Assessment of Haddock on Eastern Georges Bank

by

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Abstract

The establishment of the maritime boundary between Canada and the USA by the International Court of Justice crossed the former management unit for haddock on Georges Bank. An assessment of haddock in unit areas 5Zj and 5Zm was undertaken as this would permit Canada to pursue its goals of conservation and long term benefits to the fishery in the absence of co-ordinated management by the two coastal countries. Subsequent evaluation of the results did not provide evidence to invalidate such analyses.

Catches were down in 1989 due in part to the closing of the Canadian otter trawl fishery in June and the lack of a directed haddock fishery by the USA. Since 1977 only Canada and the USA have had directed haddock fisheries on Georges Bank and since 1985 the catch by Canada has exceeded that of the USA. The catch at age for both countries was similar, with the strong 1963, 1975, and 1978 year-classes being dominant in the early years and the moderately strong 1983 and 1985 year-classes supporting the recent fishery. The sequential population analysis was calibrated using the 3 available surveys, US spring and fall and Canadian spring, with a weighted analysis by age group within a survey. The analysis confirmed the strength of the 1983, 1985, and 1987 year-classes. The biomass has recovered somewhat from the low early 1970s and mid-1980s levels. Recruitment however fluctuates widely between relatively good and poor year-classes and production has not increased to historical levels.

Résumé

La frontière maritime canado-américaine établie par la Cour internationale de justice traverse l'ancienne unité de gestion de l'aiglefin du banc Georges. En l'absence d'une gestion coordonnée par les deux pays riverains, on a entrepris une évaluation de l'aiglefin dans les secteurs 5Zj et 5Zm de l'unité afin de permettre au Canada de pousuivre ses objectifs en matière de conservation et d'avantages à long terme pour la pêche. L'examen subséquent des résultats obtenus n'a pas fourni de motif d'invalider cette évaluation.

Les prises d'aiglefin étaient à la baisse en 1989, en partie à cause de la fermeture de la pêche au chalut à panneaux en juin et de l'absence d'une pêche dirigée chez les Américains. Depuis 1977, seuls le Canada et les États-Unis ont pratiqué une pêche dirigée sur l'aiglefin dans les eaux du banc Georges; depuis 1985; les prises du Canada dépassent celles des États-Unis. Les prises selon l'âge sont comparables de part et d'autre de la frontière. Les fortes classes de 1963, 1975 et 1978 ont dominé dans les prises des premières années et ont été supplantées récemment par les classes de 1983 et 1985, qui étaient moyennement fortes. L'analyse séquentielle de population a été étalonnée d'après les résultats des trois campagnes d'évaluation effectuées, soit celles de printemps et d'automne par les Américains et celle de printemps chez les Canadiens, et une analyse pondérée par groupe d'âge pour une de ces campagnes. L'analyse a confirmé la force des classes annuelles de 1983, 1985 et 1987. La biomasse s'est quelque peu relevée de ses faibles niveaux du début des années 1970 et du milieu des années 1980. Toutefois, le recrutement a connu d'importantes fluctuations entre des classes annuelles relativement bonnes et d'autres médiocres, tandis que la production n'a pas retrouvé ses niveaux historiques.

Definition of Management Unit

Prior to 1989, the management units employed by Canada for haddock in the Gulf of Maine area were those established by ICNAF in the early 1960s. Three distinct units were recognized; a) Division 4X, b) Division 5Y, and c) Division 5Z (Fig. 1). However the maritime boundary between Canada and the United States defined in 1984 by the International Court of Justice crossed several of the former management units. The northern part of the boundary approximated the existing Subarea 4/5 boundary. A review of biological and fisheries data (Halliday et.al. 1985) indicated that replacement of the Division 4X/5Y boundary by the maritime boundary established by the International Court of Justice would not result in significant disruption to historical statistical data series. Consequently, in 1986 Division 4X and Division 5Y, were retained as haddock management units but incorporating the revised Subarea 4/5 boundary. In recognition of the split in jurisdiction and in the absence of effective mechanisms for joint management of fishery resources in Division 5Z however, a review was undertaken to identify management units which reflected current knowledge about stock structure, movements of fish and the nature of the fisheries while allowing Canada to take advantage of conservation opportunities and to pursue objectives of long-term benefits to its fishery. Results from tagging experiments, both published and unpublished, as well as spatial distribution patterns from bottom trawl surveys and from the commercial fishery were considered. A conclusion of the review was that, given practical considerations related to the availability of statistics, haddock in unit areas 5Zj and 5Zm could be treated as a distinct management unit.

Advice for the management of haddock in unit areas 5Zj and 5Zm could be generated in two ways:

- assess haddock in Division 5Z, as has been the past practice, and determine a suitable way of partitioning the resource in unit areas 5Zj and 5Zm.

- assess haddock in unit areas 5Zj and 5Zm.

It was considered preferable to assess haddock in unit areas 5Zj and 5Zm as this was more consistent with the results of the review which suggested that haddock on eastern Georges Bank were a distinct population. This assessment was undertaken recognizing the approximation in population boundaries and the results were subsequently examined to determine that the migration rate between unit areas 5Zj and 5Zm with the remainder of Division 5Z was low enough to avoid complications in the analysis. This is discussed below.

Description of Fishery

The haddock on Georges Bank have supported an important commercial fishery since the early 1920s, harvested primarily by the USA in those early years. Substantial quantities of haddock were caught (Table 1) after 1960 by both Canada and distant water fleets from other countries, mainly USSR and Spain. The fisheries of the USSR, Poland, Romania, and minor landings by some other countries were not targeted on haddock and employed small mesh gear. These are collectively referred to as the small mesh fishery. Since 1977, with the establishment of the 200 mile limit, only the USA and Canada have had directed haddock fisheries on Georges Bank. Nominal catches include estimates of discards by the USA fishery (Overholtz et. al. 1983). There is no data pertaining to Canadian discards and it was assumed negligible.

Historical landings for Canada and the USA were available by unit area (Table 2, Fig. 2). The proportion of catch taken in unit areas 5Zj and 5Zm by the USA prior to 1985, when establishment of the international maritime

boundary altered fishing patterns, was about 40% . Therefore it was assumed that in all years, 40% of USA discards and of the catch by foreign fisheries targeting on groundfish (eg. Spain) was from unit areas 5Zj and 5Zm.

For the small mesh fisheries, the proportion caught in unit areas 5Zj and 5Zm was determined through analysis of an atlas describing the USSR fishery distribution. The atlas contained monthly maps of the eastern seaboard which outlined areas fished by the USSR fleet from 1961 to 1968. Each area was keyed with fishing statistics including species composition. It was assumed that the haddock catch was uniformly distributed within each of these fishing areas. We partitioned ICNAF catch records by relating them directly to the proportion of the atlas fishing areas which lay within 5Zj and 5Zm on a monthly basis. For months when haddock was not reported in the atlas, fishing areas which did not indicate haddock were used. The catch proportioned in this way for the 8-year period indicated that roughly 40% of the haddock caught in Division 5Z was from unit areas 5Zj and 5Zm.

High catches were taken from unit areas 5Zj and 5Zm during the mid-1960s (roughly 60,000 t) when the exceptionally strong 1963 year-class was being exploited. Since then, catches declined to a low of 2,352 t in 1976 before increasing again to 19,094 t in 1980 as a result of good 1975 and 1978 year-classes. Catches subsequently declined and stabilized between 5,000 and 8,000 t during the mid to late 1980s. The decline in landings to 3,846 t in 1989 was due primarily to the early closure of the Canadian trawler fishery. The USA catch in unit areas 5Zj and 5Zm dropped to a record low of 787 t in 1989 reflecting the absence of a directed commercial fishery.

The Canadian fishery is generally active through the summer although, there have, on occasion, been significant landings in winter (Table 3). In part, this pattern has been a result of the seasonal spawning area closure to bottom trawling (Halliday 1988). The dominant gear in the Canadian fishery is the otter trawl although there is a substantial longline component (Table 4). Between 1977 and 1984, tonnage class 5 trawlers were a major component but in recent years tonnage classes 2 and 3 have increased in importance. Side trawlers were phased out during the late 1970s and early 1980s.

The USA catch is fairly evenly distributed over the year but since 1985 catches in late summer and fall have been low (Table 5). Bottom trawling gained in popularity in the USA fishery during the 1920s (Clark et.al. 1982) and in recent years virtually all of the catch was taken by otter trawlers (Table 6) and these are primarily tonnage classes 3 and 4.

Catch and Weight at Age

The Canadian commercial fishery landings have been sampled by the Department of Fisheries and Oceans, Canada. When Canadian length samples were available they were pooled and weighted by the landed weight within each month, gear and market category (although most samples were taken from "no cull" landings) and applied to the respective landings. Monthly results for each gear category were aggregated by quarter or half year and age-length keys applied to obtain statistics by age. The length-weight relationship

$$\text{round weight(kg)} = 0.0000158\ \text{length(cm)}^{2.91612}$$

derived from Canadian fishery samples (Waiwood and Neilson 1985), was used in these calculations. When Canadian samples were not available USA samples, aggregated by quarter or half year, were used against Canadian landings. Canadian age-length keys for 1974 to 1983 were suspect of errors in ageing when compared to USA keys and known yearclass strengths so only USA age-length keys were used for this period and applied to Canadian length frequencies when these were available. When necessary, the USA age-length keys were augmented for missing lengths. Table 7 provides a summary of the treatment of

Canadianlandings. Resulting catch and average weight at age are presented in Tables 8 and 9, respectively.

The USA commercial fishery landings have been sampled by National Marine Fisheries Service, USA. The length samples were pooled, weighted according to sample weight within each month and market category and applied to the respective landings. This weighting is different than the treatment of Canadian samples but is consistent with the usual use of this information by the USA. Monthly results were then aggregated by quarter or half year incorporating landings from those months without samples. Pooled quarterly or half year age-length keys were applied to these results to obtain the catch composition and size by age. These quarterly or half year statistics were combined over each year to obtain Tables 10 and 11. These derivations required the use of length-weight relationships. USA workers employ monthly length-weight relationships (R. Mayo pers. comm.) but as these relationships are derived from gutted samples, there is little variation between them. We considered that using quarterly relationships would be adequate, therefore we employed the following results which were extracted from the information provided by NMFS:

Quarter 1 $\quad \text{round weight(kg)} = 0.0000186\ \text{length(cm)}^{2.852}$

Quarter 2 $\quad \text{round weight(kg)} = 0.0000217\ \text{length(cm)}^{2.790}$

Quarter 3 $\quad \text{round weight(kg)} = 0.0000093\ \text{length(cm)}^{3.023}$

Quarter 4 $\quad \text{round weight(kg)} = 0.0000212\ \text{length(cm)}^{2.827}$

Age and size composition of the foreign small mesh catch were derived by Clark et. al.(1982, pers. comm.) for Division 5Z and it was assumed that these were applicable to unit areas 5Zj and 5Zm. Length frequencies from the small mesh fisheries were estimated from a retention curve for USSR trawls relative to the USA survey trawl. This curve was calculated from USSR length frequencies of catches in the spring of 1973 and USA bottom-trawl survey data for April of the same year. This curve was applied to 1963-76 small mesh fishery catch data using length frequencies from USA spring, summer and autumn surveys. USA survey age-length keys were then applied to these frequencies. In 1962, when no USA survey data were available, commercial sampling data were used and in 1966 and 1973 USSR length frequencies were applied against USA age-length keys to obtain the age composition. Discards by the USA fishery were assumed to be either age 2 or age 3 according to the age of the dominant year-class (Overholtz et. al. 1983).

The Canadian and USA catch composition and size at age were combined. Landings by foreign countries targeting on groundfish (eg. Spain) were also applied against these age statistics. These were augmented by the catch composition and size at age information for the USA discards and foreign small mesh fishery to obtain Tables 12 and 13.

In recent years, the 1983, 1985, and 1987 year-classes have been dominant in the Canadian fishery. The 1985 and 1987 year-classes have not been as strong in the USA catch where the 1983 year-class was dominant in the catch up to 1988. Size at age has been stable in recent years in the catches of both countries.

Research Survey

Annual surveys have been conducted by Canada during the spring of 1986-1990 and by the USA during the spring of 1968-1990 and during the fall of 1963-1989. USA spring surveys employed different trawl gear from 1973-1981 than during other years. A new type of otter trawl door was introduced to both spring and fall USA surveys in 1985. The impact of these gear changes on

abundance estimates has not been determined. Both Canadian and USA surveys are based on a stratified random survey design though the stratification differs (Figs. 3-5).

Abundance indices were obtained by calculating the mean number per tow using sets occurring in the 5Zj and 5Zm portion of strata (strata 16 to 22 for USA surveys and 5Z1 to 5Z4 for Canadian surveys) and applying the mean to the area of the stratum lying within 5Zj and 5Zm. In some years, no sets were made in the 5Zj/5Zm portion of strata 20 and 22. The mean numbers per tow for the entire stratum and the 5Zj/5Zm means were compared over the available time series (Table 14). No consistent differences were observed, therefore the stratum mean was used to fill in the missing observations. For stratum 18, zeroes were used for two years of missing observations since haddock were not typically found there. The age composition for the whole stratum was then extrapolated to the area of the stratum within 5Zj/5Zm.

Because of the way the USA survey age samples are taken there are often gaps in their age-length keys. These gaps were filled in by using known length-to-age relationships, data from previous and subsequent keys, adjacent proportions at age and consideration of year-class strengths. Ageing for the 1990 USA spring survey had not been completed, therefore the Canadian 1990 spring survey age-length key was applied to the USA survey length frequency to obtain the age composition.

The strong 1983, 1985, and 1987 year-classes have been detected by all three surveys (Tables 15, 16 and 17). The Canadian spring survey shows relatively higher estimates of these year-classes than the USA spring survey, especially at age 3 in 1988. The USA fall 1987 estimates show consistently low values for all age groups when compared to the adjacent fall surveys, suggesting that reduced catchability may have impacted the results of that survey.

Estimation of Stock Parameters

The ADAPT framework (Gavaris 1988) was used for the calibration of the sequential population analysis with the survey results. Spring surveys were considered comparable to the beginning of year population, while the fall survey was compared to the population at one age older in the beginning of the subsequent year. The natural mortality rate was assumed to be 0.2 and error in the catch at age was assumed negligible. The fishing mortality rate on the oldest age group, 8, was calculated as the "full F" for age groups 4 to 7. "Full F" here refers to mortality rate calculated in the following manner:

$$\text{full } F_{8y} = \left(\ln\left(\sum_{a=4}^{6} N_{ay}\right) / \left(\sum_{a=5}^{7} N_{ay}\right)\right) - M$$

where a = index for age
y = index for year

The formulation was set up to estimate the survivors at ages 1-5 in 1990 (the 1985-89 year-classes) and the calibration constants at age for the surveys. The survivors in 1990 for the 1982, 1983, and 1984 year-classes (ages 6-8) were calculated by assuming that the fishing mortality rates on these year-classes during 1989 was equal to the "full F" on the 1985 and 1986 year-classes in 1989. Logarithmic transformation of the survey data was used to stabilize variance. Observations of zero were excluded from further consideration.

Each of the three survey indices was used separately and compared to a formulation which included all of them simultaneously (Table 18). Examination of the residuals from these analyses and comparison of the estimated populations did not indicate any shifts or trends in catchability or other systematic anomalies. Caution was warranted regarding the influence of the Canadian survey due to the shortness of that time series. As might be expected,the estimate of the 1989 year-class was variable since there was only one observation on the size of that year-class from each of the surveys.

The analysis suggested that the assumption of homogeneity of residuals was invalid despite the use of a logarithmic transformation. Generally, the youngest age group, 1, showed the greatest variation and the 4 plus age groupwas the least variable. As well, the two spring surveys had smaller residualsthan the fall survey. To rectify this problem a weighted analysis was employed. Weights for the observations in each age group within a survey were estimated by taking the inverse of the mean square residuals for that subgroup of observaHxons (Judge et. al. 1980) where mean square residuals were obtained as follows:

$$MSR = \left(\sum_{y} e_{say} \right) / n_{sa}$$

where s = index for survey

The value of n_{sa} represents the length of the time series used. These weights were scaled so that their sum was equal to the number of observations. Generally the degrees of freedom, the denominator, should be reduced to account for the estimation of parameters. For convenience this was not done here but since the MSR are scaled and their absolute value is of no importance, it would only impact on the inclusion of the Canadian survey where the length of the time series, n_{sa} varies substantially. The parameter estimates from weighted analyses with only the two USA surveys were comparable to results with all three surveys (Table 19). Further, the inclusion of an additional survey index improves the reliability of the estimates, therefore the results from the weighted analyses with the three surveys were used. Plots of the residuals from this analysis are presented in Fig. 6 and demonstrate an adequate fit.

Assessment Results

The analysis confirmed that the 1983, 1985, and 1987 year-classes, while not as big as the 1975 and 1978 year-classes, were considerably better than the intervening year-classes (Table 20, Fig. 7). There are indications that the 1989 year-class may also be comparable in size but further confirmation is needed before reliable predictions can be made. The adult population biomass has recovered somewhat from the extremely low values it had reached during the early 1970s and again in the mid 1980s (Fig. 8). The recent increase in population abundance has been supported by the recruitment of the 1983, 1985, and 1987 year-classes while the fishing mortality rate has remained relatively stable at about 0.3 (Table 21, Fig. 9). The early closure of the Canadian trawler fishery in 1989 resulted in a moderate reduction in the fishing mortality rate on older fish but was a major factor in conserving the 1987 year-class allowing it to realize some of its growth potential. Generally, the population is showing signs of recovery but production continues to be low compared to historical observations. Recruitment fluctuates widely and for the past 8 years appears to alternate between good and poor year-classes.

As noted earlier, the approximations invoked for population boundaries warrant examination with respect to the potential for excessive net migration. Examination of the fishing mortality rates in Table 21 do not reveal any anomalous trends with age as might be observed if there was considerable migration. The ratios of survey abundance estimates in unit areas 5Zj and 5Zm to those in Division 5Z by year-class from the spring and fall USA survey results provide further evidence of a lack of any consistent trends with age indicating net migration (Figs. 10 and 11). There does appear to be a tendency for the ratios to be somewhat higher in spring, suggesting a net seasonal migration, but the results are not consistent. We are unable to determine if there is a pronounced differential exploitation rate over Georges Bank which might complicate the interpretation of these observations. The available evidence therefore, does not invalidate the analysis of the assessment for unit areas 5Zj and 5Zm.

Though there are no consistent increasing or decreasing trends by age in Figs. 10 and 11 there is a notable increase in both the spring and fall results of the ratio for the recent year-classes. This suggests the hypothesis that the population component on western Georges Bank is not contributing to the production of haddock to the extent which may have occurred during the 1960s and 1970s.

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Table 1. Nominal catches (t) of haddock from NAFO Division 5Z from 1969-89. USSR, Spain and others data were obtained from ICNAF/NAFO, USA data from NMFS and Canadian landings from DFO.

Year	USA	Canada	USSR	Spain	Others	Total
1969	16450	3990	66	1206	470	22182
1970	8402	1978	103	782	7	11272
1971	7302	1630	374	1310	242	10858
1972	3877	609	137	1098	20	5741
1973	2785	1563	602	386	3	5339
1974	2405	462	109	764	559	6199*
1975	3969	1358	8	61	4	5400
1976	2893	1361	4	46	9	4313
1977	7902	2909	0	0	0	20499*
1978	12100	10179	0	0	0	26221*
1979	14219	5182	0	0	0	14901
1980	17380	10101	0	0	0	50994*
1981	19129	5659	0	0	3	24788
1982	12576	4931	0	0	0	17507
1983	8668	3212	0	0	0	11880
1984	8801	1463	0	0	0	10264
1985	4267	3485	0	0	0	7752
1986	3324	3415	0	0	0	6739
1987	2154	4703	0	0	0	6857
1988	2491	4046**	0	0	0	6537
1989	1435	3059	0	0	0	4494

* Values include discards of 1900, 9686, 3942, and 23510 for 1974, 1977, 1978, and 1980 respectively.

** 1895 T excluded because of suspected misreporting.

Table 2. Nominal catches (t) of haddock from unit areas 5Zj and 5Zm from 1969-89. For "others" it was assumed that 40% of the 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	19094*
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

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

** 1895 T excluded because of suspected misreporting.

Table 3. Monthly catch (t) of haddock by Canada in unit areas 5Zj and 5Zm for 1969-1989.

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

* Catches of 3, 1846 and 46 T 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. Canadian catch (t) of haddock in unit areas 5Zj and 5Zm by gear and otter trawl tonnage class 2 to 5 from 1969 to 1989.

	OTTER TRAWL SIDE				OTTER TRAWL STERN					LL	MISC	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

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

Table 5. Monthly catch (t) of haddock by USA in unit areas 5Zj and 5Zm for 1969-1989.

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

Table 6. USA catch (t) of haddock in unit areas 5Zj and 5Zm by gear category and otter trawl class for 1969 to 1989.

Year	Otter Trawl			LL	Misc.	Total
	Class 3	Class 4	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

Table 7. Summary of treatment of Canadian landings from unit areas 5Zj and 5Zm for 1969 to 1989 to obtain age composition of catch (lf = length frequency, alk = age-length key, LL = longline, OT = otter trawl). For example, "CAN-lfxUS-alk" means Canadian length frequency applied to USA age-length key.

Year	GEAR	Months J	F	M	A	M	J	J	A	S	O	N	D	
1969		US-lfxUS-alk			US-lfxUS-alk			US-lfxUS-alk			US-lfxUS-alk			(1)
1970		US-lfxUS-alk			US-lfxUS-alk			US-lfxUS-alk			US-lfxUS-alk			(1)
1971		US-lfxUS-alk			US-lfxUS-alk			US-lfxUS-alk			US-lfxUS-alk			(1)
1972		US-lfxUS-alk			US-lfxUS-alk			US-lf x US-alk						(1)
1973		US-lfxUS-alk			US-lfxUS-alk			US-lf x US-alk						(1)
1974		US-lfxUS-alk			US-lfxUS-alk			CAN-lf x US-alk						(2)
1975		US-lfxUS-alk			US-lfxUS-alk			CAN-lf x US-alk (3)						(2)
1976		CAN-lf x US-alk (3)						CAN-lf x US-Q2-alk (3)						(2,4)
1977		CAN-lfxUS-alk						CAN-lf x US-alk						(2)
1978		CAN-lf x US-alk						CAN-lf x US-alk (3)						(2)
1979		CAN-lfxUS-alk			CAN-lfxUS-alk			CAN-lf x US-alk						(2)
1980		CAN-lfxUS-alk			CAN-lfxUS-alk		(3)	CAN-lf x US-alk (3)						(2)
1981		CAN-lfxUS-alk			CAN-lfxUS-alk			CAN-lf x US-alk						(2)
1982		CAN-lf x US-alk						CAN-lfxUS-alk(3	CAN-lfxUS-alk(3					(2)
1983		CAN-lf x US-alk (3)						CAN-lf x US-alk (3)						(2)
1984	OT	US-lfxUS-alk			US-lfxUS-alk			US-lf x US-alk						(5)
	LL					CAN-lf x CAN-alk								
1985	OT		CAN-lf x CAN-alk					CAN-lf x CAN-alk						(5)
	LL					CAN-lf x CAN-alk								
1986	OT		CAN-lf x CAN-alk					CAN-lf x CAN-alk						(5)
	LL					CAN-lf x CAN-alk								
1987	OT		CAN-lf x CAN-alk					CAN-lf x CAN-alk						(5)
	LL					CAN-lf x CAN-alk								
1988	OT		CAN-lf x CAN-alk					CAN-lf x CAN-alk						(5)
	LL					CAN-lf x CAN-alk								
1989	OT	CAN-lfxCAN-alk|CAN-lfxCAN-alk						CAN-lf x CAN-alk						(5)
	LL		CAN-lf x CAN-alk					CAN-lf x CAN-alk						

(1) Pooled gears for each grouping.
(2) Longline and miscellaneous landings added in last.
(3) Modified age-length keys to accommodate smaller Canadian size range.
(4) No samples taken in second half of year.
(5) Miscellaneous landings added in last.

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

Year	Age Groups 1	2	3	4	5	6	7	8	9+	0-9+
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

Table 9. Average weight (kg) at age 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	3.288	3.237
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

Table 10. USA commercial catch (numbers 000's) by age of haddock from unit areas 5Zj and 5Zm.

Year	Age Groups 1	2	3	4	5	6	7	8	9+	0-9+
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	14	8	151	27	98	11	9	42	361

Table 11. Average weight (kg) at age 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	-	1.188	1.577	1.741	2.056	2.370	2.362	3.365

Table 12. Total(1) commercial catch (numbers 000's) by age of haddock from unit areas 5Zj and 5Zm.

Year	Age Groups 1	2	3	4	5	6	7	8
1969	0	19	1449	262	333	2881	816	88
1970	25	83	7	350	148	127	1140	366
1971	0	1219	261	32	249	163	166	748
1972	281	1	398	75	22	87	42	13
1973	1015	1728	7	360	37	10	37	8
1974	17	2080(2)	272	0	40	3	0	35
1975	0	184	1418	237	6	46	1	3
1976	67	148	175	818	121	0	16	0
1977	0	7623(2)	65	178	305	163	0	15
1978	1	289	9832(2)	160	169	299	81	10
1979	0	22	202	4403	325	182	195	39
1980	2	9519	351	305	2391	192	128	52
1981	0	661	6593	384	585	1220	121	31
1982	0	714	1048	2809	196	379	724	62
1983	0	205	582	512	1652	221	108	413
1984	0	79	252	348	256	1062	196	160
1985	0	2063	374	176	189	123	371	53
1986	6	38	2557	173	142	122	118	173
1987	0	1990	127	1515	96	56	82	68
1988	4	51	2145	121	877	109	36	46
1989	0	1146	76	774	91	300	24	16

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

Table 13. Average weight (kg) at age 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	-	0.865	1.463	1.780	2.167	2.528	2.591	3.199

Table 14. The mean number of haddock per tow showing imputed values, in parentheses, for those strata which had no sets in the 5Zj,m portion of Georges Bank during some years. For stratum 18, zero was used since haddock were not typically found there, while for strata 20 and 22, the mean number per tow for 5Z was used since densities were similar in other years.

	Spring survey			Fall survey			
	Stratum 18	Stratum 20		Stratum 20		Stratum 22	
	5Zj,m	5Zj,m	5Z	5Zj,m	5Z	5Zj,m	5Z
1968	3.33	8.00	2.17	1.00	4.67	12.50	9.50
1969	0	1.00	0.83	16.00	2.83	2.00	1.25
1970	0	(0.60)	0.60	0	0	10.00	11.25
1971	0.50	0	0	0	0	7.00	2.75
1972	0	0	1.83	0	0	1.00	3.00
1973	0	1.33	1.50	0	0	(7.25)	7.25
1974	0.33	0	1.00	(0)	0	4.00	5.00
1975	0	0	0.67	161.00	55.00	14.00	8.75
1976	0	(4.50)	4.50	(0)	0	5.00	3.67
1977	0	31.00	18.67	0	0.29	129.50	65.50
1978	0.33	0	47.00	3.67	50.93	18.40	14.10
1979	0	0	0.83	0.25	0.25	333.80	1246.38
1980	0.50	(32.83)	32.83	4.50	38.67	70.00	50.38
1981	(0)	77.67	43.17	0.67	0.22	40.50	32.80
1982	0.33	7.33	4.33	0.50	0.17	1.33	1.25
1983	0	5.00	2.50	0	0	7.00	3.50
1984	0	0.5	2.00	0	0	5.00	1.25
1985	1.50	0	1.00	0	0	2.00	1.75
1986	0	0	1.83	0	0	0.50	0.25
1987	0.33	54.67	27.50	3.00	0.50	16.67	12.50
1988	0	0	0	0	0	14.50	7.25
1989	12.00	0	0.17	3.00	1.00	16.33	13.25
1990	(0)	0	0				

Table 15. Total estimated abundance (numbers in 000's) at age 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+	1-9+
1986	5057	306	8175	997	189	348	305	425	401	16205
1987	46	4290	930	3448	653	81	375	133	1106	11062
1988	1081	49	11176	213	3643	232	207	112	578	17290
1989	47	6478	957	2787	233	481	38	32	238	11291
1990	844	113	12823	166	4177	277	1302	130	372	20204

Table 16. Total estimated abundance (numbers in 000's) at age 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.

	Age Group									
Year	1	2	3	4	5	6	7	8	9+	1-9+
1968	0	2184	45	456	3257	1373	161	83	157	7715
1969	12	23	412	158	351	2169	819	240	328	4513
1970	321	128	0	376	670	296	2127	1683	523	6123
1971	0	440	175	0	97	68	39	778	182	1778
1972	1741	0	517	88	17	32	142	18	815	3369
1973	1648	3785	0	692	103	0	185	0	810	7224
1974	888	13823	2741	0	238	0	29	48	216	17983
1975	355	381	4038	714	0	146	85	30	140	5888
1976	5556	270	291	825	391	0	0	0	26	7359
1977	93	17397	198	574	548	393	0	15	66	19282
1978	0	499	14000	430	591	781	60	16	78	16454
1979	7044	296	881	6553	319	48	299	28	6	15474
1980	2929	45611	757	750	3907	421	256	473	246	55350
1981	2942	2489	22667	2363	589	1955	274	47	18	33343
1982	478	3026	1349	6338	610	366	547	0	0	12714
1983	159	517	460	241	1739	20	0	536	39	3711
1984	917	950	669	672	628	836	92	60	315	5138
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	102	8128	754	1638	326	965	71	112	58	12154
1990	1895	240	11878	124	2220	122	457	44	86	17067

Table 17. Total estimated abundance (numbers in 000's) at age of haddock in unit areas 5Zj and 5Zm from the fall USA survey.

	Age Groups										
Year	0	1	2	3	4	5	6	7	8	9+	0-9+
1963	71450	33469	9931	3389	5088	4142	1544	402	58	125	129599
1964	790	77101	37410	4113	655	1634	337	188	96	16	122340
1965	174	1015	34578	5611	328	201	99	111	95	50	42263
1966	6258	504	1169	13640	2437	450	93	89	11	45	24696
1967	0	2683	49	220	1238	453	94	59	28	31	4854
1968	37	76	537	19	25	1492	367	119	30	180	2881
1969	257	0	0	349	43	20	505	308	22	55	1559
1970	0	4295	225	11	278	226	335	606	256	132	6365
1971	1762	0	529	65	0	178	18	49	275	124	3001
1972	3186	1608	0	155	0	0	36	0	0	185	5169
1973	902	11273	1078	0	121	1	0	11	2	77	13465
1974	102	157	645	113	0	4	0	0	0	47	1067
1975	20379	446	129	683	149	0	0	0	0	17	21803
1976	526	89008	306	17	325	48	0	12	0	25	90266
1977	38	195	21545	364	102	173	69	3	3	0	22491
1978	11984	448	433	6307	46	34	77	0	0	0	19330
1979	1288	17283	12	268	1196	36	10	0	0	0	20092
1980	2931	2306	4810	0	83	888	89	21	3	0	11130
1981	504	3779	2115	2252	86	112	243	0	0	12	9103
1982	42	0	449	309	1729	107	61	315	19	9	3038
1983	2422	298	217	292	190	266	13	6	53	0	3757
1984	30	2583	524	148	141	29	170	0	0	32	3658
1985	12148	381	1646	199	70	68	46	30	0	21	14611
1986	30	7471	109	961	52	50	72	24	5	18	8793
1987	508	4	839	28	152	38	22	0	0	0	1592
1988	122	3983	206	2326	155	400	142	140	0	38	7513
1989	204	101	3225	137	620	83	89	0	0	0	4459

Table 18. Population estimates (numbers 000's) at the begining of 1990 for haddock in unit areas 5Zj and 5Zm. Results are from calibrations using each of the surveys individually and all three surveys simultaneously.

Age	USA fall	USA spring	Canadian	All
1	1,760	18,402	8,777	6,087
2	550	815	463	548
3	7,545	10,646	12,623	9,162
4	34	417	230	152
5	2,557	2,375	5,218	2,680
6	276	297	581	301
7	908	979	1,914	993
8	74	79	155	80

Table 19. Comparison of approximate statistics assuming linearity near the solution, from the calibration of haddock in unit areas 5Zj and 5Zm with A) the USA spring, USA fall and Canadian spring surveys and B) only the USA spring and USA fall surveys. Both analyses weighted the observations based on mean square residuals within each age group in each survey.

		A		B	
		ORTHOGONALITY OFFSET... 0.002695		ORTHOGONALITY OFFSET... 0.01089	
		MEAN SQUARE RESIDUALS . 0.544598		MEAN SQUARE RESIDUALS . 0.62971	
		ESTIMATE	REL. ERROR	ESTIMATE	REL. ERROR
Survivors	1	7.76335E3	5.97704E-1	6.68811E3	7.83931E-1
	2	5.30521E2	3.83887E-1	7.41588E2	5.58560E-1
	3	1.21744E4	3.04033E-1	1.20892E4	4.79369E-1
	4	2.40192E2	3.94593E-1	2.23526E2	6.78902E-1
	5	3.28929E3	2.12142E-1	3.09637E3	2.42168E-1
k USA fall	1	9.81632E-2	3.09950E-1	9.81015E-2	3.07215E-1
	2	2.59817E-1	3.37501E-1	2.57360E-1	3.33312E-1
	3	1.91521E-1	2.66224E-1	1.93418E-1	2.63711E-1
	4+	1.69910E-1	1.16123E-1	1.71691E-1	1.16292E-1
k USA spr	1	1.09239E-1	2.84643E-1	1.09148E-1	2.87022E-1
	2	2.97421E-1	2.03724E-1	2.95029E-1	2.02991E-1
	3	4.00164E-1	2.09685E-1	4.04128E-1	2.09760E-1
	4+	4.49126E-1	9.43440E-2	4.53834E-1	9.51500E-2
k Canadian	1	1.00948E-1	3.60725E-1		
	2	2.26658E-1	2.82141E-1		
	3	1.19879E0	2.33982E-1		
	4+	7.71598E-1	1.91596E-1		

Table 20. Estimated population numbers (000's) at the beginning of the year for haddock in unit areas 5Zj and 5Zm.

Year	Age Group 1	2	3	4	5	6	7	8
1969	797	197	3640	878	924	8263	2754	253
1970	3642	653	144	1670	482	455	4158	1517
1971	256	2959	459	111	1051	260	258	2373
1972	5174	209	1320	140	62	635	65	60
1973	11131	3981	171	721	47	32	441	16
1974	2832	8194	1696	134	264	5	17	328
1975	3326	2303	4827	1142	110	180	2	14
1976	53161	2723	1719	2669	720	84	106	0
1977	6325	43464	2096	1249	1444	480	69	72
1978	4246	5179	28688	1657	862	906	246	56
1979	40788	3475	3979	14592	1212	552	472	129
1980	6130	33394	2826	3074	7963	698	287	210
1981	4478	5017	18728	1996	2242	4356	398	119
1982	2106	3666	3509	9368	1287	1306	2462	216
1983	2133	1724	2355	1925	5128	876	726	1361
1984	17221	1746	1226	1401	1113	2704	517	497
1985	1748	14100	1358	776	833	680	1253	246
1986	15110	1431	9677	773	476	511	445	690
1987	632	12366	1138	5609	476	261	307	258
1988	19713	517	8323	817	3222	303	164	178
1989	648	16136	377	4873	560	1844	149	101
1990	7763	531	12174	240	3289	376	1238	100

Table 21. Estimated fishing mortality rate for haddock in unit areas 5Zj and 5Zm.B

Year	Age Group 1	2	3	4	5	6	7	8
1969		0.11	0.58	0.40	0.51	0.49	0.40	0.49
1970	0.01		0.06	0.26	0.42	0.37	0.36	0.31
1971		0.61		0.38	0.30	1.18	1.25	0.43
1972	0.06		0.40		0.48	0.16	1.24	0.28
1973	0.11	0.65		0.80		0.42	0.10	0.85
1974	0.01	0.33	0.20		0.18		0.00	0.13
1975	0.00	0.09	0.39	0.26		0.33		0.25
1976	0.00	0.06	0.12	0.41	0.21		0.19	
1977	0.00	0.22	0.03	0.17	0.27	0.47		0.26
1978	0.00	0.06	0.48	0.11	0.24	0.45	0.45	
1979	0.00	0.01	0.06	0.41	0.35	0.45	0.61	0.41
1980	0.00	0.38	0.15	0.12	0.40	0.36	0.68	0.32
1981	0.00	0.16	0.49	0.24	0.34	0.37	0.41	0.33
1982	0.00	0.24	0.40	0.40	0.18	0.39	0.39	0.38
1983	0.00	0.14	0.32	0.35	0.44	0.33	0.18	0.41
1984	0.00	0.05	0.26	0.32	0.29	0.57	0.54	0.44
1985	0.00	0.18	0.36	0.29	0.29	0.22	0.40	0.27
1986	0.00	0.03	0.35	0.28	0.40	0.31	0.35	0.32
1987	0.00	0.20	0.13	0.35	0.25	0.27	0.35	0.35
1988	0.00	0.11	0.34	0.18	0.36	0.51	0.28	0.33
1989	0.00	0.08	0.25	0.19	0.20	0.20	0.20	0.20

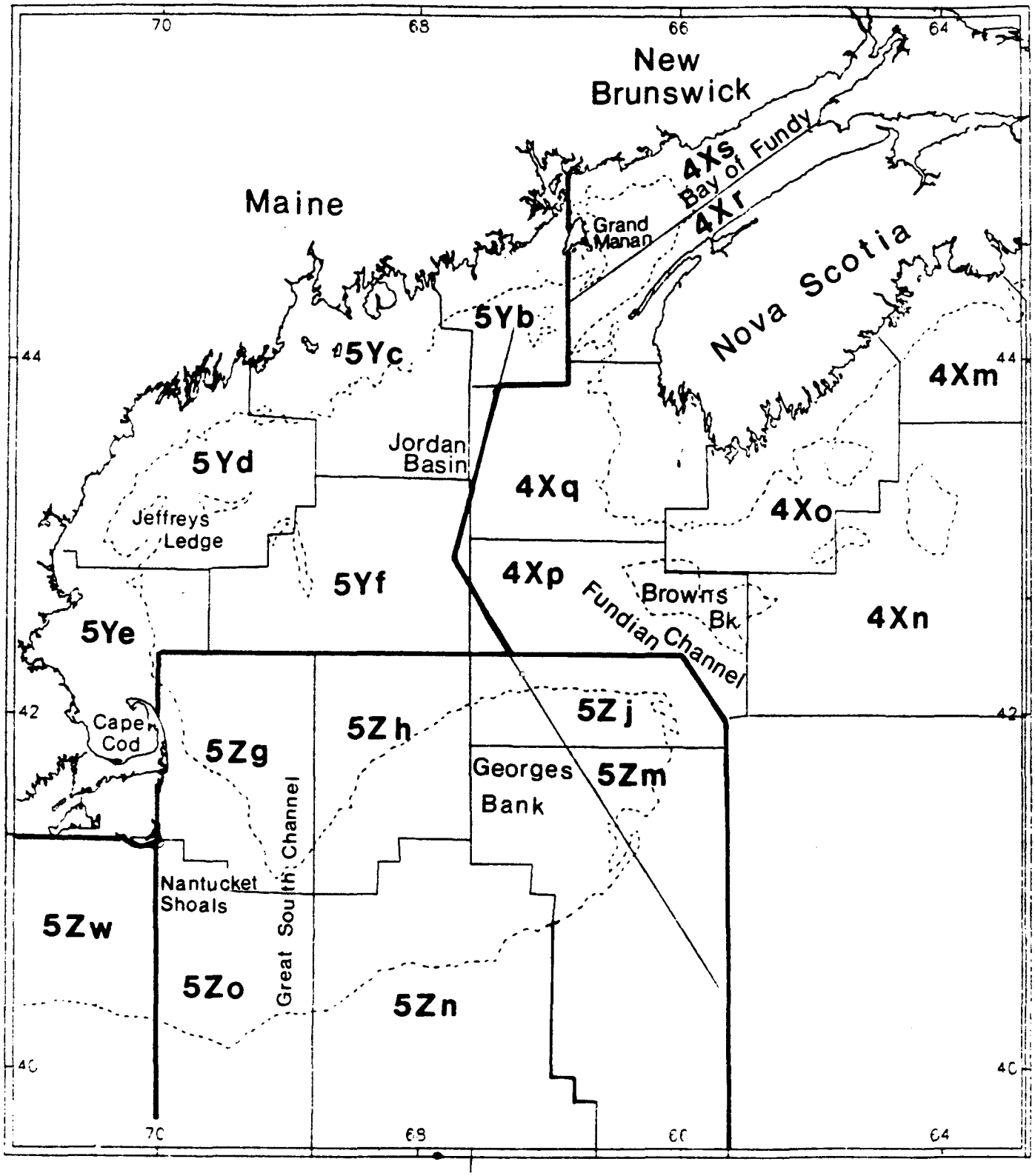

Fig. 1. Map of the Gulf of Maine area showing unit areas.

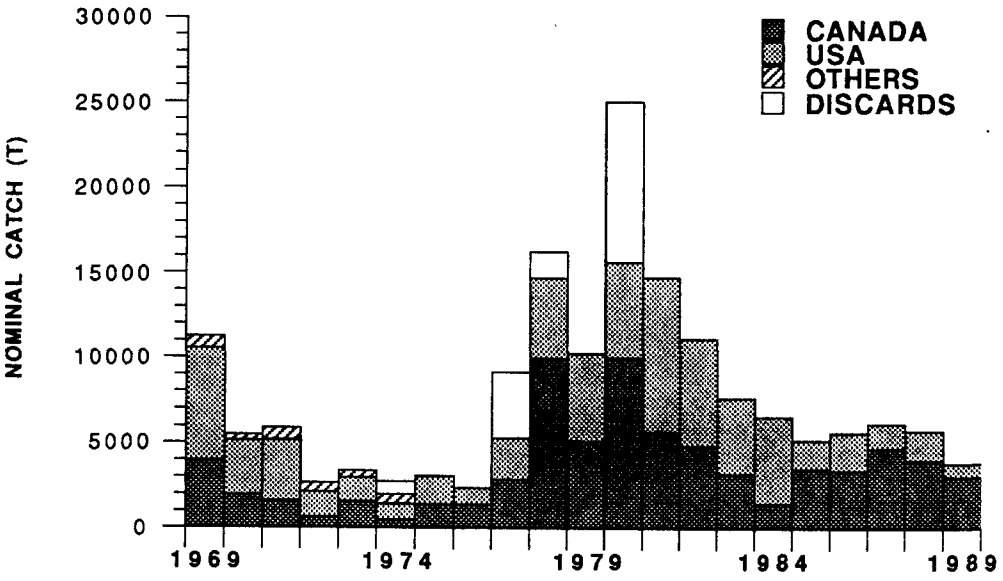

Fig. 2. Nominal catch of haddock in unit areas 5Zj and 5Zm.

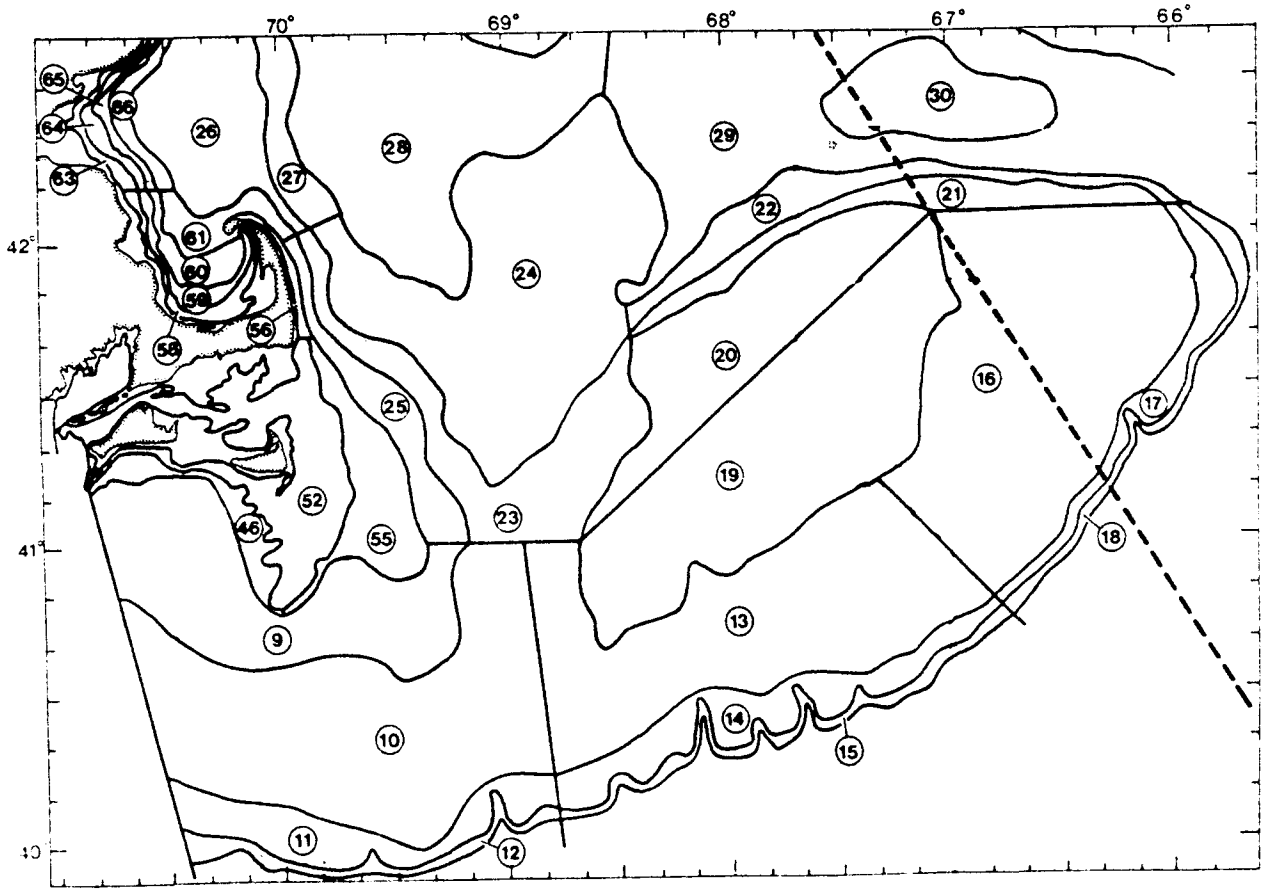

Fig. 3. Stratification scheme used for USA surveys.

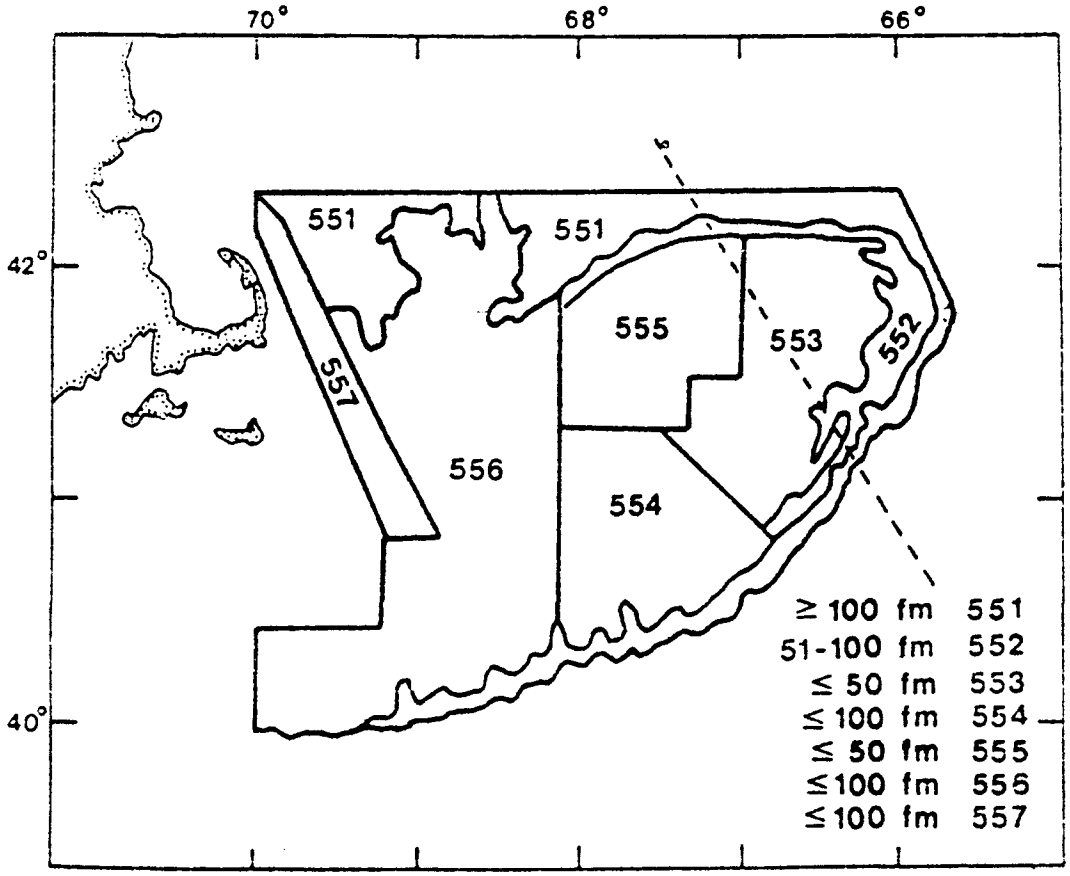

Fig. 4. Stratification scheme used for 1986 spring survey.

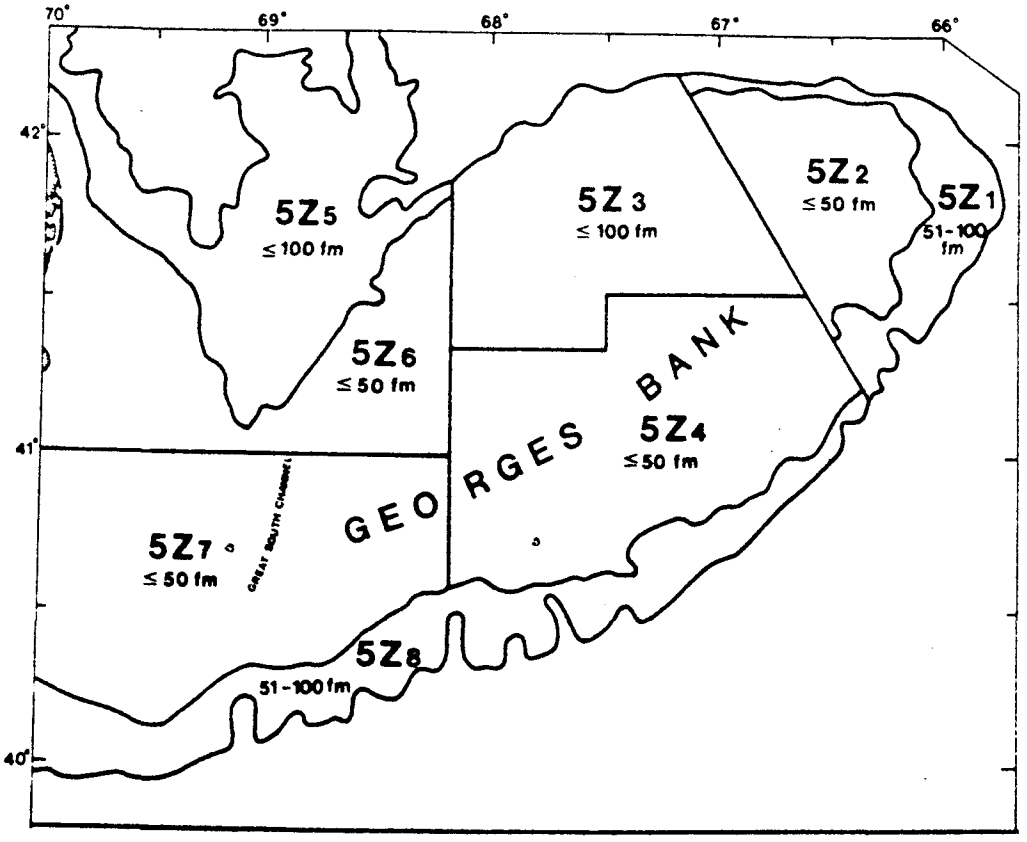

Fig. 5. Stratification scheme used for Canadian spring surveys since 1987.

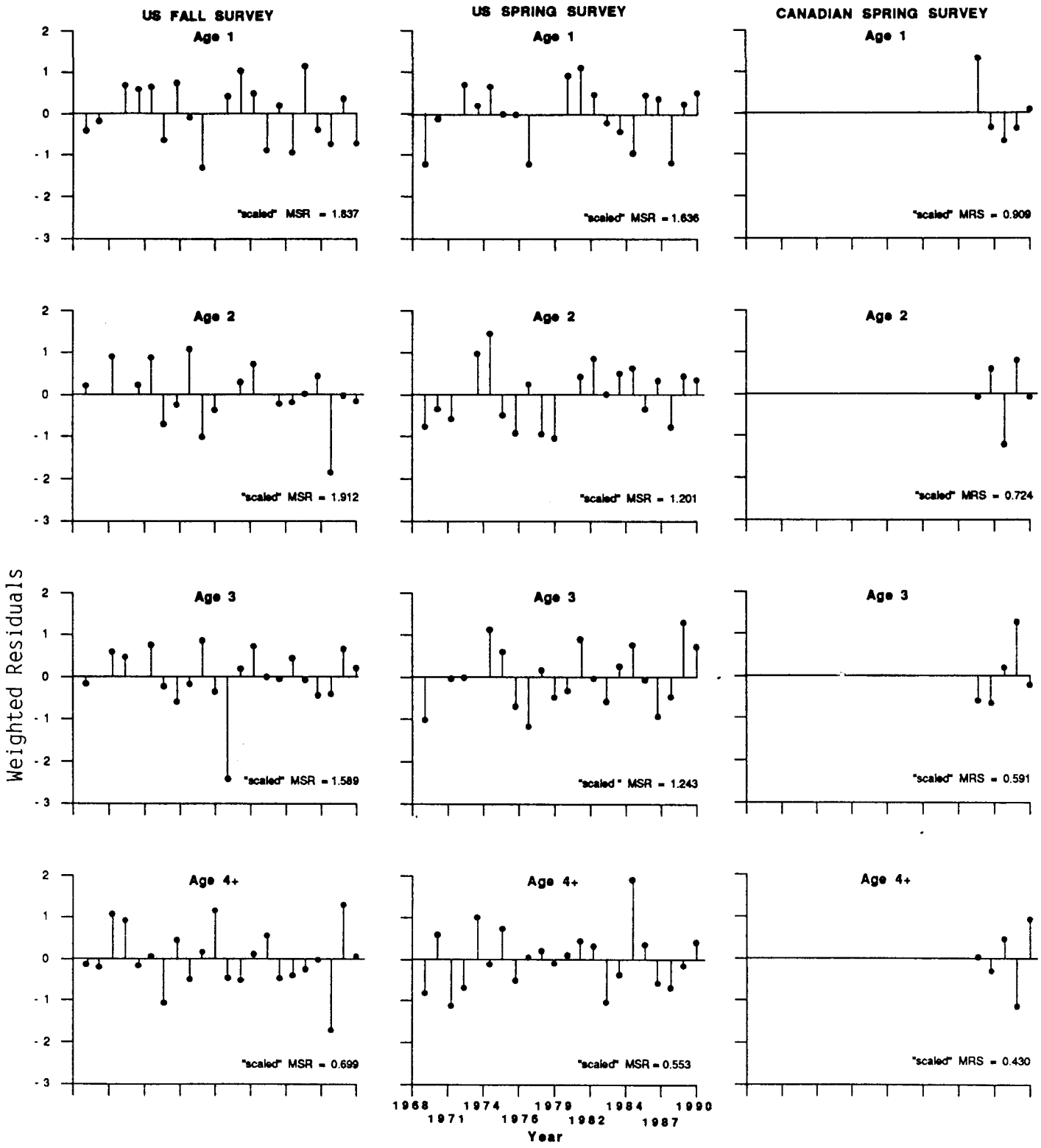

Fig. 6. Weighted residuals from the calibration of the sequential population analysis for haddock in unit areas 5Zj and 5Zm are plotted by age group for each survey. The results do not display any problematic patterns although within each year for any given survey there is a tendency for residuals to be predominantly positive or predominantly negative. The "scaled" MSR for each series is inversely proportional to the weight that series was given.

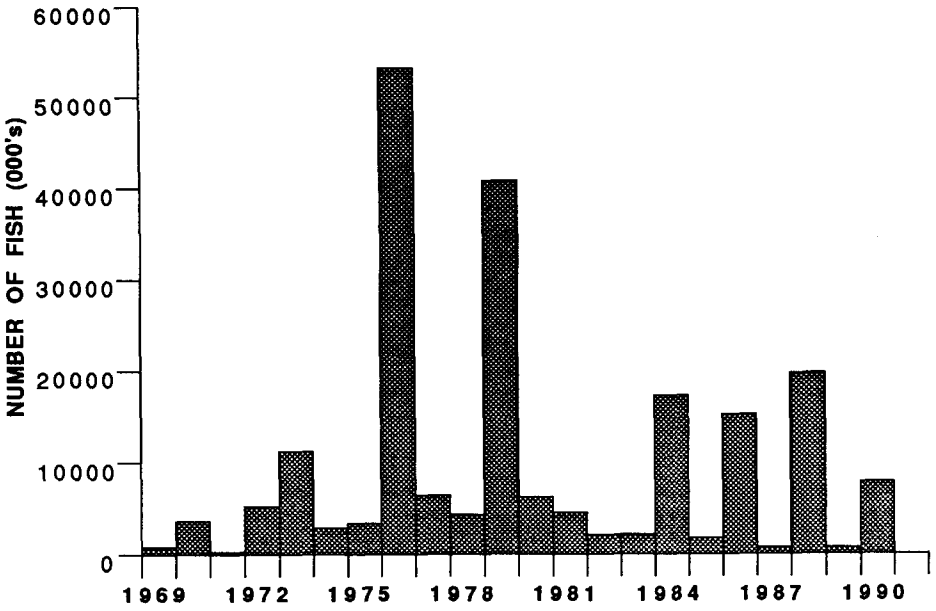

Fig. 7. Recruitment for haddock (age 1) in unit areas 5Zj and 5Zm.

Fig. 8. Biomass of adult (ages 3+) haddock in unit areas 5Zj and 5Zm.

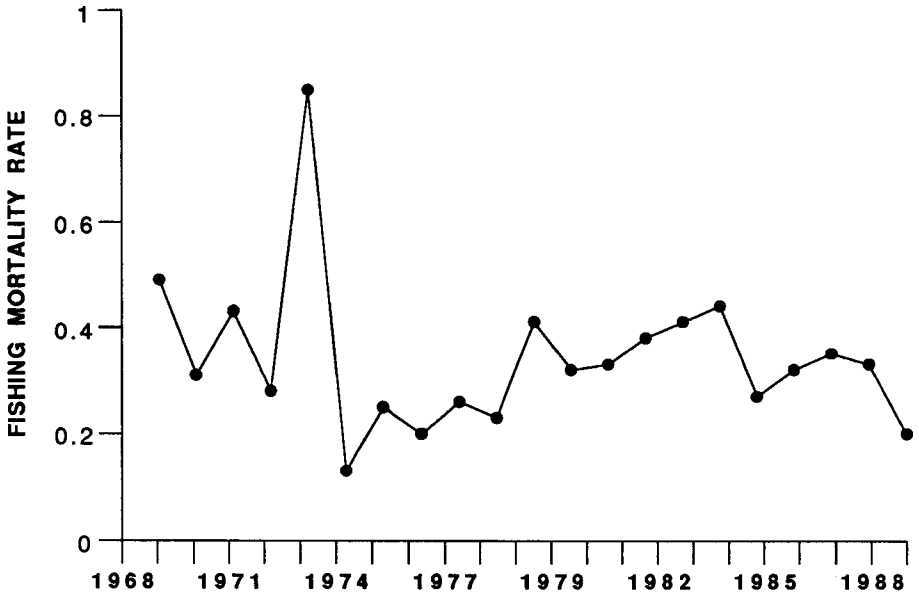

Fig. 9. Fishing mortality rate (ages 3+) for haddock in unit areas 5Zj and 5Zm.

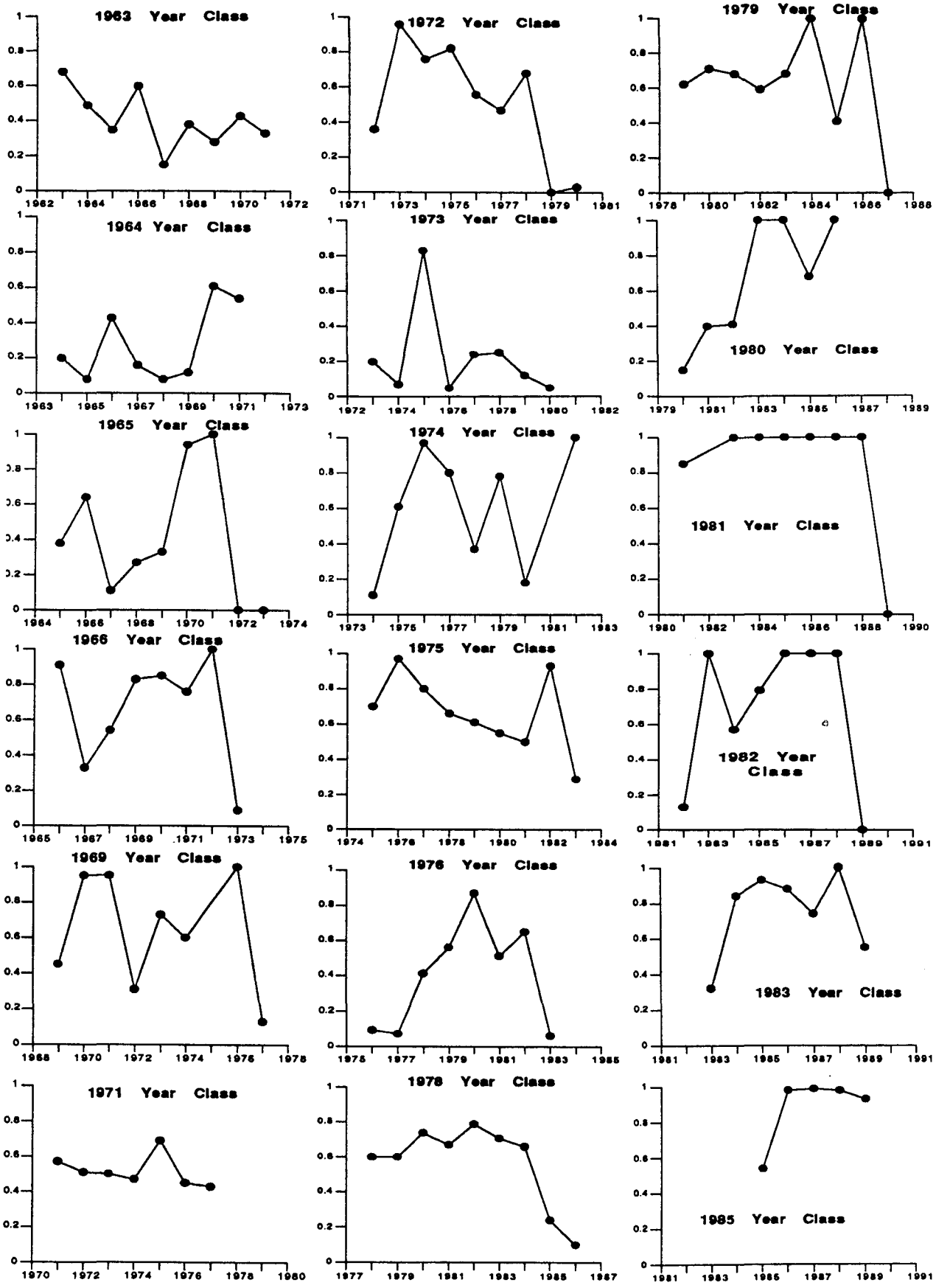

Fig. 10. Ratios of survey abundance estimates in unit areas 5Zj and 5Zm to those in Division 5Z by year-class from the US fall surveys. The poor year-classes of 1967, 1968, 1970, 1977 and 1984 are excluded.

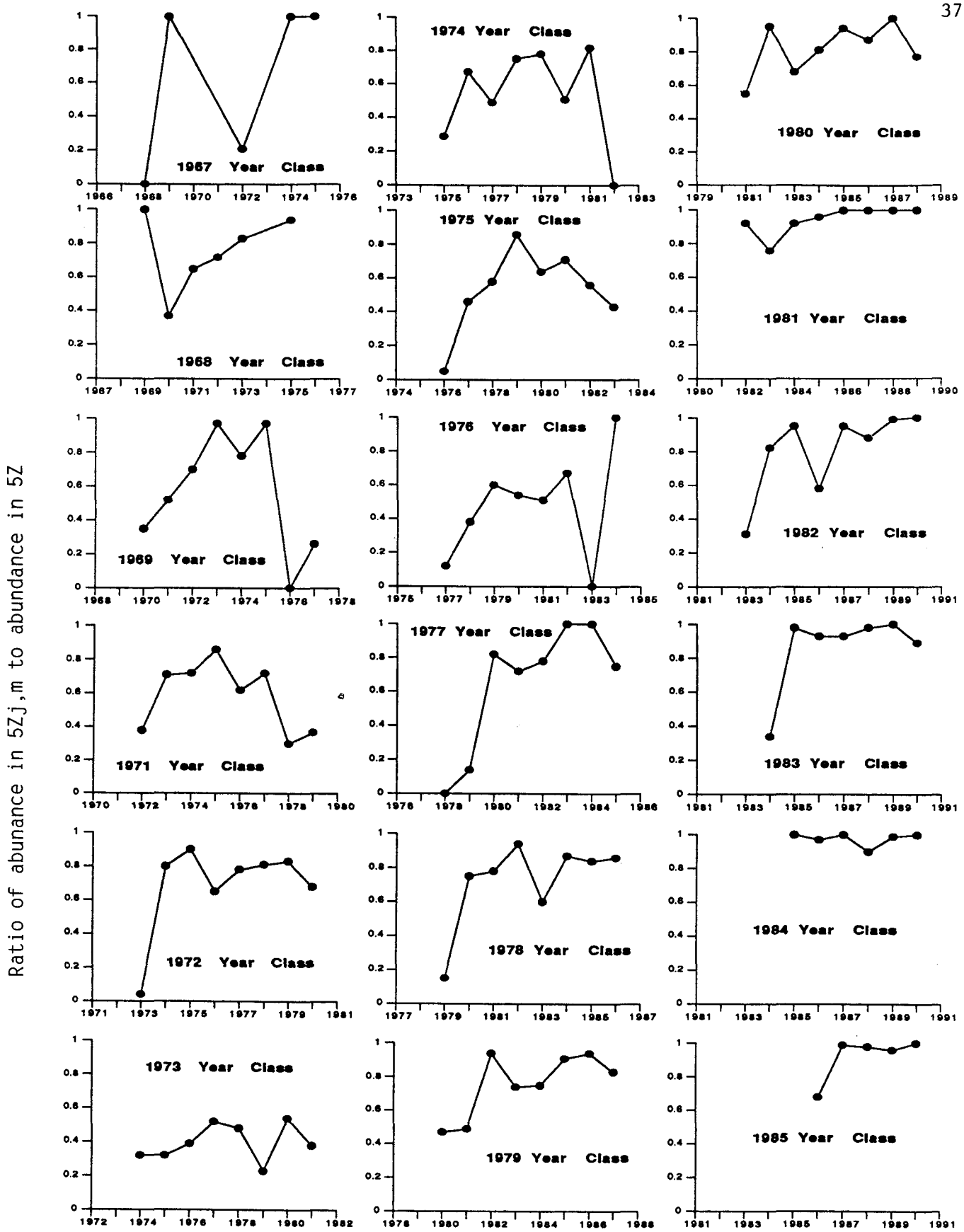

Fig. 11. Ratios of survey abundance estimates in unit areas 5Zj and 5Zm to those in Division 5Z by year-class from the US spring surveys. The 1970 year-class is excluded.