group									
Year	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	24	35	17	84	26	10	5	202
1994 [1]	0	12	69	21	10	4	30	1	7	154

[1]Estimated

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

	Age Group							
Year	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	-	1.044	1.395	1.794	1.772	2.273	2.217	2.825
1994 [1]	-	0.923	1.491	2.091	2.395	2.146	2.805	2.593

[1]Estimated

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

	Age Group									
Year	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	7	247	343	279	85	635	34	153	74	1857
1994	0	223	772	158	59	37	138	14	45	1446

[1] Prior to 1977 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 5Zjm.

	Age Group							
Year	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	0.659	1.160	1.724	2.181	2.047	2.623	2.386	3.112
1994	0.405	1.129	1.653	2.226	2.619	2.407	2.829	3.208

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
1994	DELAWARE II	POLY	0.852

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
1994	ALBATROSS IV	POLY	1.000

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

	Age Group									
Year	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	48	6664	991	2910	247	528	40	36	260	11724
1990	726	108	12302	166	4465	299	1370	144	389	19968
1991	393	2159	137	10876	116	1899	119	507	225	16431
1992	1914	3879	1423	221	4810	18	1277	52	655	14249
1993	3448	1759	545	431	34	1186	19	281	147	7849
1994	4197	15163	5332	549	314	20	915	18	356	26864
1995	1197	3583	5984	2968	755	374	0	655	907	16422

Table 15. Total estimated abundance-at-age (numbers in 000's) of haddock in unit areas 5Zjm 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.

	Age Group									
Year	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
1994	1065	4439	1545	279	192	123	289	29	88	8047

Table 16. Total estimated abundance-at-age (numbers in 000's) of haddock in unit areas 5Zjm 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
1994	625	782	927	419	96	32	0	24	0	2905

Table 17. Statistical properties of estimates for population abundance and survey calibration constants.

Age	Par. Est.	Std. Err.	Rel. Err.	Bias	Rel. Bias
			Population Abundance		
1	5207	3873	0.74	1464	0.28
2	5894	2771	0.47	675	0.11
3	10406	3924	0.38	771	0.07
4	2548	1002	0.39	174	0.07
5	323	146	0.45	30	0.09
6	110	58	0.53	15	0.14
7*	71	24	0.34	1	0.01
8	224	164	0.73	47	0.21
			Survey Calibration Constants		
USA Fall Survey					
1	0.1565	0.0318	0.2031	0.0028	0.0180
2	0.3481	0.0728	0.2092	0.0067	0.0193
3	0.2420	0.0494	0.2040	0.0044	0.0183
4	0.2261	0.0462	0.2041	0.0043	0.0189
5	0.1824	0.0396	0.2171	0.0042	0.0230
6	0.1819	0.0374	0.2058	0.0038	0.0208
USA Spring Survey					
1	0.1615	0.0338	0.2092	0.0031	0.0193
2	0.4107	0.0837	0.2038	0.0076	0.0184
3	0.5012	0.1040	0.2076	0.0096	0.0191
4	0.5600	0.1163	0.2076	0.0108	0.0192
5	0.6571	0.1339	0.2038	0.0125	0.0190
6	0.4833	0.1026	0.2122	0.0106	0.0220
7	0.8297	0.1772	0.2135	0.0186	0.0224
8	0.7615	0.1653	0.2170	0.0193	0.0253
Canadian Spring Survey					
1	0.1763	0.0598	0.3392	0.0090	0.0510
2	0.4385	0.1445	0.3296	0.0211	0.0482
3	0.8942	0.2918	0.3263	0.0421	0.0471
4	0.7394	0.2417	0.3269	0.0361	0.0488
5	0.8452	0.2790	0.3301	0.0432	0.0511
6	0.5818	0.1938	0.3332	0.0318	0.0546
7	0.8536	0.2965	0.3474	0.0507	0.0594
8	0.7666	0.2620	0.3417	0.0525	0.0684

* estimated assuming fully recruited average F

Table 18. Bias adjusted estimates of beginning of year population numbers (000's) for haddock in unit areas 5Zjm.

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	797	3663	192	5121	11020	2841	3427	54260	6312
2	169	653	2977	157	3938	8103	2311	2805	44363
3	3167	122	459	1334	128	1660	4752	1726	2163
4	875	1282	93	140	733	99	1113	2608	1254
5	863	480	733	47	47	274	81	697	1394
6	6647	405	258	375	19	5	188	60	461
7	2260	2835	216	64	229	7	2	112	50
8	235	1112	1290	27	14	153	6	0	77
9	0	113	579	379	10	4	94	2	0
1+	15014	10664	6797	7644	16137	13147	11973	62270	56074
2+	14217	7001	6606	2523	5117	10306	8546	8010	49762
3+	14047	6348	3629	2366	1179	2203	6235	5205	5399
4+	10880	6227	3170	1032	1051	542	1483	3479	3236

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	4158	40791	6197	4461	2075	2422	15495	1548	13254
2	5168	3403	33397	5072	3652	1699	1983	12686	1268
3	29424	3969	2766	18730	3554	2344	1205	1552	8520
4	1713	15195	3067	1948	9370	1962	1392	759	932
5	866	1257	8456	2235	1247	5129	1143	825	462
6	865	556	735	4760	1301	843	2705	704	504
7	230	438	290	428	2793	722	490	1254	465
8	41	116	183	122	241	1632	494	224	691
9	50	24	59	102	72	142	962	260	136
1+	42514	65749	55151	37858	24305	16895	25870	19812	26232
2+	38356	24957	48954	33397	22230	14473	10375	18264	12978
3+	33188	21554	15557	28326	18577	12774	8392	5578	11710
4+	3764	17585	12791	9596	15024	10430	7187	4026	3190

Age	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	1254	14443	969	2075	1852	5938	14681	6374	3743
2	10846	1027	11821	793	1697	1511	4856	12014	5218
3	1004	7079	795	8635	643	990	1029	3752	9635
4	4662	707	3855	580	5926	446	530	532	2374
5	606	2446	470	2492	361	3005	250	181	292
6	250	410	1209	268	1368	216	1152	127	95
7	302	154	237	700	157	768	96	368	71
8	274	173	93	166	425	63	344	48	177
9	409	163	101	58	98	217	29	143	27
1+	19608	26602	19549	15766	12527	13153	22966	23540	21632
2+	18354	12159	18580	13692	10675	7215	8284	17166	17889
3+	7508	11133	6759	12899	8978	5704	3429	5152	12670
4+	6504	4053	5965	4263	8335	4714	2400	1399	3035

Table 19. Bias adjusted estimates of beginning of year population biomass (000's t) for haddock in unit areas 5Zjm.

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	359	2328	89	3381	6321	1414	1629	25373	2734
2	115	522	2435	121	3434	6596	1671	2125	33750
3	3132	96	488	1606	149	1979	5777	1832	2540
4	1226	1867	94	191	1230	155	1904	4387	1918
5	1370	815	1337	78	93	518	153	1556	2905
6	11564	757	533	841	36	15	411	140	1201
7	4641	5697	474	149	614	14	7	287	134
8	605	2841	3092	63	41	461	17	0	222
9	0	363	1828	1081	26	17	305	8	0
1+	23011	15286	10372	7512	11943	11170	11874	35707	45404
2+	22653	12958	10283	4131	5622	9756	10245	10335	42670
3+	22538	12436	7848	4010	2188	3159	8574	8210	8920
4+	19406	12340	7359	2404	2039	1180	2797	6378	6381

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	2037	20072	1693	2110	953	1203	7389	726	4420
2	4294	2660	24434	3046	2779	1332	1438	9577	972
3	34696	4852	2796	19875	3915	2667	1420	1611	9655
4	2948	24435	4563	2499	14066	3030	2186	1222	1412
5	1886	2677	16521	4398	2400	9976	2222	1670	984
6	2260	1507	1758	11185	3135	2037	6354	1701	1240
7	665	1343	914	1292	7762	1960	1312	3430	1317
8	112	361	623	458	849	4945	1484	675	2213
9	165	69	204	392	307	502	3060	849	455
1+	49063	57975	53506	45254	36165	27651	26864	21461	22668
2+	47026	37904	51813	43144	35213	26448	19475	20734	18248
3+	42732	35243	27378	40098	32433	25116	18037	11157	17276
4+	8036	30391	24583	20223	28518	22450	16617	9546	7621

Age	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	590	4237	451	969	760	2177	7394	3210	1715
2	6659	785	7148	614	1484	1242	3836	10366	4305
3	1189	7381	944	9583	716	1380	1457	5196	13470
4	7636	1106	5870	934	9475	639	996	1042	4172
5	1214	4924	907	4860	697	5943	460	432	605
6	620	920	2744	626	3225	491	2749	283	218
7	855	431	630	1863	425	2138	234	1004	188
8	903	542	300	500	1237	199	1048	132	528
9	1630	658	352	211	294	676	105	454	88
1+	21296	20984	19345	20159	18314	14886	18279	22119	25289
2+	20706	16747	18894	19190	17554	12708	10885	18908	23574
3+	14047	15962	11747	18576	16070	11466	7048	8542	19269
4+	12857	8580	10803	8993	15353	10086	5592	3347	5799

Table 20. Bias adjusted estimates of average (mid- year) population biomass (000's t) for haddock in unit areas 5Zjm.

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	434	2385	104	3417	6483	1540	1863	29313	3432
2	110	587	1900	142	2643	6089	1747	2362	35305
3	2672	87	285	1567	154	1940	5445	1910	2781
4	1007	1624	86	149	841	161	1833	3600	1896
5	998	675	1074	67	42	452	140	1379	2592
6	8212	639	314	741	19	12	355	148	933
7	3719	4315	204	80	544	17	2	252	121
8	480	2320	1945	42	28	379	12	0	193
1+	17631	12632	5912	6205	10754	10590	11398	38964	47254
2+	17197	10247	5808	2788	4271	9050	9534	9652	43822
3+	17087	9659	3908	2646	1628	2961	7788	7290	8516
4+	14415	9573	3623	1079	1474	1020	2343	5380	5735

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	2332	22183	2275	2426	1128	1317	8426	842	5434
2	5228	3035	22625	3800	2847	1473	1541	9941	1109
3	30853	4542	2413	17057	3653	2450	1306	1496	8651
4	3027	20751	4482	2501	12567	2653	1993	1146	1414
5	1834	2146	13603	3919	2401	8025	1956	1452	817
6	1832	1147	1473	9632	2515	1633	4916	1557	1071
7	494	940	685	1142	6392	1730	970	2713	1073
8	89	276	501	379	660	3935	1142	560	1921
1+	45689	55021	48057	40857	32163	23216	22251	19706	21489
2+	43357	32838	45783	38431	31035	21899	13825	18864	16055
3+	38129	29803	23158	34631	28188	20426	12284	8923	14946
4+	7277	25261	20745	17574	24535	17976	10977	7428	6295

Age	1987	1988	1989	1990	1991	1992	1993	1994
1	682	5512	527	1201	973	2895	8770	2340
2	7355	882	8806	715	1571	1459	4964	12175
3	1212	6923	988	10211	669	1194	1299	4977
4	6818	991	5551	825	7751	560	708	891
5	1078	3584	784	4012	589	4195	372	349
6	514	741	2349	521	2698	368	1803	232
7	685	365	600	1548	301	1576	165	738
8	779	442	254	387	932	148	712	116
1+	19123	19442	19860	19420	15483	12396	18792	21818
2+	18441	13929	19333	18219	14509	9501	10023	19478
3+	11086	13047	10527	17504	12938	8042	5059	7303
4+	9874	6124	9538	7293	12270	6848	3760	2326

Table 21. Bias adjusted estimates of instantaneous fishing mortality rates for haddock in unit areas 5Zjm. The total (population weighted) fishing mortality for ages 4 and older is indicated.

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0.00	0.01	0.00	0.06	0.11	0.01	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
3	0.70	0.07	0.99	0.40	0.06	0.20	0.40	0.12	0.03	0.46	0.06
4	0.40	0.36	0.47	0.89	0.79	0.00	0.27	0.43	0.17	0.11	0.39
5	0.56	0.42	0.47	0.71	1.98	0.18	0.09	0.21	0.28	0.24	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
7	0.51	0.59	1.90	1.29	0.20	0.01	2.41	0.18	0.00	0.49	0.67
8	0.54	0.45	1.02	0.81	0.96	0.29	0.82	0.00	0.24	0.33	0.47
4+	0.61	0.52	0.88	0.43	0.40	0.22	0.26	0.19	0.31	0.37	0.42

Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
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	0.38	0.16	0.24	0.14	0.05	0.20	0.03	0.23	0.06	0.11	0.01	0.34
3	0.15	0.49	0.39	0.32	0.26	0.31	0.40	0.15	0.41	0.11	0.18	0.17
4	0.12	0.25	0.40	0.34	0.32	0.30	0.23	0.44	0.21	0.24	0.27	0.48
5	0.37	0.34	0.19	0.44	0.28	0.29	0.41	0.19	0.50	0.36	0.40	0.32
6	0.34	0.33	0.39	0.34	0.57	0.21	0.31	0.28	0.35	0.35	0.33	0.38
7	0.67	0.37	0.34	0.18	0.58	0.40	0.33	0.36	0.30	0.15	0.30	0.71
8	0.38	0.33	0.33	0.33	0.44	0.30	0.32	0.32	0.34	0.28	0.33	0.47
4+	0.38	0.34	0.31	0.38	0.48	0.32	0.34	0.27	0.46	0.32	0.37	0.40

Age	1992	1993	1994
1	0.00	0.00	0.00
2	0.18	0.06	0.02
3	0.43	0.46	0.26
4	0.38	0.87	0.40
5	0.76	0.47	0.45
6	0.61	0.94	0.39
7	0.60	0.49	0.53
8	0.59	0.68	0.39
4+	0.72	0.79	0.47

Table 22. Projections for haddock in unit areas 5Zjm.

Beginning of Year

	Weight(kg)		
	1995	1996	1997
1	0.46	0.49	0.49
2	0.82	0.83	0.83
3	1.40	1.40	1.40
4	1.76	1.87	1.87
5	2.07	2.10	2.10
6	2.30	2.30	2.30
7	2.65	2.60	2.60
8	2.99	2.93	2.93
9	3.32	3.38	3.38

	Population Numbers (000)		
	1995	1996	1997
1	3743	10000	10000
2	5218	3065	8187
3	9635	4219	2478
4	2374	6961	3049
5	292	1514	4439
6	95	186	965
7	71	60	119
8	177	45	39
9	27	113	29
1+	21632	26164	29304
2+	17889	16164	19304
3+	12670	13099	11117
4+	3035	8880	8639

	Population Biomass(t)		
	1995	1996	1997
1	1715	4884	4884
2	4305	2531	6762
3	13470	5905	3468
4	4172	12989	5688
5	605	3178	9320
6	218	429	220
7	188	157	309
8	528	133	113
9	88	381	98
1+	25289	30589	32864
2+	23574	25704	27979
3+	19269	23173	21217
4+	5799	17267	17749

Mid-Year

	Weight (kg)	
	1995	1996
1	0.53	0.53
2	1.15	1.15
3	1.67	1.67
4	2.02	2.02
5	2.28	2.28
6	2.51	2.51
7	2.73	2.73
8	3.24	3.24

	Population Numbers(000)	
	1995	1996
1	3393	9063
2	4701	2761
3	8226	3602
4	1911	5606
5	235	1219
6	76	150
7	57	49
8	142	36
1+	18743	22487
2+	15350	13423
3+	10649	10662
4+	2423	7060

	Biomass (t)	
	1995	1996
1	1812	4841
2	5409	3177
3	13710	6004
4	3861	11325
5	536	2777
6	191	376
7	156	133
8	461	118
1+	26138	28752
2+	24326	23910
3+	18916	20733
4+	5206	14729

Catch

	Fishing Mortality	
	1995	1996
1	0.00	0.00
2	0.01	0.01
3	0.13	0.13
4	0.25	0.25
5	0.25	0.25
6	0.25	0.25
7	0.25	0.25
8	0.25	0.25

	Numbers (000)	
	1995	1996
1	0	0
2	59	35
3	1028	450
4	478	1401
5	59	305
6	19	38
7	14	12
8	36	9
1+	1693	2250
2+	1693	2250
3+	1634	2215
4+	606	1765

	Biomass (t)	
	1995	1996
1	0	0
2	68	40
3	1714	750
4	965	2831
5	134	694
6	48	94
7	39	33
8	115	29
1+	3083	4473
2+	3083	4473
3+	3015	4433
4+	1302	3682

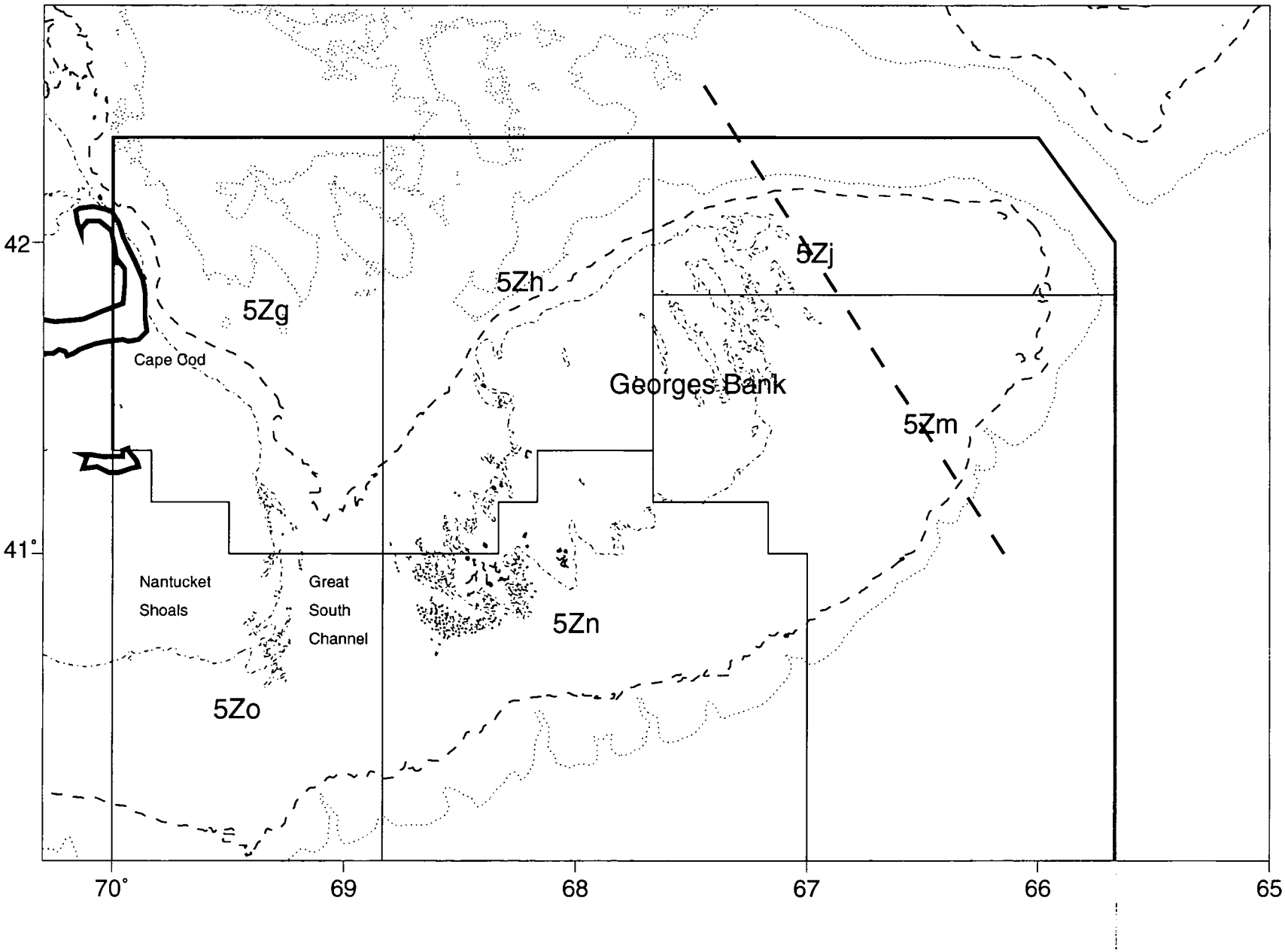

Fig. 1. Canadian fisheries statistical unit areas in NAFO Division 5Z.

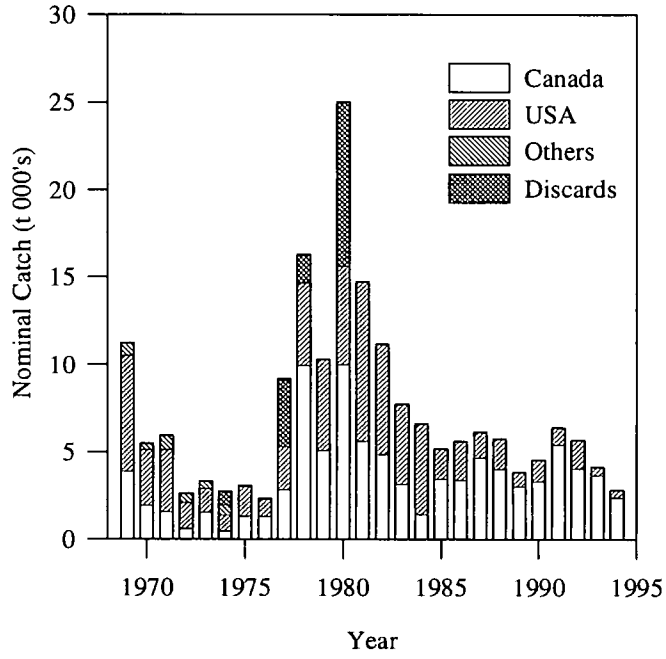

Fig. 2. Nominal catch of haddock in unit areas 5Zjm.

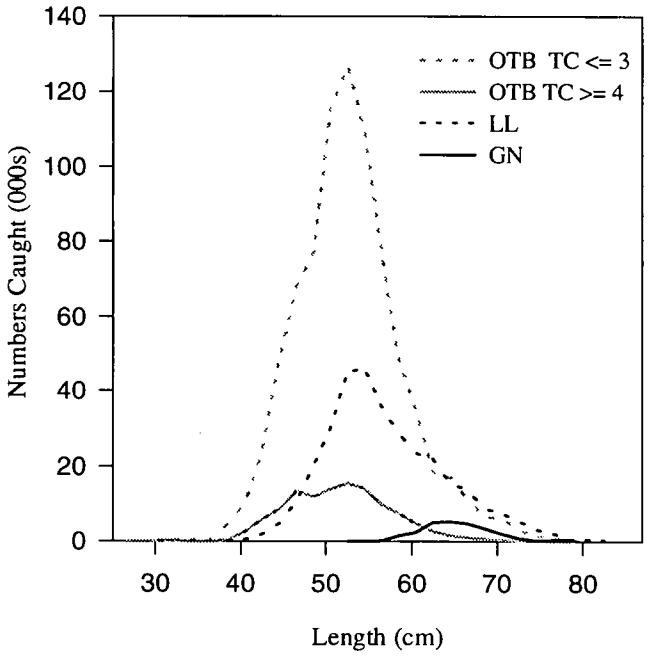

Fig. 3. Length composition of haddock catch in 1994 by the principle gears sectors for the Canadian fishery in unit areas 5Zjm.

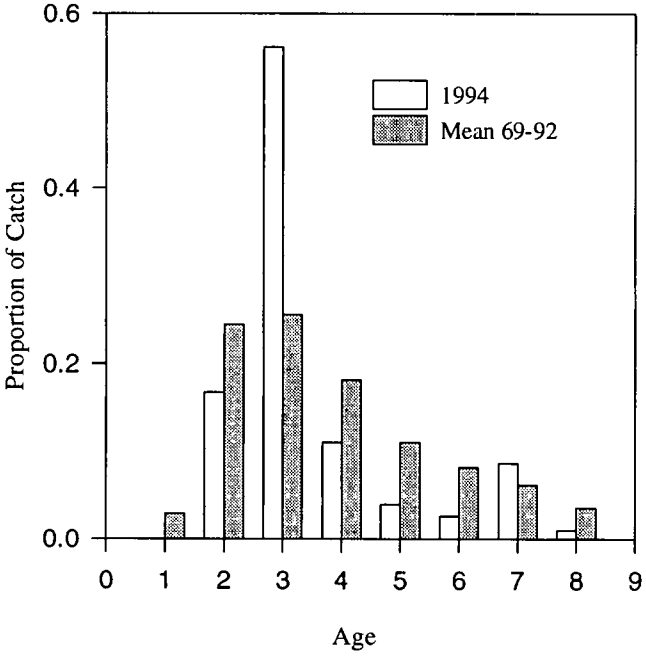

Fig. 4. Commercial fishery catch proportioned by age for 1994 compared to the average for 1969-92.

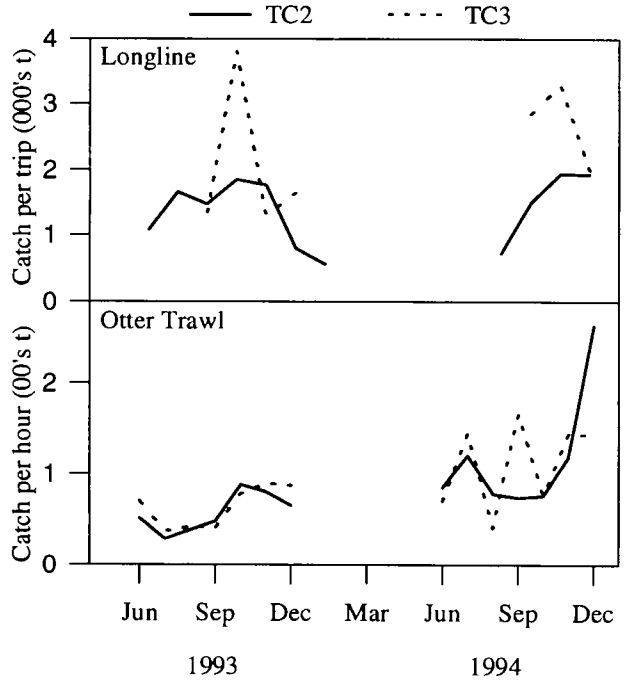

Fig. 5. Indices of catch per hour for otter trawls and catch per trip for longlines from the Canadian commercial fisheries.

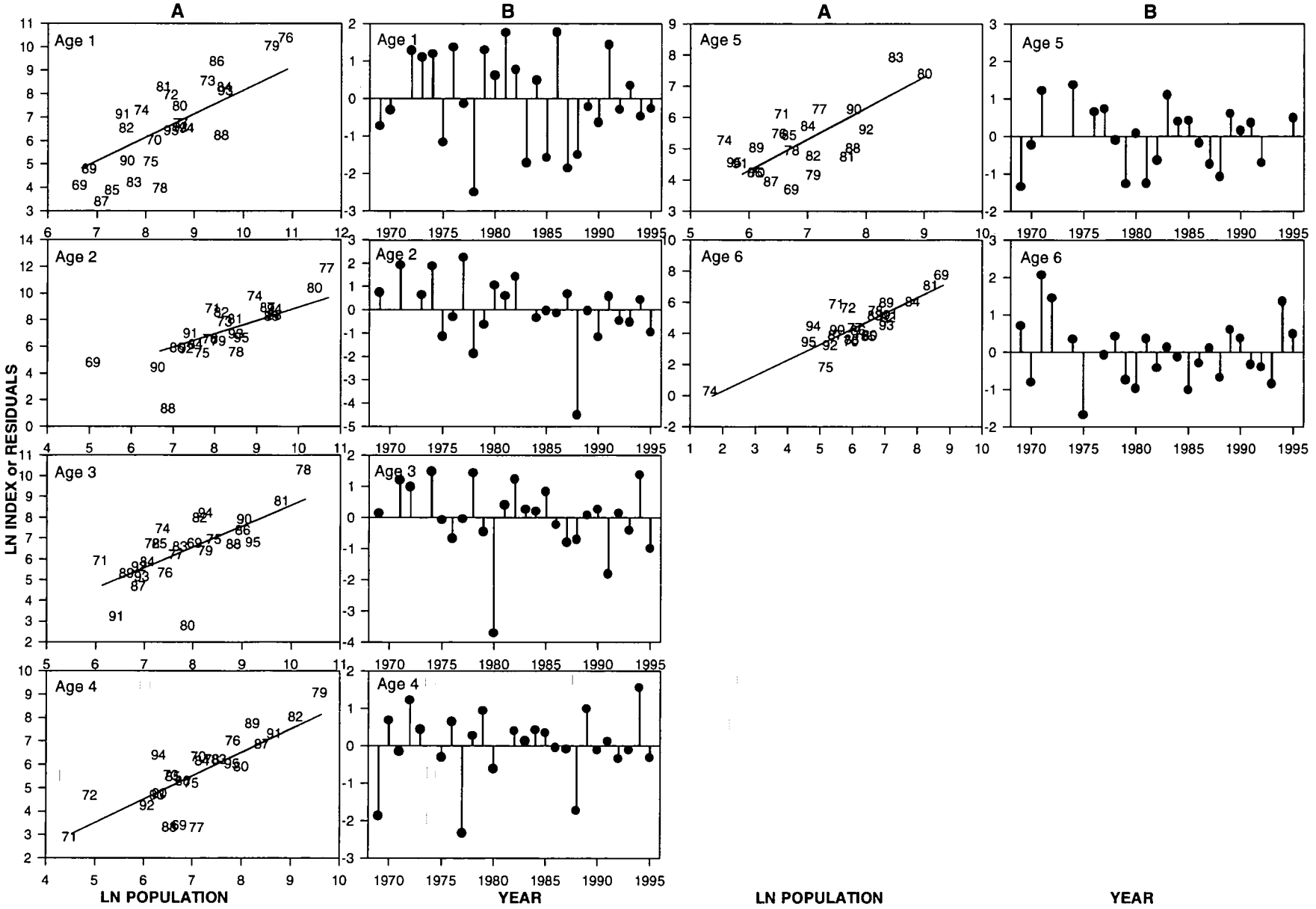

Fig. 6a. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers, and B) residuals plotted against year for haddock in unit areas 5Zj and 5Zm for the USA fall survey.

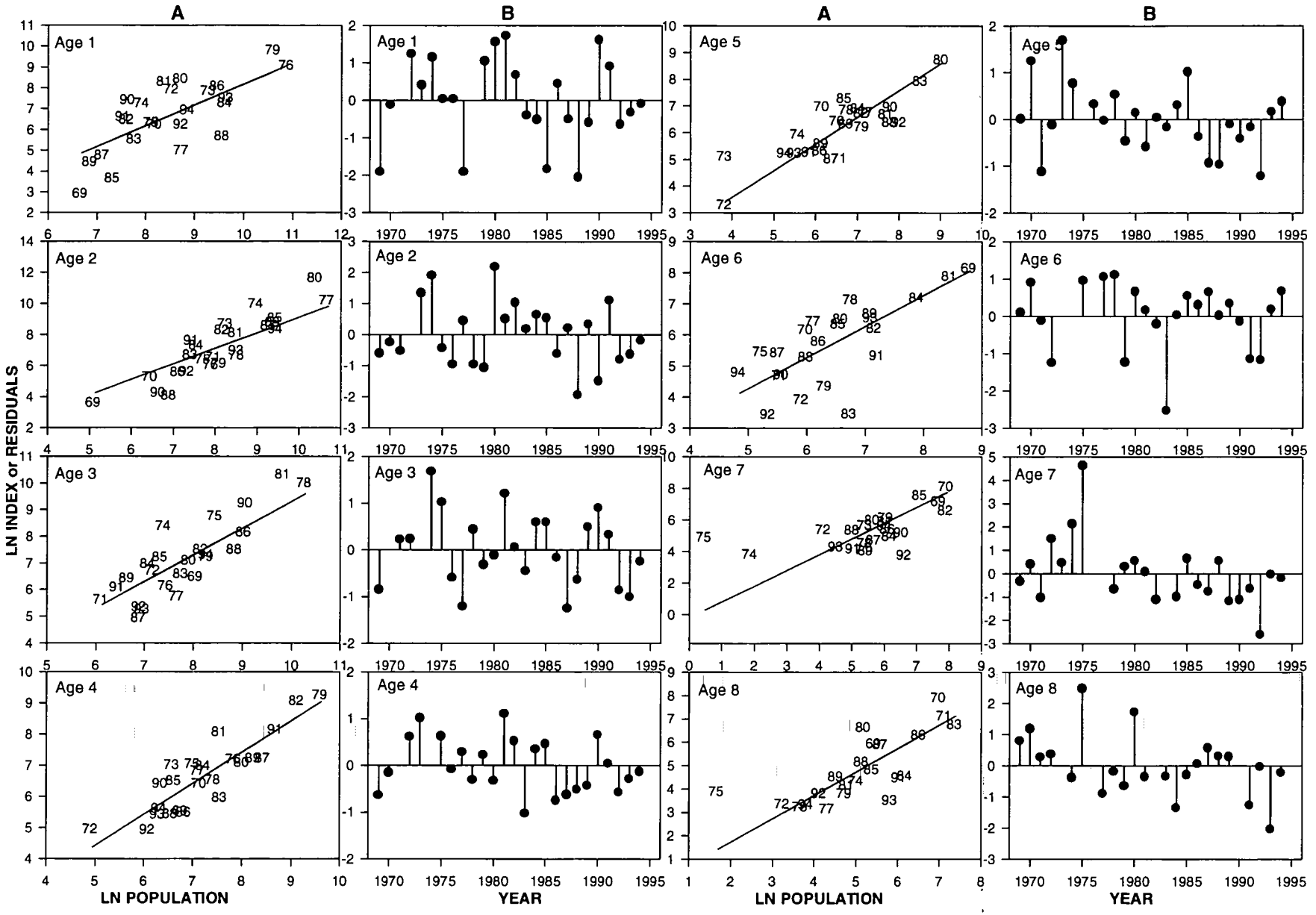

Fig. 6b. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers, and B) residuals plotted against year for haddock in unit areas 5Zj and 5Zm for the USA spring survey.

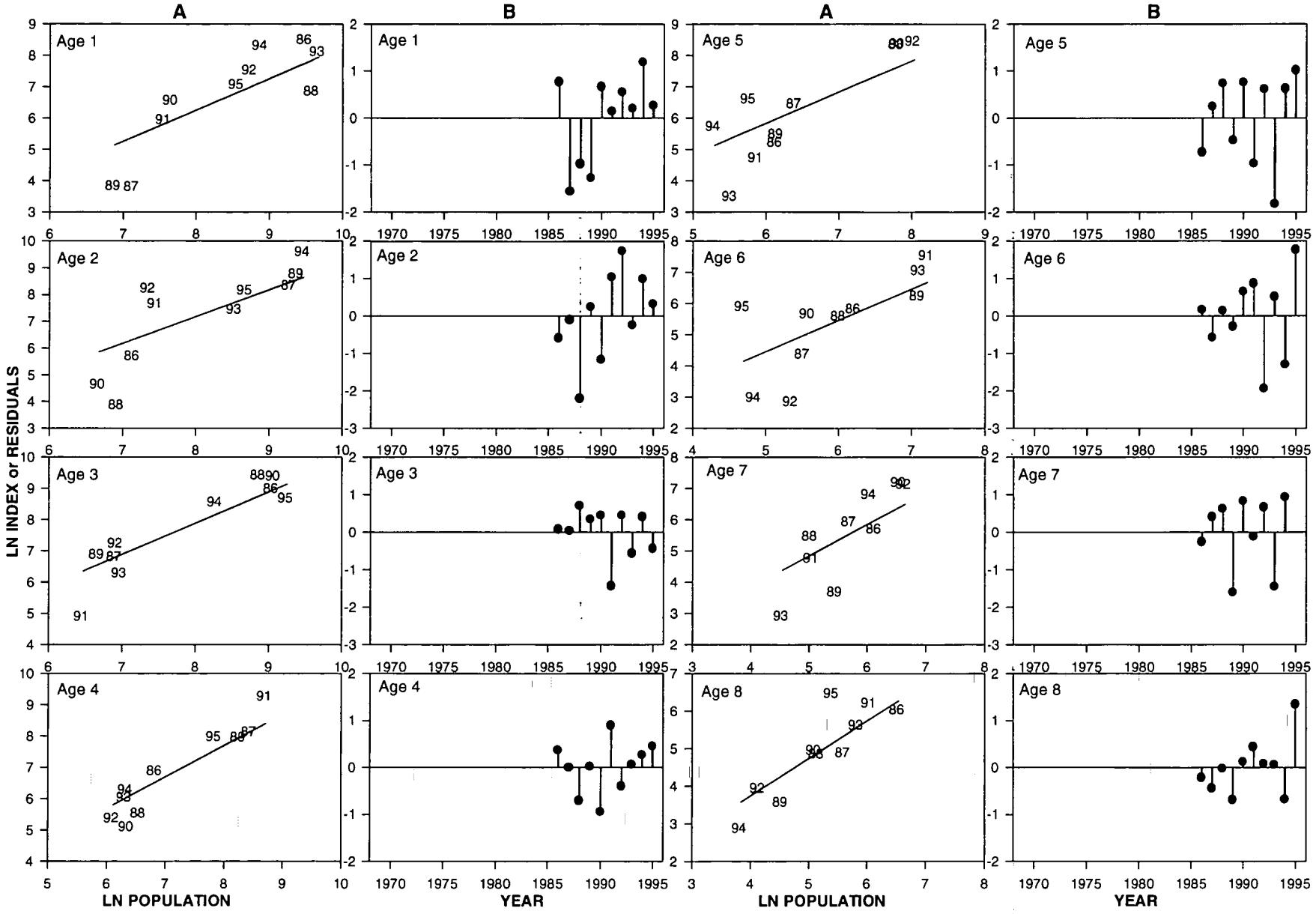

Fig. 6c. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers, and B) residuals plotted against year for haddock in unit areas 5Zj and 5Zm for the Canadian spring survey.

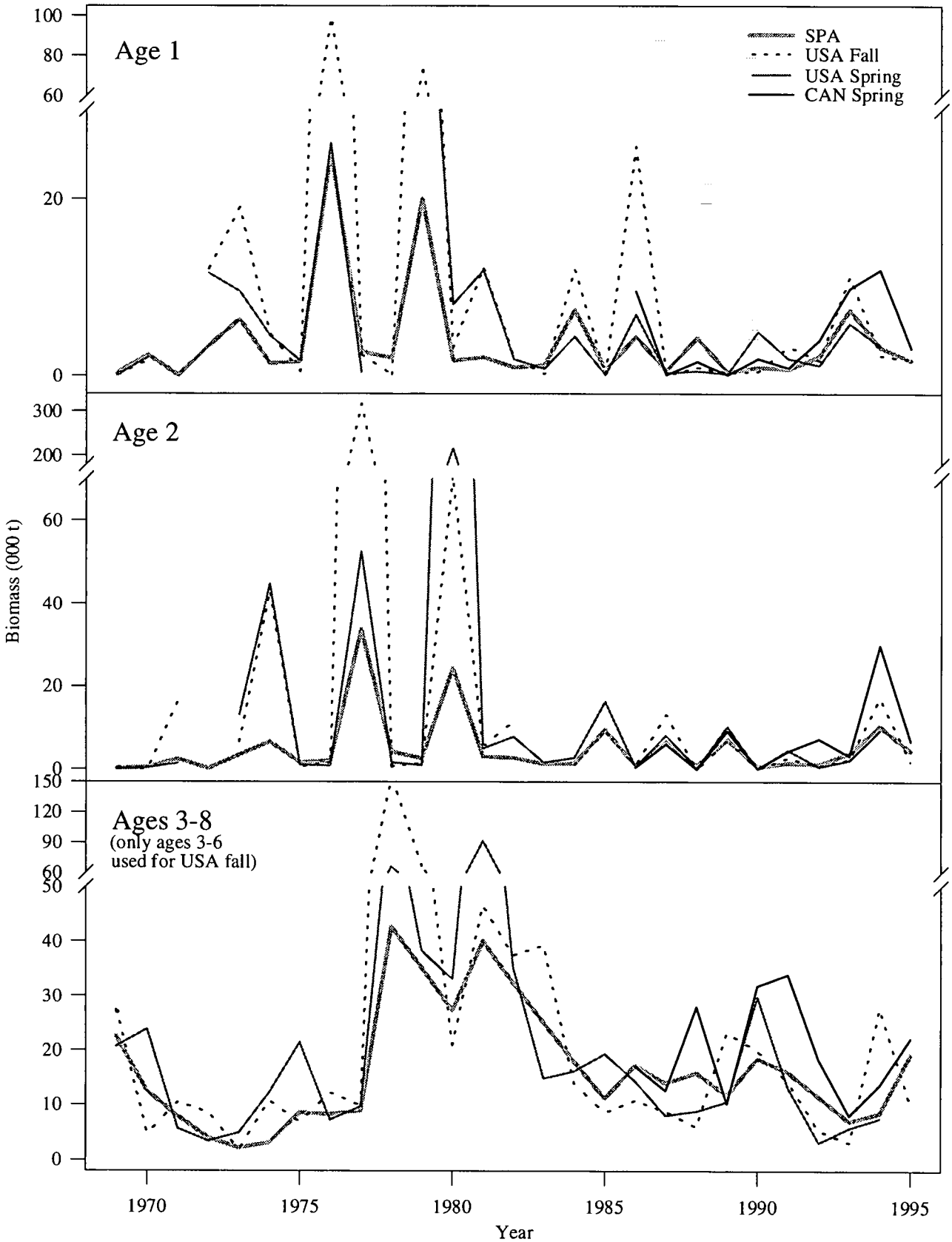

Fig. 7. Beginning of year biomass from sequential population analysis (bias adjusted SPA) and research survey indices (adjusted by calibration constants) for haddock in unit areas 5Zjm. Fall values are compared to the beginning of the subsequent year.

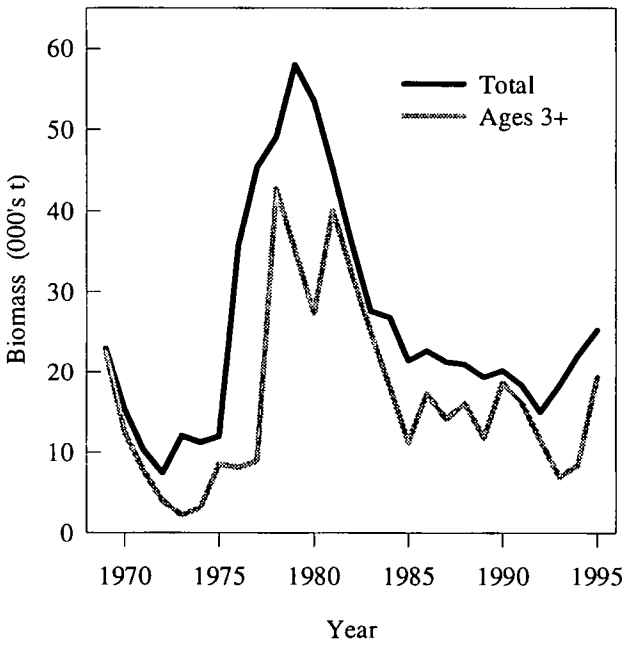

Fig. 8. Beginning of year biomass for haddock in unit areas 5Zjm.

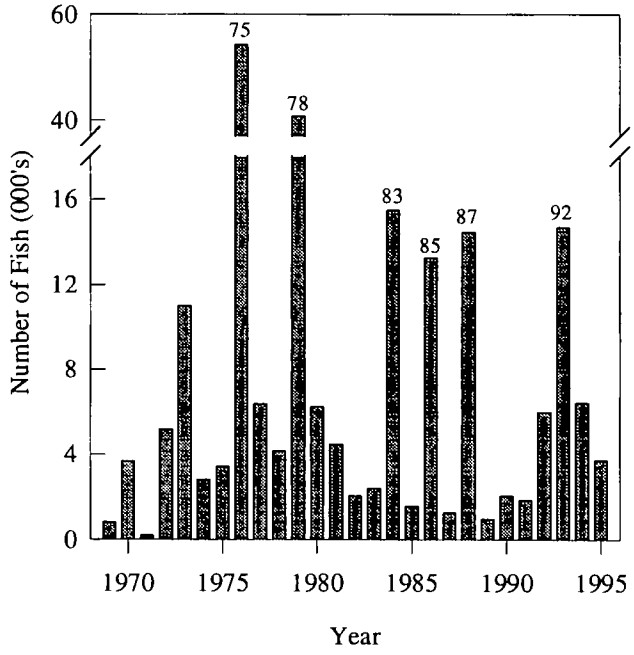

Fig. 9. Recruitment (age 1) for haddock in unit areas 5Zjm. Numbers above bars indicate the yearclass.

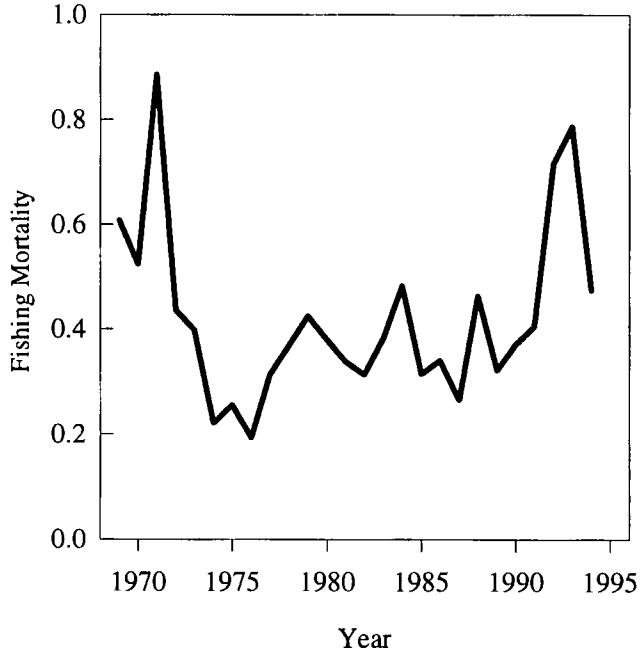

Fig. 10. Instantaneous fishing mortality rate for haddock ages 4 and older in unit areas 5Zjm.

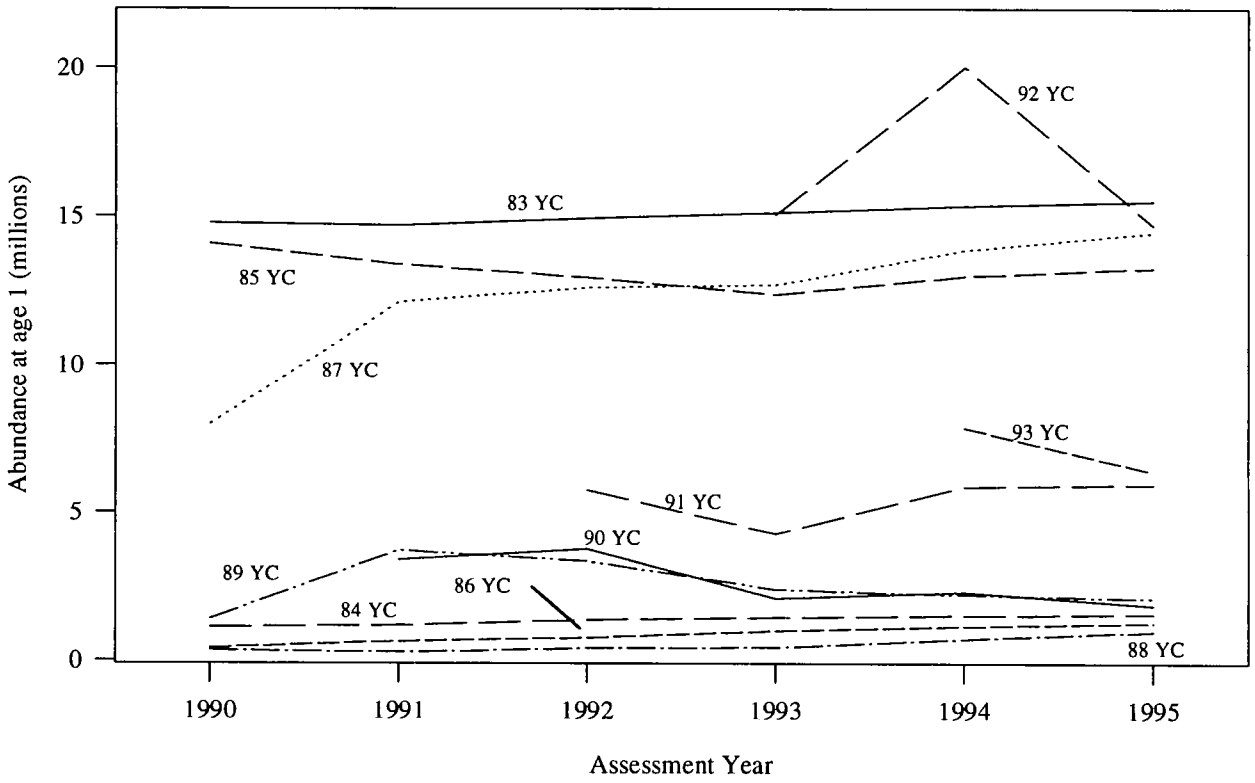

Fig. 11. Successive estimates of year-class abundance as additional years of data were included in the assessment did not display any persistent trends.

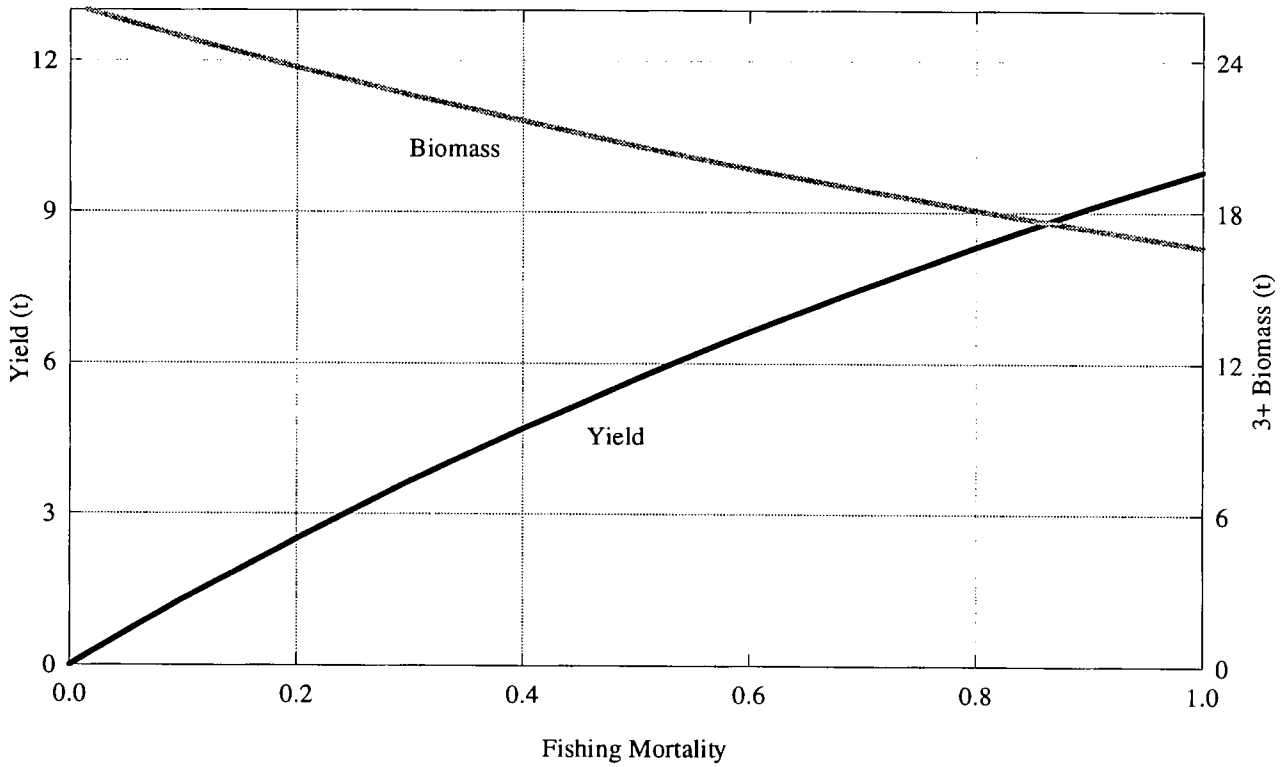

Fig. 12. Projected yield for 1995 and beginning of year biomass in 1996 of haddock in unit areas 5Zjm.

Appendix A. Derivation of catch at age for 1994 5Zjm haddock fishery. OT=Otter Trawl, GN=Gill Net, LL=Long Line, IN=Inshore (Tonnage Classes <=3), OF=Offshore (Tonnage Classes >=4), Q=Quarter, s=square mesh, d=diamond mesh.

Country	Qtr.	Length Frequency Samples									Aged Samples	
		Gear	Month	OBSERVER		PORT		Landings (kg)	Combinations		No. of Samples	No. Aged
				Samples	Measured	Samples	Measured					
Canada	1	Misc.						5,259		CanQ2	8	283
	2	OTsIN	June	2	691	7	1631	317,402	Q2OTIN			
		OTdIN	June					3,719				
		GN	Used Q3					6,972	Q2GN			
		LL	June			1	344	69,599	Q2LL			
		Misc.						2,154				
	3	OTsIN	Jul	4	1618	7	1551	407,786	Q3OTIN	CanQ3	14	415
		OTsIN	Aug			1	221	69,153				
		OTsIN	Sept	4	1658	3	700	206,878				
		OTdOF	Jul	9	5133			39,893				
		GN		1	359			75,670	Q3GN			
		LL	Jul	7	1403	1	237	195,331	Q3LL			
		LL	Aug	4	3132			281,693				
		LL	Sept			2	498	155,868				
		Misc.						8,584				
	4	OTsIN	Oct	9	3440	3	728	182,903		Q4OTIN	CanQ4	9	231
		OTsIN	Nov			3	649	85,546	NovOTIN			
		OTdIN	Nov	2	1585			1,639				
		OTIN	Nov					29,549				
		OTIN	Dec					101,501				
		OTdOF	Oct	3	1660			29,287	Q4OTOF			
		OTsOF	Oct	3	1128			2,660				
		OTsOF	Nov	2	695	1	250	86,190				
		OTsOF	Dec	4	602	3	604	32,539				
		GN	Used Q3 GN					747	Q4GN			
		LL	Used Q3LL					11,941	Q4LL			
		Misc.						554				
	Totals			54	23,104	32	7,413	2,411,017			31	929
USA	Total	Can. If samples from Jun-OTsIN						300,000				
Total for Canada and USA								2,711,017				

Appendix B

This stock has been aged by L. Van Eeckhaute since 1990. In 1994, M. Strong assumed half the responsibility for ageing this stock. M. Strong had several years experience with this stock prior to 1990. The results of an inter-reader ageing comparison test between the 2 readers is presented in Table Al. Intra-reader tests for both readers are presented in Tables A2 and A3. The selection of otoliths for the tests covered the whole length range and incorportated seasonality where possible.

Table B1. Comparison of ages derived for haddock otoliths from independent readings by L. Van Eeckhaute and Mike Strong from the 1993 Canadian commercial fishery in 5Zj,m and the 1994 Canadian spring 5Z survey (N200).

L. Van Eeckhaute

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Omit	Tot
1	21	1																	22
2	2	42	1																45
3		3	18	1														1	23
4		1	4	16	3	1	1											1	27
5				3	3	1		1											8
6					1	28													29
7						6	3	2											11
8						2	2	15											19
9								2	2										4
10				1						3									4
11										5									5
12																			0
13																			0
14																			0
15															3				3
16																			0
17																			0
18																			0
19																	1		1
Omit				1						1					1				3
Tot	23	47	23	22	7	38	6	20	2	9	0	0	0	0	4	0	1	2	0
Agreement =													77 %						204

Mike Strong (trainee)

Table B2. Comparison of ages from independent readings by Mike Strong for haddock otoliths from the 1994 Canadian commercial fishery in 5Zj,m.

Mike Strong (1st reading)

Mike Strong (2nd reading)	1	2	3	4	5	6	7	8	9	10	11	Omit	Tot
1													0
2		24	1										25
3		1	31	2									34
4			3	8								1	12
5					7	1						1	9
6					1							3	4
7						1	13	2				1	17
8								2				1	3
9								1	3			1	5
10											1	2	3
11										1			1
Omit			1		1							2	4
Tot	0	25	36	10	9	2	13	5	3	1	1	12	117
Agreement =								87 %					117

Table B3. Comparison of ages from independent readings by L. Van Eeckhaute of haddock otoliths from the 1994 Canadian commercial fishery in 5Zj,m.

L. Van Eeckhaute (1st reading)

L. Van Eeckhaute (2nd reading)	1	2	3	4	5	6	7	8	9	10	11	Omit	Tot
1	1												1
2		28											28
3		2	19										21
4			1	12									13
5					6	2							8
6						3							3
7							14						14
8							1						1
9									5				5
10													0
11											1		1
Omit												1	1
Tot	1	30	20	12	6	5	15	0	5	0	1	1	96
Agreement =								95 %					96