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Assessment of Haddock on Eastern Georges Bank

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Abstract

Haddock catches from eastern Georges Bank fluctuated around 5,000 t from 1985 to 1990. Under restrictive management measures, catches declined from over 6,400 t in 1991 to a low of about 2,100 t in 1995 and have since fluctuated between about 3,000 t and 4,000 t.

Total population biomass has steadily increased from near historic low levels of about 13,000 t in 1993 to about 50,000 t at the beginning of 2000 but remains below the average biomass during 1930-55 when productivity was higher. The recent increase is due principally to improved recruitment in the 1990's which produced the three strongest year-classes since 1978. The exploitation rate for fully recruited ages 4-8 has consistently been below the $F_{0.1}$ reference since 1995. Reduced fishing mortality and avoidance of small fish in the fisheries in recent years has resulted in increased survival of incoming year-classes and greater abundance at older ages.

Projected total Canada/USA yield at $F_{0.1} = 0.25$ in 2000 would be about 8,800 t and results in a probability of less than 30% for not achieving 20% biomass increase between 2000 and 2001. If fished at that rate in 2000, the adult biomass is projected to increase from 36,000 t to 46,000 t by the beginning of 2001. The population age structure shows good representation at all ages and a broad age range is expected to contribute to the 2000 catch.

Résumé

Les captures d'aiglefin de la partie est du banc Georges ont oscillé aux environs de 5 000 t de 1985 à 1990. L'imposition de mesures de gestion strictes a donné lieu à une baisse des captures qui sont passées de plus de 6 400 t en 1991 à 2 100 t environ en 1995, après quoi elles ont fluctué entre 3 000 t et 4 000 t environ.

La biomasse totale de la population s'est accrue de façon constante pour passer d'un minimum presque historique de 13 000 t environ en 1993 à 50 000 t environ au début de l'an 2000. Elle s'est ensuite maintenue, mais à une valeur en deçà de la moyenne de la période 1930-1955 où la productivité était supérieure. L'augmentation récente s'explique surtout par un meilleur recrutement au cours des années 1990 qui a donné lieu à l'apparition des trois meilleures classes d'âges depuis 1978. Le taux d'exploitation des groupes d'âges 4 à 8 pleinement recrutés a constamment été inférieur à la valeur cible du $F_{0.1}$ depuis 1995. Une mortalité par pêche réduite et la protection des poissons de petite taille au cours de la pêche des dernières années se sont traduites par un accroissement de la survie des classes d'âges à venir et une plus grande abondance des classes plus âgées.

Le rendement total prévu Canada/États-Unis au niveau $F_{0.1} = 0{,}25$ en 2000 est de 8 800 t environ et correspond à une probabilité de moins de 30 % de ne pas obtenir une augmentation de la biomasse de 20 % entre 2000 et 2001. Une pêche à ce niveau en 2000 devrait donner lieu à une augmentation de la biomasse des adultes qui passerait de 36 000 t à 46 000 t au début de 2001. La structure des âges de la population indique une bonne représentation de tous les groupes et on prévoit qu'une gamme d'âges étendue contribuera aux captures de l'an 2000.

Introduction

Since 1990, Canada has used eastern Georges Bank, fishery statistical unit areas 5Zej and 5Zem (Figure 1), as the basis for a management unit (Gavaris 1989), referred to as 5Zjm for brevity. In this assessment update, we included the latest information from the 1999 Canadian and USA fisheries. Results from the Department of Fisheries and Oceans, Canada (DFO) survey in the spring of 2000 and the National Marine Fisheries Service, USA (NMFS) surveys in the spring and fall of 1999 were incorporated. Methods similar to those used in the last assessment were applied to the updated information with a minor difference in that an age 9+ group was included in population calculations.

The Fishery

Commercial Catches

The haddock on Georges Bank have supported a commercial fishery since the early 1920s (Clark et al 1982). For details on the historical aspects of the Georges Bank haddock fishery see Gavaris and Van Eeckhaute (1998).

Under restrictive management measures, combined Canada/USA catches declined from over 6,400 t in 1991 to a low of about 2,100 t in 1995 and have since fluctuated between about 3,000 t and 4,000 t (Table 1, Figure 2). Greater catches in the late 1970s and early 1980s, ranging up to about 23,000 t, were associated with good recruitment. Substantial quantities of small fish were discarded in those years (Overholtz et al 1983). Catches subsequently declined and fluctuated about 5,000 t during the mid to late 1980s.

Total catches during the 1930s to 1950s ranged between 15,000 t and 40,000 t (Figure 3), averaging about 25,000 t (Schuck 1951, R. Brown pers. com.). Records of catches by unit area for the early 1960s period have not been located, however based on records for Subdivision 5Ze, catches probably attained record high levels of about 60,000 t during the early 1960s. Since the early 1970s catches have been substantially lower, generally fluctuating between 5,000 t and 10,000 t.

As in 1995 to 1998, Canadian catches in 1999 of 3,680 t were below the quota due to closure of the fisheries when the cod quotas were reached. During 1994 to 1999, all Canadian groundfish fisheries on Georges Bank remained closed from January to early June to protect spawning concentrations.

Weight of all 1999 Canadian landings were monitored at dockside and at-sea monitoring by observers accounted for about 10% of the cod and haddock catch. Comparison of observer samples with port samples did not reveal any persistent patterns to indicate that discarding or highgrading occurred commonly. Discarding and misreporting have been considered negligible since 1992.

In recent years, the Canadian fishery has been conducted by vessels using otter trawls, longlines, handlines and gillnets. During 1999, all vessels over 65 ft operated on enterprise

allocations, otter trawlers under 65 ft and fixed gear vessels 45-65 ft operated on individual quotas while fixed gear vessels under 45 ft operated on community quotas administered by local boards (Table 2). Most haddock were caught by otter trawlers and longliners in tonnage classes 1 and 2 (Table 3), approximately 35-65 ft. Total catch was greatest during June and July in 1999 (Table 4), while catches by otter trawlers peaked in June and catches by longliners peaked in August (Figure 5).

Fishery Sector	1995		1996		1997		1998		1999	
	Quota	Catch	Quota	Catch	Quota	Catch	Quota	Catch	Quota	Catch
Fixed gear <65’	592	357	1085	919	754	714	915	856	928	902
Mobile gear <65'	1268	1175	2280	1713	1625	1451	1984	1997	1972	1964
Fixed gear 65'-100'	25	0	45	49	32	36	39	39	39	8
Mobile gear 65'-100'	25	27	189	181	32	35	94	93	188	186
Vessels >100'	590	444	921	513	757	573	868	386	773	590
Totals	2500	2003	4500	3375	3200	2809	3900	3371	3900	3650

Source: Quota reports (will not match statistics exactly)

USA catches for 1999 were derived from logbooks coupled with dealer reports, as was done for 1994-98. Effort in the USA fishery was regulated using closed areas and Days-at-Sea limits (Table 2). To curtail targeting of haddock, a 500 lb trip limit was introduced in 1994 and raised to 1,000 lb in July 1996. The trip limit resulted in an increase in the discard rate. The trip limit has been adjusted periodically and in 1999 it was established at 3,000 lb/day, maximum of 30,000 lb/trip during January through April, 2,000 lb/day, maximum of 20,000 lbs/trip during May through October and 5,000 lb/day, maximum of 50,000 lbs/trip during November and December. The combination of area closures, effort restrictions, and trip limits has precluded most operators from making long trips to 5Zjm, with the result that USA catches from 5Zjm have been low since 1993. While Area II remained closed in 1999, landings from 5Zjm which come exclusively from tonnage classes 3 and 4 otter trawlers (Table 5), increased to 355 t and discards declined because the day and trip possession limits were increased. Catches by month were not available for recent years (Table 6).

Size and Age Composition

Comparison of length frequencies by quarter and gear collected at ports to those collected at sea did not reveal any persistent differences (Figure 4). The size and age composition of the 1999 Canadian fishery was characterised by port and at sea samples from all principle gears and all seasons (Table 7, Figure 5). The size composition of the catch peaked at 53 cm (21 in) for both otter trawlers and longliners (Figure 6). Gill-netters caught few haddock but they were larger. No sampling was available for discards of groundfish by-catch in the Canadian scallop fishery, though in previous years the amount caught has not been large.

Available port samples were inadequate to characterise the size and age composition of the USA fishery catch from eastern Georges Bank. Length composition from the USA fishery in the Great South Channel area were used with Canadian fishery and DFO survey age-length keys from eastern Georges Bank to derive the catch at age.

Survey and commercial otoliths were read by L. Van Eeckhaute for DFO and by N. Munroe for NMFS. Intra-reader agreement tests were available for the DFO reader and indicate that DFO age interpretations are consistent. Results of between reader comparisons raised some concerns of a small degree of bias which is being investigated, however these are not considered substantial enough to seriously compromise analyses (Appendix A).

The updated 1997 catch at age by quarter reported by Gavaris and Van Eeckhaute (1999) was erroneous. The correct 1997 catch at age along with the 1998 catch at age and the new 1999 catch at age by quarter for Canada and the USA (Table 8) were used to augment the 1969-96 results (Gavaris and Van Eeckhaute, 1997). Combined Canada/USA annual catch at age and average fishery weights at age are summarized in Tables 9 and 10 and Figure 7. In comparison to the average age composition of the catch during various earlier periods in this century, some of the older age groups were present at higher porportions in the 1999 catch (Figure 8). The 1996 year-class (age 3) dominated the 1999 catch, even though this age group is not fully recruited to the fishery. In contrast to pre-1994, few age 2 haddock were caught in 1999, due in part to the type of gear used and to avoidance of areas with small fish.

Abundance Indices

Commercial Catch Rates

Catch rates from the Canadian commercial fishery for selected trips (only those vessels which reported more than 1 t from 5Zjm during 1994 where cod, haddock and pollock comprised over 90% of the total catch) by tonnage class 2 and 3 otter trawlers and longliners increased from 1993 to 1995, remained relatively stable but variable from 1996 through 1998 and increased substantially in 1999 (Figure 9). Changes to regulations, gear modifications and varying fishing practices in recent years make comparison of catch rates from year to year difficult to interpret. Therefore, these were not used as indices of abundance.

Research Surveys

Surveys of Georges Bank have been conducted NMFS each fall since 1963 and each spring since 1968, and by DFO each spring since 1986. All these surveys use a stratified random design (Figures 10 and 11). For the NMFS surveys, two vessels have been employed and there was a change in the trawl door in 1985. Conversion factors (Table 11), derived experimentally from comparative fishing, have been applied to the survey results to make the series consistent. Additionally, two trawl nets were used on the NMFS spring survey, a modified Yankee 41 during 1973-81 and a Yankee 36 in other years, but no conversion factors are available for haddock.

The spatial distribution of catches for the most recent surveys of each series was similar to the distribution over the previous 5 year period. (Figures 12, 13 and 14). In spring, adults are more abundant in unit area 5Zej but age 1 fish are distributed broadly over unit areas 5Zej and 5Zem. In fall, adult haddock are more concentrated in the deeper waters along the

slopes of the Northeast Peak and the Northeast Edge, however, age 1 fish remain somewhat more widespread.

The percent of biomass, ages 3-8, on the Canadian side of 5Zjm from the three surveys was summarised for recent years (for method see Van Eeckhaute, et al 1999). During the NMFS fall surveys, almost all of the biomass occurred on the Canadian side. During the DFO spring surveys, generally conducted in late February, most of the biomass was on the Canadian side although the percentage was lower in 1992-93 and 2000. During the NMFS spring surveys, generally conducted in late March, the percentage on the Canadian side was typically lower but these results were more variable.

Percentage of biomass on Canadian side

	Feb.-Mar.	Mar.-Apr.	Oct.-Nov.
Year	DFO	NMFS	NMFS
1992	66	78	100
1993	67	42	99
1994	99	100	100
1995	98	59	100
1996	95	17	100
1997	90	91	100
1998	100	68	100
1999	98	41	100
2000	78	N/A	N/A

Age specific abundance patterns from the three surveys track year-class strengths fairly well (Tables 12, 13 and 14; Figure 15). Some year affects are evident as well, for example, the low spring catches observed for both the 1997 DFO and NMFS surveys. The index for ages 3-8 survey biomass peaked at record highs during the early 1960s. After declining to a record low in the early 1970s, it peaked again in the late 1970s, though at a lower level, and again during the mid to late 1980s at about half the level of the 1970s peak. Biomass increased from 1992 to 1996, fluctuated somewhat and increased again after 1998 (Figure 16).

Survey recruitment indices for ages 0, 1 and 2 indicate that the abundance of the 1996 year-class was comparable to the moderate 1983, 1985, 1987 and 1992 year-classes (Figure 17). These year-classes were considerably smaller than the strong 1975 and 1978 year-classes and the very strong 1962 and exceptional 1963 year-classes. The 1997 year-class is weaker but the 1998 year-class may be moderate to strong. First indications for the 1999 year-class suggest that it may also be moderate.

There were no persistent trends in weight at age derived from the DFO survey. Average weight at age of haddock from the 1989 to 1991 year-classes were higher than adjacent

year-classes in both the surveys (Figure 18) and the commercial fisheries (Figure 19), giving the false impression of a declining trend in recent years. The method of calculation of the weights at age from the DFO spring survey were given in Gavaris and Van Eeckhaute (1998) and were derived from actual weights observed during the survey and weighted by population numbers at length and age (Table 15). Fishery weights at age (Table 10; Figure 19) are derived from a length-weight relationship (Waiwood and Neilson 1985). In some cases, the mean weight at age in the catch is larger than the population mean weight at age at the beginning of the following year for the same cohort. This effect was investigated by an analysis of lengths at age from survey and fishery data and found to be mostly attributable to bottom trawl gear changes which resulted in a change in partial recruitment since 1994. However, some discrepancies in weights at age were more persistent and may be due to problems associated with the length weight equations and gutted to round weight conversion factors. Further investigation is warranted (Appendix B).

Estimation of Stock Parameters

Calibration of Virtual Population Analysis (VPA)

The adaptive framework, ADAPT, (Gavaris 1988) was used to calibrate the virtual population analysis with the research survey abundance information. An investigation of model formulations and model assumptions was conducted by Gavaris and Van Eeckhaute (1998) where details of model equations and the objective function are provided. The model formulation adopted assumed that the random error in the catch at age was negligible. The errors in the abundance indices were assumed independent and identically distributed after taking natural logarithms of the values. The annual natural mortality rate, M, was assumed constant and equal to 0.2. Similar model assumptions and methods were applied to the updated information here. Minor differences in the handling of zero terminal catches for a year-class were implemented as a refinement to the software to afford more flexibility. The population abundance for the 9+ age group was calculated but not calibrated to the indices. In the first quarter of the first year, the 9+ abundance calculation was based on the assumption that the fishing mortality for the 9+ age group was equal to the population weighted fishing mortality for ages 4 - 7. In the first quarter of subsequent years, the 9+ abundance was calculated as the sum of the age 8 and age group 9+ abundances at the end of the last quarter of the previous year.

The VPA used quarterly catch at age, $C_{a,t}$, for ages a = 0, 1, 2…8, 9+, and time t = 1969.0, 1969.25, 1969.5, 1969.75, 1970.0…1999.75, where t represents the beginning of the time interval during which the catch was taken. The VPA was calibrated to bottom trawl survey abundance indices, $I_{s,a,t}$, for

s = DFO spring, ages a = 1, 2, 3…8, time t = 1986.16, 1987.16…1999.16, 2000.0

s = NMFS spring (Yankee 36), ages a = 1, 2, 3…8, time t = 1969.29, 1970.29, 1971.29, 1972.29, 1982.29, 1983.29…1999.29

s = NMFS spring (Yankee 41), ages a = 1, 2, 3…8, time t = 1973.29, 1974.29…1981.29

s = NMFS fall, ages a = 0, 1, 2…5, time t = 1969.69, 1970.69…1999.69

Since forecast projections were required for the entire year 1999, the DFO spring survey in 2000 was designated as occurring at time 2000.0 instead of 2000.16. The NMFS fall survey captures young of the year and that information is included as 0 group, but older haddock appear less available during this season. Survey indices for older ages where catches were sparse and there were frequent occurrences of zero catches were not included. Zero observations for abundance indices were treated as missing data as the logarithm of zero is 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.

Statistical properties of estimators were obtained from model conditioned non-parametric bootstrap of the residuals (Efron and Tibshirani 1993). The population abundance estimates show a large relative error and substantial bias at ages 1 and 2 while the relative error for other ages is about 30% and the bias is small (Table 16). The average magnitude of residuals is large and though several large residuals can be identified, the respective observations do not appear influential and should not impact parameter estimates of current abundance (Figures 20-24). Some patterns in the residuals (by cohort and by age) merit further investigation.

Retrospective Analysis

Assessment results for several other stocks have identified a discrepancy between past and current estimates of stock status (retrospective pattern). This stock assessment does not suffer from a retrospective pattern. Figure 25 tracks successive estimates of year-class abundance at age and shows that estimates are fairly stable although there is sometimes a substantial change after the first estimate of a year-class when more data becomes available, as evidenced for the 1992 and 1996 year-classes. There were no trends of concern in the 3+ biomass pattern and the 4+ F when weighted by population numbers (Figure 26).

Stock Status

The results from the calibrated VPA were considered appropriate on which to base the status of the stock. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias and used to construct the history of stock status (Tables 17-18). This approach for bias adjustment, in the absence of an unbiased point estimator with optimal statistical properties, was considered preferable to using the biased point estimates (O'Boyle 1998). Bias adjusted VPA results were based on bootstrap statistics. The weights at age from the DFO spring survey (Table 15) were used to calculate beginning of year population biomass (Table 19). A weight of 2.4 kg, which was midway between the age 6 and 8 weight for that cohort, was used for age 7 in 1995 as no data were available for that age group. For 1969-85, the 1986-95 average weight at each age was used.

Population biomass (ages 1+) has steadily increased from near historic low levels of about 13,000 t in 1993 to about 50,000 t at the beginning of 2000 (Figure 27). The recent increase, due principally to the 1992 and 1996 year-classes, but also supported by the 1991 and 1993 year-classes, was enhanced by increased survivorship and by reduced capture of small fish in the fisheries. The biomass increase is expected to be sustained by the 1998 year-class. The adult biomass (ages 3+) trend is similar to the ages 1+ trend, with a 20% increase from 1999 to 2000, due largely to recruitment of the 1996 year-class.

Population biomass during the late 1970s and early 1980s was almost 50,000 t, due to recruitment of the strong 1975 and 1978 year-classes whose abundance was estimated at about 50 million. However, biomass declined rapidly in the early 1980s as subsequent recruitment was poor and these two year-classes were fished intensely at a young age.

The strength of the 1996 year-class was estimated to be about 18 million at age 1, the second highest since 1978 (Figure 28). The 1991, 1993, 1995 and 1997 year-classes appeared weaker at between 6 and 10 million. The 1998 year-class was estimated to be relatively strong at about 29 million recruits, the strongest since 1978. Preliminary indications for the 1999 year-class suggest it may be the third largest since 1978 at about 16 million.

Exploitation rate for fully recruited ages 4-8 has consistently been below that corresponding to $F_{0.1}$ (20%) since 1995 (Figure 29). Historically, exploitation rate has generally exceeded that corresponding to $F_{0.1}$ and showed a marked increase between 1989 and 1993 to almost 50%, the highest level observed. Reduced fishing mortality in recent years has resulted in increased survival of incoming year-classes. The number of haddock of the 1992 year-class surviving to age 8 was over four times that of the equally abundant 1983 year-class, and about the same as that of the 1975 or 1978 year-classes which were more than 3 times as abundant (Figure 30). In both absolute numbers and percent composition, the population structure displays a broad representation of age groups, reflecting improved recruitment and lower exploitation since 1995 (Figure 31).

Gains in fishable biomass may be partitioned into those associated with somatic growth of haddock, which have previously recruited to the fishery, and those associated with new recruitment to the fishery (Rivard 1980). We used age 2 as a convenient age of first recruitment to the fishery. Since 1993, biomass gains from growth and from recruitment have exceeded the losses due to natural deaths and to fishery harvest, resulting in net increase (Figure 32). Growth of fish is the dominant component of the biomass gain but recruitment accounts for significant portions when stronger year-classes enter (Figure 33).

Prognosis

Yield projections were done using the bias adjusted 2000 beginning of year population abundance estimates. The abundance of the 2000 year-class was assumed to be 6 million at age 0. Partial recruitment to the fishery for ages 1, 2 and 3, fishery weights at age and beginning of year population weights at age were averaged over the previous 5 years for use in the 2000 forecasts (Table 20). Projected total Canada/USA yield at $F_{0.1} = 0.25$ in 2000

would be about 8,800 t. If fished at $F_{0.1}$ in 2000, the adult biomass is projected to increase from 36,000 t to 46,000 t by the beginning of 2001. The 1996 year-class (age 4) is expected to comprise almost 40% of the total yield in 2000. The 1992 –1995 (ages 5-8) and 1997 (age 3) year-classes will contribute almost equally to the remaining yield (Figure 34).

Uncertainty about year-class abundance generates uncertainty in forecast results. This uncertainty was expressed as risk of achieving reference targets. For example, a combined Canada/USA catch of 8,000 t in 2000, about twice what was caught in 1999, results in about 25% probability that fishing mortality rate will exceed $F_{0.1}$ and a low probability that the adult biomass will decrease. At this yield there is a probability of about 10% of not achieving 10% biomass increase and a probability of 25% of not achieving 20% biomass increase (Figure 35). A catch corresponding to $F_{0.1}$ in 2000 results in a probability of less than 30% of not achieving 20% biomass increase between 2000 and 2001.

These calculations do not include uncertainty due to variations in weight at age, partial recruitment to the fishery and natural mortality, or systematic errors in data reporting and model mismatch.

Management Considerations

A Canadian quota of 3,900 t in 1999 was expected to result in a negligible chance of exceeding $F_{0.1}$ and a 50% chance of getting 10% growth in the stock. The Canadian catch in 1999 was about 3,700 t and resulted in a fishing mortality about half of $F_{0.1}$ and an increase in adult biomass of about 20%.

Data were available to approximate the age composition of the catch from unit areas 5Zej and 5Zem in order to reconstruct an illustrative population analysis for the period between 1930 and 1955 which is suitable for comparing productivity. The results indicated that although biomass has been increasing, it remains below the average biomass during 1930 to 1955 when productivity was higher (Figure 36).

The pattern of recruitment indicates that the chance of a strong year-class is significantly reduced for adult biomass below about 40,000 t (Figure 37). Since 1969, only the 1975 and 1978 (and possibly the 1998) year-classes have been near the average abundance of year-classes observed during the 1930 to 1955 period. Examination of the recruits per spawning biomass ratio suggests that survivorship to age 1 for several years during the 1980s may have been lower than the norm (Figure 38). The present survivorship appears comparable to that of the 1930s to 1950s period, suggesting that higher recruitment might result if the biomass increases.

Attributes like exploitation rate and biomass respond directly and immediately to management actions and can be used to compare consequences of alternative harvest yields. The projections above show those results. Other attributes, like recruitment, age structure and spatial distribution reflect possible fluctuations in the productive potential and can be used to qualify reference points and acceptable risk. Biomass can be considered both a response attribute and a productivity attribute. The states of these attributes suggests that

while conditions have improved, further rebuilding is required, therefore some moderation is indicated.

Cod and haddock are often caught together in groundfish fisheries. However, their catchabilities to the fisheries differ and they are not necessarily caught in proportion to their relative abundance. With current fishing practices, exploitation of haddock at $F_{0.1}$ may compromise the achievement of rebuilding objectives for cod.

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

Year	Canada	USA	Other	Discards	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	757	2747
1975	1353	1705	29		3087
1976	1355	973	24		2352
1977	2871	2429		2966	8266
978	9968	4724		1556	16248
1979	5080	5211			10291
1980	10017	5615		7561	23193
1981	5658	9077			14735
1982	4872	6280			11152
1983	3208	4454			7662
1984	1463	5121			6584
1985	3484	1683			5167
1986	3415	2200			5615
1987	4703	1418			6121
1988	4046[1]	1693			5739
1989	3060	787			3847
1990	3340	1189			4529
1991	5456	949			6405
1992	4058	1629			5687
1993	3727	421			4148
1994	2411	33		258	2702
1995	2065	22		25	2112
1996	3663	36		41	3740
1997	2749	48		63	2859
1998	3371	311		14	3696
1999	3680	355			4035

[1] 1895 t excluded because of suspected area misreporting.

Table 2. Regulatory measures implemented for the 5Z and 5Zjm fishery management units by the USA and Canada, respectively, from 1977, when jurisdiction was extended to 200 miles for coastal states, to the present.

	USA	**Canada**
1977-82	**Mesh** size of 5 1/8" (140 mm), seasonal spawning closures, quotas and trip limits.	
1982-85	**All** catch controls eliminated, retained closed area and mesh size regulations, implemented minimum landings size (43 cm).	**First** 5Ze assessment in 1983.
1984 Oct.	**Implementation of the 'Hague' line .**	
1985	**5 ½"** mesh size,. **Areas** 1 and 2 closed during February-May.	
1989		**Combined** cod-haddock-pollock quota for 4X-5Zc
1990		**5Zjm** adopted as management unit. **For** MG < 65 ft. – trip limits with a 30% by-catch of haddock to a maximum of 8 trips of 35,000 lbs per trip between June 1 and Oct. 31 and 130 mm square mesh required. **Fixed** gear required to use large hooks until June
1991	**Established** overfishing definitions for haddock.	**MG** < 65 ft similar to 1990 but mesh size increased to 145 mm diamond.
1992		**Introduction** of ITQs and dockside monitoring.
1993	**Area** 2 closure in effect from Jan 1-June30.	**OT** fishery permitted to operate in Jan. and Feb. **Increase** in use square mesh.
1994	Jan.: **Expanded** Area 2 closure to include June and increased extent of area. **Area** 1 closure not in effect. **500** lb trip limit. **Catch** data obtained from mandatory log books combined with dealer reports (replaces interview system). May: **6**" mesh restriction. Dec.: **Area** 1,2 closed year-round.	**Spawning** closure extended to Jan. 1 to May 31. **Fixed** gear vessels must choose between 5Z or 4X for the period of June to September. **Small** fish protocol. **Increased** at sea monitoring. **OT** > 65 could not begin fishng until July 1. **Predominantly** square mesh by end of year.
1995		**All** OT vessels using square mesh. **Fixed** gear vessels with a history since 1990 of 25t or more for 3 years of cod, haddock pollock, hake or cusk combined can participate in 5Z fishery. **ITQ** vessel require at least 2t of cod and 8t of haddock quota to fish Georges.
1996	July: **Additional** Days-at-Sea restrictions, trip limit raised to 1000 lbs.	**Fixed** gear history requirement dropped.
1997	May: **Additional** scheduled Days-at-sea restrictions. September: **Trip** limit raised to 1000 lbs/day, maximum of 10,000 lbs/trip.	**Vessels** over 65 ft operated on enterprise allocations, otter trawlers under 65 ft on individual quotas, fixed gear vessels 45-65 ft on self-administered individual quotas and fixed gear vessels under 45 ft on community quotas administered by local boards.
1998	Sept. 1: **Trip** limit raised to 3000 lbs/day, maximum of 30,000 lbs/trip.	**Fixed** gear vessels 45-65 ft operated on individual quotas.
1999	May 1: Trip limit 2,000 lbs/day, max. 20,000 lbs/trip. Square mesh size increased to 6.5". June 15: Scallop exemption fishery in Closed Area II. Nov. 5: Trip limit 5,000 lbs/day, max. 50,000 lbs/trip. Nov. 15: New overfishing definitions and harvest control rules.	Same as 1997 and 1998.

Table 3. Canadian catch (t) of haddock in unit areas 5Zjm by gear category and tonnage class for principle gears.

Year	Otter Trawl						Longline			Other	Total
	Side	Stern									
		2	3	4	5	Total[1]	2	3	Total[1]		
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[2]	72	1091	1456	186	398	3183	428	200	695	97	4046
1989	0	489	573	376	536	1976	713	175	977	106	3060
1990	0	928	890	116	471	2411	623	173	853	76	3340
1991	0	1610	1647	81	689	4028	900	271	1309	119	5456
1992	0	797	1084	56	645	2583	984	245	1384	90	4058
1993	0	535	1179	67	699	2489	794	156	1143	96	3727
1994	0	495	911	79	112	1597	498	47	714	100	2411
1995	0	523	896	14	214	1647	256	75	390	28	2065
1996	1	836	1405	166	270	2689	561	107	947	26	3663
1997	0	680	1123	91	96	1991	501	116	722	36	2749
1998	0	863	1340	98	71	2422	570	252	921	27	3371
1999	0	954	1471	174	145	2760	486	241	887	33	3680

[1] Total includes catches for tonnage classes which are not listed, only tonnage classes with substantial catches listed

[2] 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 4. 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	33	94	48	7	20	1398	356	566	141	272	108	18	3060
1990	35	14	50	0	7	1178	668	678	469	199	18	22	3340
1991	144	166	49	26	21	1938	1004	705	566	576	123	137	5456
1992	118	205	97	152	36	1381	619	414	398	401	209	28	4058
1993	468	690	96	78	25	723	505	329	202	198	230	183	3727
1994	3	3	1	2	0	398	693	373	375	220	211	133	2411
1995	5	1	1	1	0	762	327	290	281	109	197	93	2065
1996	0	0	0	0	0	1067	672	706	359	278	191	391	3663
1997	0	0	0	0	0	328	751	772	426	190	116	166	2749
1998	0	0	0	0	0	687	420	580	707	542	164	271	3371
1999	37	0	0	0	0	898	975	562	573	295	268	70	3680

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

Table 5. USA catch (t) of haddock (excluding discard estimates) in unit areas 5Zjm by gear category and tonnage class. Details for 1994-1999 are not available because data is preliminary.

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			32	0	33
1995			21	0	22
1996			36	0	36
1997			48	0	48
1998			311	0	311
1999			355	0	355

Table 6. Monthly catch (t) of haddock (excluding discard estimates) by USA in unit areas 5Zjm. Details for 1994-1999 are not available because data is preliminary.

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													33
1995													22
1996													36
1997													48
1998													311
1999													355

Table 7. Derivation of catch at age for the 1999 5Zjm Canadian haddock fishery.

Country	Qtr.	Length Frequency Samples										Aged Samples			
		Gear	Month	Observer		Port		Landings	Combinations			Observer		Port	
				Samples	Measured	Samples	Measured	(kg)				Samples	Aged	Samples	Aged
Canada	1	OT OF	Jan	1	976			36886				2000 Can. 5Zjm spring survey n=560			
	2	OT IN	June	19	20349	8	2022	781256		Q2 OT IN					
		OT OF	June	4	4794	1	200	86506		Q2 OT OF	Q2	9	135	10	296
		GN	June	Q3GN				5180		Q2 GN					
		LL	June	2	459	2	521	25353		Q2 LL					
	3	OT IN	July	7	7334	4	1069	661943	Jul OT IN						
		OT IN	Aug	4	4254	1	210	206806	Aug OT IN	Q3 OT IN					
		OT IN	Sept	12	11890	4	881	369424	Sep OT IN						
		OT OF	Jul	1	1059			63960	Jul OT OF						
		OT OF	Aug	1	589			61649	Aug OT OF	Q3 OT OF					
		OT OF	Sept			1	250	30096	Sep OT OF						
		GN	July					9788							
		GN	Aug			1	205	6742	Aug GN	Q3 GN	Q3	17	268	15	454
		GN	Sept			1	170	4297	Sep GN						
		LL	July	6	3395	2	521	239329	Jul LLHL						
		HL	July					108		Q3 LLHL					
		LL	Aug	8	5756	6	1365	287215	Aug LL						
		LL	Sept			1	200	169312	Sep LL						
	4	OT IN	Oct	6	3317	5	1074	169662	Oct OT IN						
		OT IN	Nov			3	640	200319	Nov OT IN	Q4 OT IN					
		OT IN	Dec	1	687	3	702	51520	Dec OT IN						
		OT OF	Oct	1	518			1112							
		OT OF	Nov					34684		Q4 OT OF					
		OT OF	Dec					4207			Q4			16	411
		GN	Oct			1	163	3943							
		GN	Nov					1566		Q4 GN					
		GN	Dec					1178							
		LL	Oct	1	1221	3	719	120670	Oct LL						
		LL	Nov			1	267	31815	Nov LL	Q4 LL					
		LL	Dec	1	1292			13534	Dec LL						
	Totals			48	67890	48	11179	3680060				26	403	41	1161

OTB=Otter Trawl Bottom, GN=Gill Net, LL=Longline, HL=Handline, IN=Inshore (Tonnage Classes <=3), OF=Offshore (Tonnage Classes >=4).

Table 8. Components of catch at age numbers of haddock from unit areas 5Zjm by quarter.

Quarter	Age Group										Annual
	1	2	3	4	5	6	7	8	9+	1+	Total
Canada											
1997	0	0	0	0	0	0	0	0	0	0	
1997.25	20	613	2427	37160	69322	32539	4355	1835	6372	154641	
1997.5	91	44041	45146	411285	311587	134305	3455	3409	21114	974433	
1997.75	777	28045	21052	76918	88967	19722	3790	1759	4061	245092	1374166
1998	0	0	0	0	0	0	0	0	0	0	
1998.25	0	2347	19864	39177	81124	103001	43108	2694	14563	305879	
1998.5	0	97563	136277	136588	274232	182064	42564	6326	14479	890094	
1998.75	33	53342	109739	61895	145098	123639	15879	1676	1569	512871	1708844
1999	0	14	1074	2714	1680	4370	4386	1296	892	16426	
1999.25	31	4071	83980	71310	46876	101233	79900	34831	6339	428571	
1999.5	0	16798	445526	180561	146689	175530	109896	32189	6445	1113634	
1999.75	905	13971	191059	45492	24719	33986	27856	11205	898	350091	1908722
USA											
1997	0	0	0	335	1183	934	148	89	276	2965	
1997.25	0	0	0	828	2925	2309	367	220	682	7332	
1997.5	0	16	22	923	2165	1634	65	92	510	5427	
1997.75	0	35	45	585	1509	610	179	80	153	3196	18919
1998	0	82	692	1365	2826	3588	1501	94	507	10654	
1998.25	0	439	3713	7322	15163	19252	8057	503	2722	57171	
1998.5	0	5694	7953	7971	16004	10625	2484	369	845	51944	
1998.75	1	1198	2465	1390	3259	2777	357	38	35	11519	131288
1999	0	0	265	3957	10301	4225	2656	3967	4664	30035	
1999.25	0	0	1264	4259	8914	14525	18156	9629	3703	60450	
1999.5	0	296	13157	6104	4490	8830	9074	3865	1875	47691	
1999.75	0	61	1082	755	758	1159	1002	460	125	5402	143578
USA Discards											
1997	680	4321	6554	7914	2889	1117	316	194	291	24275	
1997.25	452	2876	4363	5268	1923	743	210	129	194	16159	
1997.5	391	1006	670	806	313	102	3	48	61	3399	
1997.75	75	194	129	155	60	20	1	9	12	656	44490
1998	0	636	428	548	644	136	96	0	0	2487	
1998.25	0	834	561	718	845	178	125	0	0	3262	
1998.5	999	1307	683	991	277	424	0	0	0	4681	
1998.75	0	0	0	0	0	0	0	0	0	0	10429

Table 8. continued

Quarter	Age Group										Annual
	1	2	3	4	5	6	7	8	9+	1+	Total
Total											
1997	680	4321	6554	8249	4072	2051	464	283	567	27240	
1997.25	472	3489	6790	43256	74170	35592	4932	2184	7248	178132	
1997.5	482	45063	45838	413014	314065	136041	3523	3548	21685	983258	
1997.75	852	28275	21226	77658	90536	20352	3970	1848	4226	248944	1437575
1998	0	718	1120	1912	3470	3723	1597	94	507	13141	
1998.25	0	3620	24138	47218	97132	122431	51291	3197	17285	366311	
1998.5	999	104564	144913	145550	290512	193113	45048	6695	15324	946719	
1998.75	34	54540	112204	63285	148357	126416	16236	1714	1604	524389	1850561
1999	0	14	1339	6671	11981	8595	7042	5263	5556	46461	
1999.25	31	4071	85244	75569	55790	115758	98056	44460	10042	489021	
1999.5	0	17094	458683	186665	151179	184360	118970	36054	8320	1161325	
1999.75	905	14032	192141	46247	25477	35145	28858	11665	1023	355493	2052300

Table 9. Total annual commercial catch at age numbers (000's) of haddock from unit areas 5Zjm.

Year	Age Group										
	0	1	2	3	4	5	6	7	8	9+	Total
1969	0	0	18	1441	260	331	2885	819	89	279	6123
1970	0	25	82	7	347	147	126	1140	364	189	2425
1971	0	0	1182	247	31	246	157	159	756	407	3185
1972	0	259	1	376	71	21	92	37	16	431	1303
1973	0	1015	1722	6	358	37	10	37	8	163	3358
1974	0	17	2105	247	0	31	3	0	29	57	2488
1975	0	0	270	1428	201	5	34	1	2	28	1969
1976	0	73	149	166	814	125	0	19	0	17	1363
1977	0	0	7836	64	178	303	162	0	15	14	8571
1978	0	1	285	9831	161	169	302	80	10	9	10848
1979	0	0	15	199	4250	362	201	215	43	14	5300
1980	0	3	17561	342	299	2407	191	129	51	12	20995
1981	0	0	660	6687	393	494	1234	119	33	7	9627
1982	0	0	713	1048	2799	201	377	723	62	65	5988
1983	0	0	140	648	546	1629	207	104	402	34	3710
1984	0	0	76	249	341	264	1120	186	165	314	2716
1985	0	0	2063	374	176	189	123	371	53	114	3463
1986	0	6	38	2557	173	142	122	118	173	41	3369
1987	0	0	1990	127	1515	96	56	82	68	108	4042
1988	0	4	51	2145	121	877	109	36	46	98	3487
1989	0	0	1153	78	734	129	320	31	20	45	2510
1990	0	2	7	1265	126	743	68	163	42	42	2457
1991	0	6	441	89	2041	88	389	72	145	61	3332
1992	0	7	230	311	127	1446	89	315	26	90	2640
1993	0	7	247	343	279	85	635	34	153	74	1856
1994	0	1	241	737	148	54	48	125	29	39	1423
1995	0	2	60	525	414	53	25	3	51	16	1149
1996	0	1	29	481	862	419	61	18	3	72	1946
1997	0	2	81	80	542	483	194	13	8	28	1288
1998	0	1	163	282	258	539	446	114	12	35	1851
1999	0	1	35	737	315	244	344	253	97	25	2052

Table 10. Average weight at age (kg) of haddock from the commercial fishery in unit areas 5Zjm. The 1989 to 1991 year-classes (shaded) grew faster than adjacent year-classes.

Year	Age Group							
	1	2	3	4	5	6	7	8
1969	0.600	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	0.600	0.928	1.059	1.272	2.011	2.255	2.262	2.613
1972	0.759	1.000	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	0.600	0.970	1.418	1.800	1.984	3.760	2.700	3.128
1975	0.600	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	2.700	2.702	3.000
1977	0.600	0.970	1.442	1.809	2.337	2.809	2.700	3.095
1978	0.619	1.151	1.433	2.055	2.623	2.919	2.972	2.829
1979	0.600	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	0.600	0.890	1.262	1.592	2.270	2.611	3.505	4.009
1982	0.600	0.965	1.363	1.786	2.327	2.557	2.958	3.531
1983	0.600	1.024	1.341	1.750	2.118	2.509	2.879	3.104
1984	0.600	0.876	1.354	1.838	2.159	2.605	2.856	3.134
1985	0.600	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	0.600	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	0.600	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	1.135	1.661	2.235	2.639	2.422	2.831	3.223
1995	0.797	1.055	1.511	2.033	2.550	2.755	2.908	3.010
1996	0.576	1.022	1.439	1.795	2.294	2.485	3.322	2.032
1997	0.685	1.215	1.336	1.747	2.120	2.476	3.034	3.365
1998	0.568	1.131	1.573	1.697	1.983	2.312	2.864	3.395
1999	0.678	1.095	1.570	1.910	1.865	2.182	2.535	2.773
Low	0.405	0.763	0.812	1.272	1.649	1.631	2.199	2.032
High	0.797	1.215	1.724	2.235	2.639	3.760	4.114	4.009
Median	0.600	0.987	1.367	1.800	2.148	2.522	2.885	3.134
Average	0.599	1.003	1.378	1.812	2.171	2.528	2.890	3.156

Table 11. Conversion factors used to adjust for changes in door type and survey vessel in the NMFS surveys.

		Spring		Fall	
Year	Door	Vessel	Conversion	Vessel	Conversion
1968	BMV	Albatross IV	NA	Albatross IV	1.49
1969	BMV	Albatross IV	1.49	Albatross IV	1.49
1970	BMV	Albatross IV	1.49	Albatross IV	1.49
1971	BMV	Albatross IV	1.49	Albatross IV	1.49
1972	BMV	Albatross IV	1.49	Albatross IV	1.49
1973	BMV	Albatross IV	1.49	Albatross IV	1.49
1974	BMV	Albatross IV	1.49	Albatross IV	1.49
1975	BMV	Albatross IV	1.49	Albatross IV	1.49
1976	BMV	Albatross IV	1.49	Albatross IV	1.49
1977	BMV	Albatross IV	1.49	Delaware II	1.2218
1978	BMV	Albatross IV	1.49	Delaware II	1.2218
1979	BMV	Albatross IV	1.49	Delaware II	1.2218
1980	BMV	Albatross IV	1.49	Delaware II	1.2218
1981	BMV	Delaware II	1.2218	Delaware II	1.2218
1982	BMV	Delaware II	1.2218	Albatross IV	1.49
1983	BMV	Albatross IV	1.49	Albatross IV	1.49
1984	BMV	Albatross IV	1.49	Albatross IV	1.49
1985	Polyvalent	Albatross IV	1	Albatross IV	1
1986	Polyvalent	Albatross IV	1	Albatross IV	1
1987	Polyvalent	Albatross IV	1	Albatross IV	1
1988	Polyvalent	Albatross IV	1	Albatross IV	1
1989	Polyvalent	Delaware II	0.82	Delaware II	0.82
1990	Polyvalent	Delaware II	0.82	Delaware II	0.82
1991	Polyvalent	Delaware II	0.82	Delaware II	0.82
1992	Polyvalent	Albatross IV	1	Albatross IV	1
1993	Polyvalent	Albatross IV	1	Delaware II	0.82
1994	Polyvalent	Delaware II	0.82	Albatross IV	1
1995	Polyvalent	Albatross IV	1	Albatross IV	1
1996	Polyvalent	Albatross IV	1	Albatross IV	1
1997	Polyvalent	Albatross IV	1	Albatross IV	1
1998	Polyvalent	Albatross IV	1	Albatross IV	1
1999	Polyvalent	Albatross IV	1	Albatross IV	1

Table 12. Total estimated abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from the DFO spring surveys.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1986	5057	306	8175	997	189	348	305	425	401	16205
1987	46	4286	929	3450	653	81	387	135	1132	11099
1988	971	49	12714	257	4345	274	244	130	686	19671
1989	48	6664	991	2910	247	528	40	36	260	11725
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	14248
1993	3448	1759	545	431	34	1186	19	281	147	7849
1994	4197	15163	5332	549	314	20	915	18	356	26864
1995	1231	3224	6236	3034	720	398	0	729	849	16422
1996	1477	2059	4784	5247	3391	326	246	20	698	18247
1997	1033	1550	1222	2742	2559	1397	150	65	372	11090
1998	2419	10626	5350	3190	5312	5028	2248	348	601	35124
1999	24593	4787	10067	3104	1963	1880	1759	453	175	48780
2000	3177	15865	7679	12108	2900	2074	2726	1591	813	48932

Table 13. Total estimated abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from the NMFS spring surveys. From 1973-81, a 41 Yankee trawl was used while a 36 Yankee trawl was used in other years. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1968	0	3254	67	679	4853	2046	240	124	234	11497
1969	17	35	614	235	523	3232	1220	358	489	6724
1970	478	190	0	560	998	441	3169	2507	769	9113
1971	0	655	261	0	144	102	58	1159	271	2650
1972	2594	0	771	132	25	47	211	27	1214	5019
1973	2455	5639	0	1032	154	0	276	0	1208	10763
1974	1323	20596	4084	0	354	0	43	72	322	26795
1975	528	567	6016	1063	0	218	127	45	208	8773
1976	8279	402	433	1229	582	0	0	0	22	10948
1977	138	25922	294	855	816	586	0	22	98	28730
1978	0	743	20859	641	880	1163	89	23	116	24516
1979	10496	441	1313	9764	475	72	445	42	9	23057
1980	4364	67961	1129	1117	5822	628	381	705	359	82466
1981	3595	3041	27694	2887	719	2389	335	57	21	40738
1982	584	3697	1649	7743	745	447	669	0	0	15534
1983	238	770	686	359	2591	30	0	798	57	5529
1984	1366	1415	996	1001	936	1245	138	89	470	7656
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	84	6665	619	1343	267	791	58	92	47	9966
1990	1654	70	10338	598	1042	110	182	0	0	13995
1991	740	2071	432	3381	192	203	66	87	25	7198
1992	529	287	214	141	609	32	46	46	0	1905
1993	1870	1116	197	232	195	717	77	35	43	4481
1994	1025	4272	1487	269	184	118	278	28	85	7745
1995	921	2307	4096	1691	259	151	51	269	214	9959
1996	912	1351	3772	3232	1896	235	36	0	496	11931
1997	1635	1226	380	595	470	343	24	44	20	4736
1998	549	6046	2005	1281	1184	303	58	15	122	11562
1999	6286	1914	3655	661	1128	1062	468	476	46	15696

Table 14. Total estimated abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from the NMFS fall surveys. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									
	0	1	2	3	4	5	6	7	8+	Total
1963	106461	49869	14797	5050	7581	6172	2301	599	273	193101
1964	1177	114880	55741	6128	976	2435	502	280	167	182287
1965	259	1512	51521	8360	489	299	148	165	216	62970
1966	9324	751	1742	20324	3631	671	139	133	83	36797
1967	0	3998	73	328	1845	675	140	88	88	7234
1968	55	113	800	28	37	2223	547	177	313	4293
1969	384	0	0	519	63	30	753	458	115	2323
1970	0	6400	336	16	415	337	500	902	578	9483
1971	2626	0	788	97	0	265	27	73	594	4471
1972	4747	2396	0	232	0	0	53	0	276	7703
1973	1345	16797	1606	0	180	1	0	16	16	19961
1974	151	234	961	169	0	6	0	0	69	1589
1975	30365	664	192	1018	222	0	0	0	26	32487
1976	784	132622	456	25	484	71	0	17	36	134496
1977	47	238	26323	445	125	211	84	4	4	27480
1978	14642	547	530	7706	56	42	94	0	0	23617
1979	1573	21117	14	327	1461	44	12	0	0	24549
1980	3581	2817	5877	0	101	1085	109	26	4	13598
1981	616	4617	2585	2752	105	136	297	0	15	11123
1982	62	0	669	460	2576	159	91	469	42	4527
1983	3609	444	324	435	283	396	19	9	79	5598
1984	45	3849	781	221	210	43	254	0	47	5451
1985	12148	381	1646	199	70	68	46	30	21	14610
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	167	83	2645	112	509	68	73	0	0	3656
1990	1217	1036	24	1474	90	172	21	5	0	4040
1991	705	331	274	68	266	25	10	0	0	1679
1992	3484	1052	172	110	0	95	0	18	18	4948
1993	677	6666	3601	585	0	87	96	30	0	11742
1994	625	782	927	419	96	32	0	24	0	2905
1995	892	1465	6165	3484	547	30	0	0	53	12637
1996	1742	453	570	2302	963	167	0	0	0	6196
1997	217	5726	3128	890	645	385	0	0	13	11004
1998	2577	3073	4364	1006	577	482	706	0	0	12784
1999	3268	1236	5364	5060	837	2825	148	1150	991	20879

Table 15. Average weight at age (kg) from the DFO spring survey.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1986	0.135	0.452	0.974	1.445	3.039	2.843	3.598	3.373	3.914
1987	0.150	0.500	0.716	1.672	2.011	2.548	3.149	3.147	3.629
1988	0.097	0.464	0.931	1.795	1.816	1.916	2.721	3.267	3.869
1989	0.062	0.474	0.649	1.392	1.995	2.528	2.155	2.820	2.963
1990	0.149	0.527	0.924	1.185	1.863	2.072	2.507	2.819	3.469
1991	0.120	0.689	0.801	1.510	1.687	2.428	2.103	3.125	3.435
1992	0.122	0.602	1.118	1.060	2.078	2.165	2.709	2.283	3.443
1993	0.122	0.481	1.227	1.803	1.272	2.333	2.340	2.740	3.293
1994	0.107	0.469	1.047	1.621	1.926	2.154	3.153	2.688	3.084
1995	0.086	0.493	0.963	1.556	2.224	2.447	2.400	2.991	3.184
1996	0.139	0.495	0.919	1.320	1.932	2.555	2.899	2.603	3.588
1997	0.132	0.507	0.782	1.205	1.664	2.177	2.450	2.586	3.163
1998	0.106	0.517	1.044	1.188	1.578	1.955	2.610	3.560	3.460
1999	0.129	0.474	0.911	1.289	1.257	1.869	2.121	2.724	2.986
2000	0.116	0.544	0.948	1.479	1.871	1.790	2.299	2.508	2.904
Low	0.062	0.452	0.649	1.060	1.257	1.790	2.103	2.283	2.904
High	0.150	0.689	1.227	1.803	3.039	2.843	3.598	3.560	3.914
Median	0.122	0.495	0.931	1.445	1.871	2.177	2.507	2.819	3.435
Average	0.118	0.514	0.930	1.433	1.880	2.252	2.614	2.882	3.359

Table 16. Statistical properties of estimates for beginning of 2000 population abundance (numbers in 000's) and survey calibration constants (unitless, survey:population) for haddock in unit areas 5Zjm obtained from a bootstrap with 600 replications.

Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
		Population Abundance (000's)			
1	20507	19317	0.942	3926	0.191
2	26005	11637	0.447	2475	0.095
3	6206	2164	0.349	359	0.058
4	9865	3199	0.324	554	0.056
5	2305	696	0.302	47	0.021
6	1804	499	0.276	32	0.018
7	1686	573	0.340	59	0.035
8	1401	483	0.345	40	0.029
		Survey Calibration Constants			
DFO Spring Survey					
1	0.187	0.049	0.260	0.007	0.037
2	0.462	0.113	0.244	0.009	0.020
3	0.894	0.233	0.261	0.024	0.026
4	0.815	0.193	0.237	0.027	0.033
5	0.980	0.234	0.239	0.026	0.026
6	0.796	0.207	0.260	0.022	0.027
7	1.102	0.281	0.255	0.036	0.033
8	1.041	0.271	0.260	0.052	0.050
NMFS Spring Survey – Yankee 36 – 1969-72/1982-99					
1	0.126	0.027	0.212	0.002	0.020
2	0.338	0.071	0.210	0.003	0.009
3	0.429	0.088	0.206	0.009	0.022
4	0.451	0.097	0.215	0.015	0.032
5	0.549	0.114	0.207	0.013	0.024
6	0.434	0.087	0.199	0.004	0.009
7	0.501	0.107	0.213	0.014	0.027
8	0.653	0.142	0.218	0.019	0.029
NMFS Spring Survey – Yankee 41 – 1973-81					
1	0.230	0.080	0.348	0.016	0.071
2	0.516	0.174	0.337	0.032	0.063
3	0.653	0.218	0.334	0.044	0.068
4	0.797	0.272	0.341	0.031	0.039
5	0.984	0.353	0.359	0.048	0.049
6	0.891	0.371	0.417	0.048	0.054
7	1.594	0.600	0.376	0.100	0.063
8	0.636	0.244	0.383	0.031	0.048
NMFS Fall Survey					
0	0.124	0.022	0.177	0.000	0.004
1	0.258	0.046	0.180	0.005	0.018
2	0.230	0.040	0.175	0.002	0.009
3	0.215	0.036	0.167	0.006	0.030
4	0.165	0.031	0.188	0.001	0.004
5	0.147	0.027	0.182	0.004	0.025

Table 17. Beginning of year population abundance (numbers in 000's) for haddock in unit areas 5Zjm from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2000.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	768	189	4376	853	905	8991	3021	185	809	20097	19328	19139
1970	3345	629	138	2295	465	448	4797	1745	487	14349	11004	10375
1971	455	2715	439	107	1570	249	253	2904	1336	10028	9573	6857
1972	5368	373	1128	138	61	1064	64	67	2442	10705	5337	4964
1973	11031	4152	305	588	49	31	792	19	1662	18629	7598	3446
1974	3339	8123	1827	244	153	7	17	614	1225	15550	12211	4088
1975	3215	2718	4751	1280	200	99	4	14	1432	13710	10496	7778
1976	53781	2632	1972	2594	868	159	51	2	1157	63217	9435	6804
1977	5900	43966	2021	1467	1403	599	131	25	934	56446	50546	6580
1978	4199	4831	28843	1599	1043	885	349	107	760	42615	38416	33585
1979	51921	3437	3681	14523	1160	703	457	213	693	76788	24867	21430
1980	6629	42509	2799	2832	8089	625	400	185	691	64759	58131	15621
1981	5118	5425	18954	1989	2051	4507	342	216	663	39264	34146	28722
1982	1711	4190	3833	9541	1280	1239	2606	176	684	25260	23549	19359
1983	2529	1401	2768	2195	5288	864	679	1487	593	17804	15275	13875
1984	14879	2071	1016	1675	1306	2884	522	462	1319	26134	11255	9184
1985	1548	12182	1627	607	1065	836	1371	264	1036	20535	18987	6805
1986	13205	1267	8040	985	338	702	574	795	916	26823	13618	12351
1987	1273	10806	1003	4296	655	150	467	368	1214	20232	18959	8152
1988	14989	1043	7045	707	2156	449	73	309	1136	27906	12917	11875
1989	786	12268	808	3830	470	991	271	28	1056	20508	19722	7454
1990	2346	644	9004	590	2472	269	525	195	829	16875	14529	13885
1991	1801	1919	521	6224	371	1356	160	284	764	13400	11599	9679
1992	7958	1469	1168	347	3241	224	760	67	673	15906	7949	6479
1993	12042	6509	991	674	171	1358	105	340	503	22693	10651	4142
1994	9829	9853	5094	499	304	65	550	56	491	26741	16911	7058
1995	6139	8047	7841	3482	271	199	8	335	385	26706	20567	12521
1996	6270	5025	6532	5935	2471	173	140	4	529	27079	20809	15784
1997	18453	5133	4087	4903	4064	1635	85	98	367	38825	20372	15239
1998	8773	15106	4126	3271	3510	2879	1159	58	347	39230	30457	15351
1999	28742	7182	12214	3112	2438	2371	1943	845	290	59137	30395	23213
2000	16581	23531	5847	9311	2258	1772	1627	1360	818	63103	46522	22992

Table 18. Fishing mortality rate for haddock in unit areas 5Zjm from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2000. The rate for ages 4+ is weighted by population numbers and is also shown as exploitation rate (%).

Year	Age Group										
	1	2	3	4	5	6	7	8	9+	4+	4+ (%)
1969	0.000	0.112	0.445	0.407	0.504	0.428	0.349	0.737	0.469	0.422	31
1970	0.009	0.159	0.057	0.180	0.425	0.371	0.302	0.258	0.542	0.287	22
1971	0.000	0.678	0.956	0.367	0.188	1.164	1.131	0.332	0.397	0.375	28
1972	0.057	0.002	0.453	0.832	0.468	0.096	0.993	0.288	0.210	0.219	19
1973	0.106	0.621	0.022	1.143	1.738	0.413	0.054	0.641	0.112	0.322	39
1974	0.006	0.336	0.156	0.000	0.242	0.491	0.002	0.051	0.050	0.059	6
1975	0.000	0.121	0.405	0.189	0.025	0.460	0.336	0.172	0.021	0.107	15
1976	0.002	0.064	0.096	0.414	0.171	0.000	0.522	0.000	0.016	0.262	26
1977	0.000	0.222	0.034	0.141	0.261	0.339	0.000	1.007	0.016	0.179	18
1978	0.000	0.072	0.486	0.121	0.194	0.460	0.293	0.107	0.012	0.195	19
1979	0.000	0.005	0.062	0.385	0.419	0.363	0.703	0.249	0.022	0.379	30
1980	0.000	0.608	0.142	0.122	0.385	0.402	0.416	0.346	0.019	0.308	25
1981	0.000	0.147	0.486	0.241	0.304	0.348	0.465	0.177	0.012	0.294	25
1982	0.000	0.215	0.358	0.390	0.192	0.401	0.361	0.481	0.107	0.358	28
1983	0.000	0.121	0.302	0.319	0.406	0.304	0.185	0.342	0.065	0.341	27
1984	0.000	0.041	0.314	0.253	0.246	0.544	0.481	0.486	0.297	0.389	31
1985	0.000	0.216	0.302	0.387	0.216	0.175	0.344	0.246	0.127	0.247	22
1986	0.000	0.034	0.427	0.208	0.610	0.208	0.246	0.263	0.049	0.221	21
1987	0.000	0.228	0.149	0.489	0.177	0.527	0.213	0.228	0.103	0.365	31
1988	0.000	0.055	0.409	0.209	0.577	0.304	0.759	0.173	0.098	0.362	33
1989	0.000	0.109	0.114	0.238	0.358	0.435	0.130	1.604	0.047	0.247	23
1990	0.001	0.012	0.169	0.265	0.401	0.320	0.416	0.269	0.056	0.318	28
1991	0.004	0.297	0.207	0.453	0.306	0.379	0.672	0.820	0.091	0.421	33
1992	0.001	0.194	0.349	0.507	0.670	0.553	0.605	0.538	0.158	0.579	43
1993	0.001	0.045	0.487	0.597	0.769	0.704	0.425	0.659	0.169	0.585	44
1994	0.000	0.028	0.181	0.409	0.225	1.874	0.295	0.872	0.094	0.332	31
1995	0.000	0.009	0.078	0.143	0.247	0.149	0.498	0.186	0.046	0.145	13
1996	0.000	0.007	0.087	0.179	0.213	0.510	0.157	1.978	0.167	0.194	16
1997	0.000	0.018	0.023	0.134	0.145	0.144	0.187	0.094	0.091	0.138	12
1998	0.000	0.013	0.082	0.094	0.192	0.193	0.116	0.257	0.117	0.154	13
1999	0.000	0.006	0.071	0.121	0.119	0.177	0.157	0.136	0.100	0.140	12

Table 19. Beginning of year biomass (tonnes in 000's) for haddock in unit areas 5Zjm from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2000.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	88	97	4092	1283	1802	21068	8106	540	2774	39851	39763	39665
1970	385	324	129	3452	926	1049	12872	5105	1669	25910	25525	25201
1971	52	1399	411	161	3125	583	679	8496	4579	19484	19432	18033
1972	618	192	1055	208	121	2494	171	196	8371	13425	12808	12616
1973	1269	2139	285	884	98	73	2125	56	5698	12627	11358	9219
1974	384	4184	1709	367	305	17	45	1797	4201	13009	12625	8440
1975	370	1400	4442	1925	397	231	10	40	4909	13724	13354	11954
1976	6187	1356	1844	3901	1728	374	137	6	3968	19500	13313	11957
1977	679	22648	1890	2207	2794	1403	350	72	3203	35247	34568	11920
1978	483	2488	26970	2405	2076	2073	937	313	2605	40351	39868	37379
1979	5973	1770	3442	21843	2309	1647	1227	624	2376	41212	35239	33468
1980	763	21898	2617	4259	16106	1464	1074	542	2370	51093	50330	28432
1981	589	2794	17723	2991	4084	10562	918	632	2271	42565	41976	39182
1982	197	2158	3584	14350	2548	2904	6992	514	2346	35594	35397	33239
1983	291	721	2588	3301	10530	2026	1823	4350	2032	27662	27371	26650
1984	1712	1067	950	2519	2600	6758	1401	1352	4523	22881	21170	20103
1985	178	6275	1521	913	2120	1959	3678	773	3550	20968	20790	14515
1986	1778	572	7834	1423	1027	1997	2067	2683	3585	22965	21187	20615
1987	192	5398	718	7184	1317	383	1470	1157	4407	22225	22034	16635
1988	1457	484	6556	1269	3915	861	198	1009	4396	20145	18688	18204
1989	48	5816	525	5332	937	2505	585	78	3128	18955	18907	13091
1990	349	339	8323	699	4605	557	1316	550	2877	19616	19266	18927
1991	217	1322	417	9401	626	3291	336	886	2624	19121	18904	17582
1992	973	885	1306	368	6736	484	2058	153	2318	15281	14308	13422
1993	1469	3131	1216	1216	218	3168	246	930	1655	13249	11781	8649
1994	1049	4623	5332	808	585	140	1734	151	1515	15936	14888	10265
1995	529	3970	7551	5419	603	486	20	1002	1227	20807	20277	16308
1996	869	2487	6003	7835	4773	443	406	11	1898	24725	23856	21369
1997	2440	2600	3194	5908	6761	3559	209	253	1160	26085	23646	21046
1998	931	7810	4310	3888	5538	5629	3025	206	1201	32539	31608	23798
1999	3721	3401	11124	4010	3066	4432	4121	2301	864	37041	33320	29920
2000	1918	12802	5543	13766	4224	3171	3739	3411	2376	50949	49031	36229

Table 20. Deterministic projection results for haddock in unit areas 5Zjm for 2000 at $F_{0.1}$ using the bootstrap bias adjusted population abundance at the beginning of 2000.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
Beginning of Year Population Numbers (000s)												
2000	16581	23531	5847	9311	2258	1772	1627	1360	818			
2001	4912	13575	18931	4331	5937	1439	1130	1037	1389			
Partial Recruitment to the Fishery												
2000	0.00	0.07	0.40	1.00	1.00	1.00	1.00	1.00	1.00			
Fishing Mortality												
2000	0.000	0.018	0.100	0.250	0.250	0.250	0.250	0.250	0.250			
Weight at beginning of year for population (kg)												
2001	0.12	0.51	0.92	1.30	1.66	2.07	2.48	2.80	3.22			
Beginning of Year Projected Population Biomass (t)												
2001	622	6886	17431	5614	9856	2979	2797	2900	4472	53558	52936	46050
Projected Catch Numbers (000s)												
2000	0	370	505	1874	454	357	328	274	165			
Average weight at age for catch (kg)												
2000	0.66	1.10	1.49	1.84	2.16	2.44	2.93	2.91	3.77			
Projected Yield (t)												
2000	0	408	750	3442	983	871	960	798	620	8833		

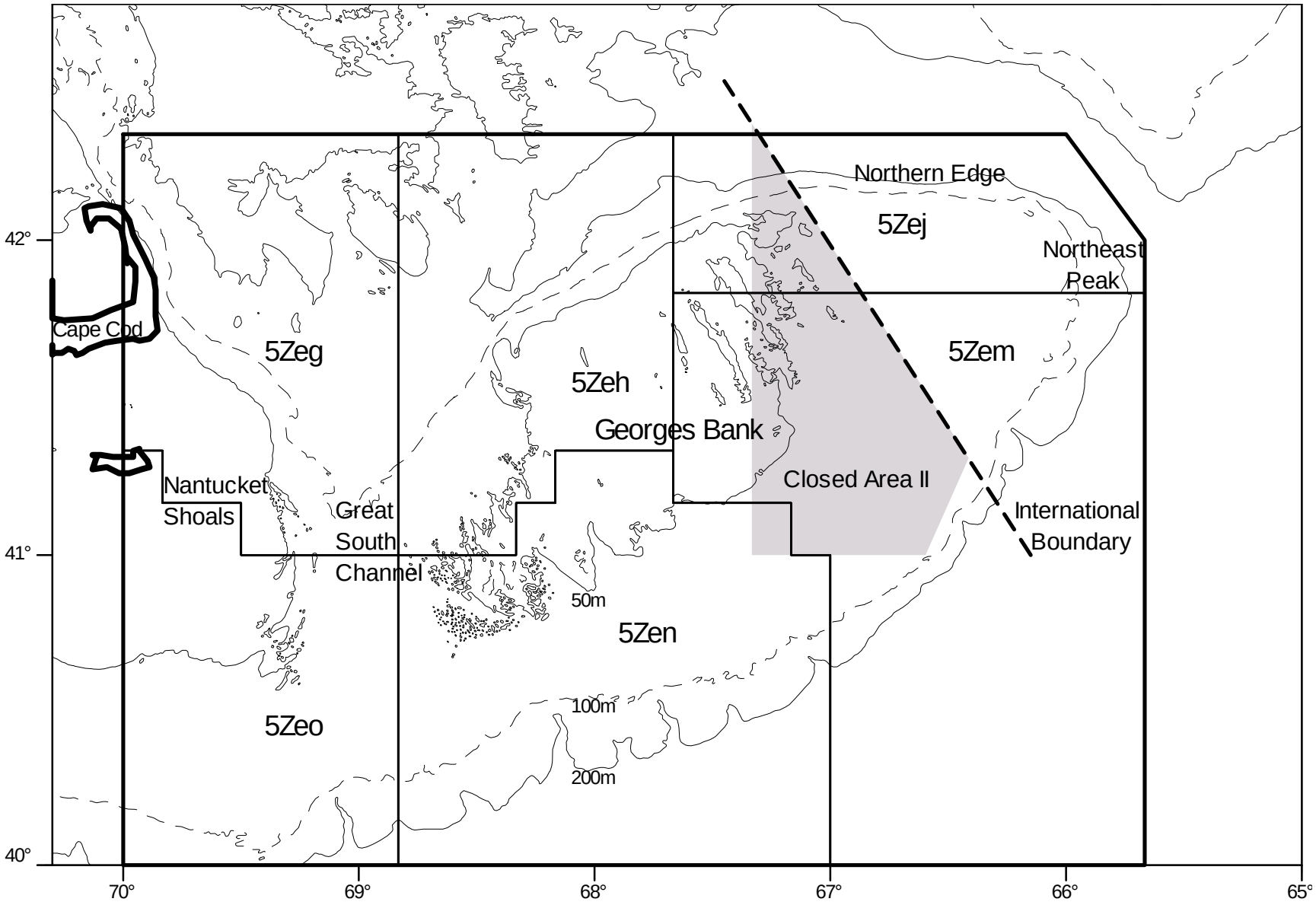

Figure 1. Fisheries statistical unit areas in NAFO Subdivision 5Ze.

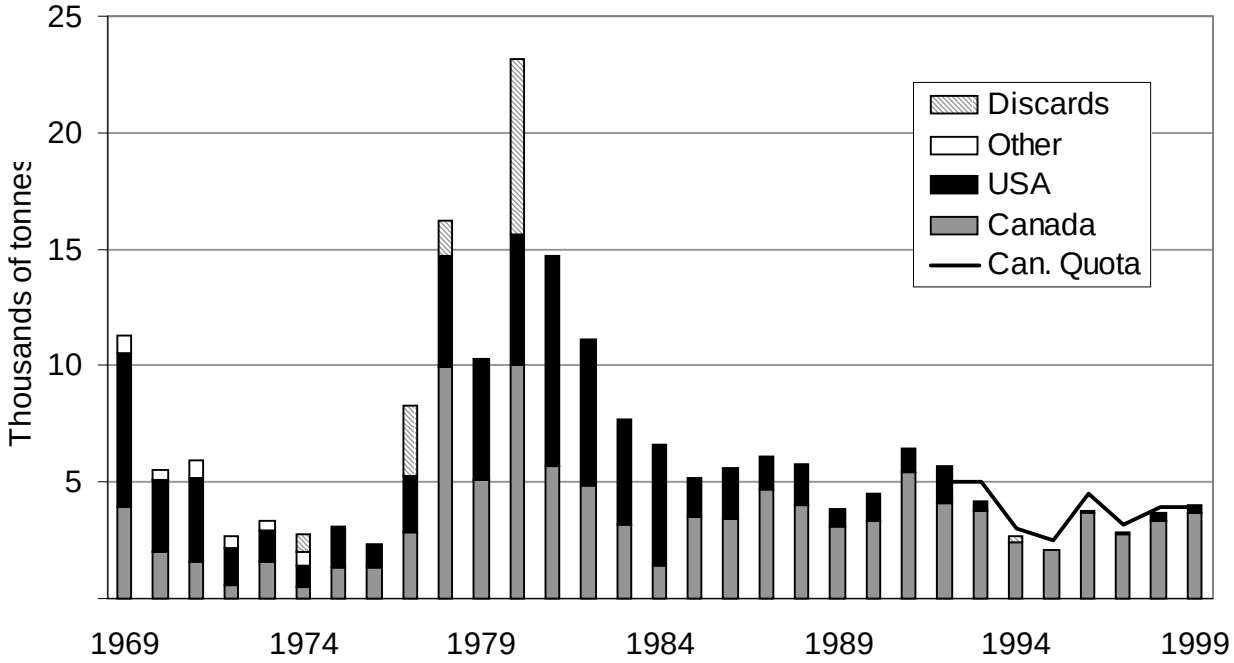

Figure 2. Nominal catch of haddock in unit areas 5Zjm.

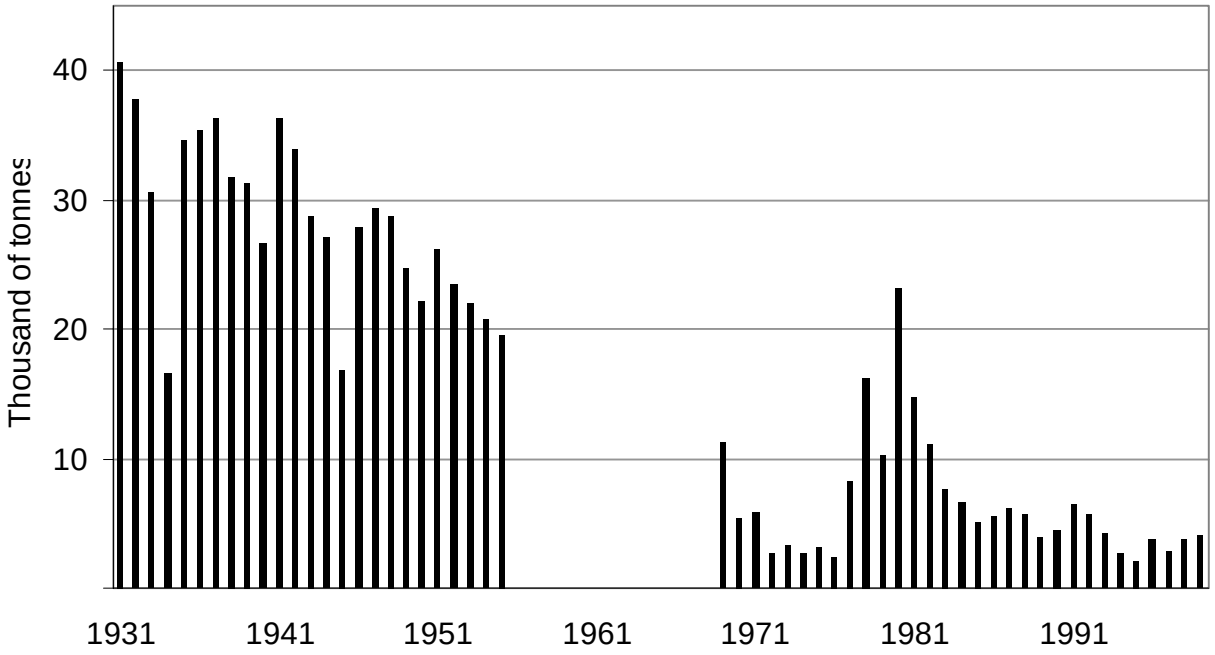

Figure 3. Historic catch of haddock in 5Zjm compared to recent catches.

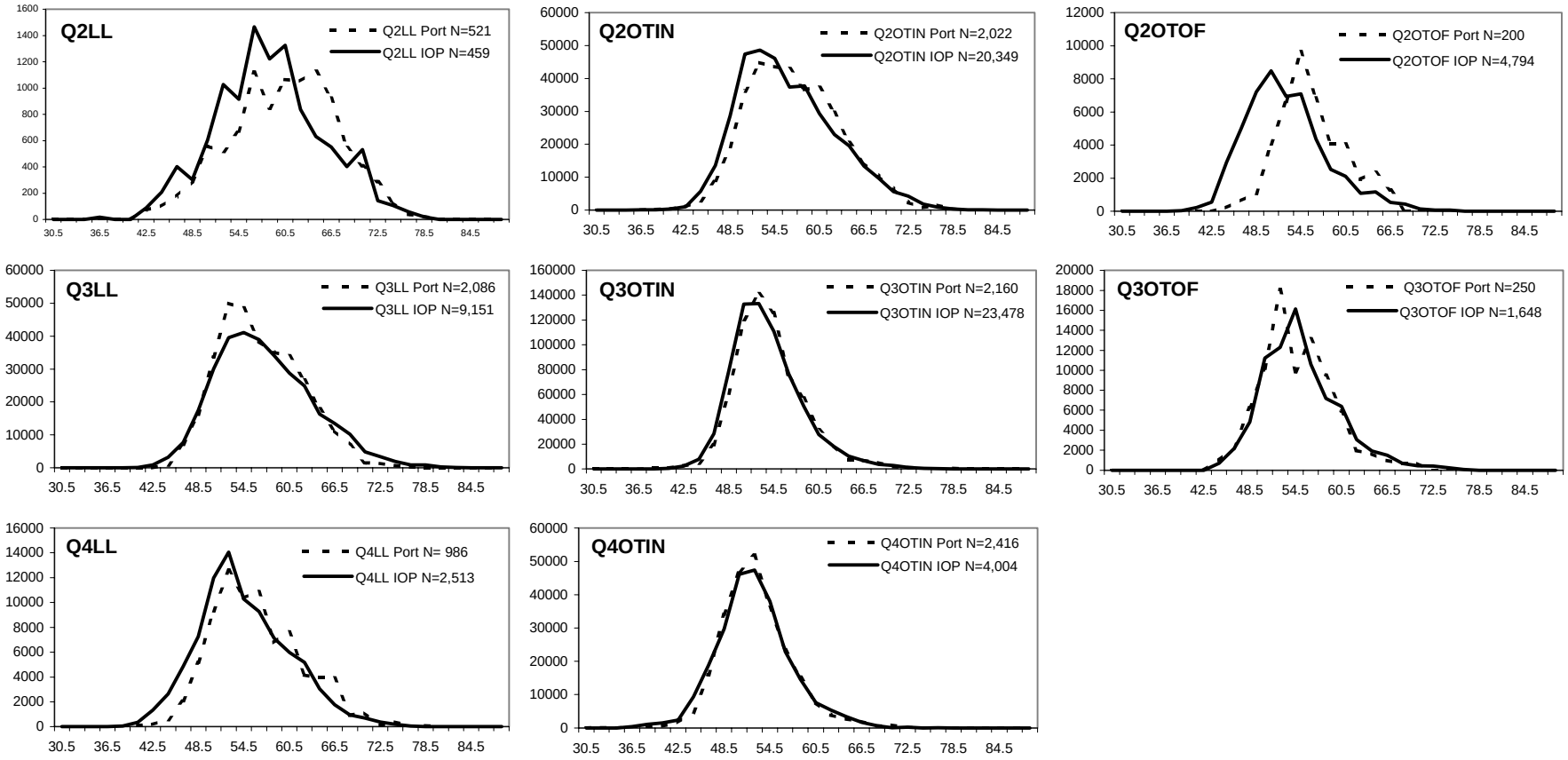

Figure 4. Comparison of length frequencies from port samples and sea samples by quarter and gear (LL = longline, OTIN = otter trawl tonnage classes 1-3, OTOF = otter trawl tonnage classes 4-5).

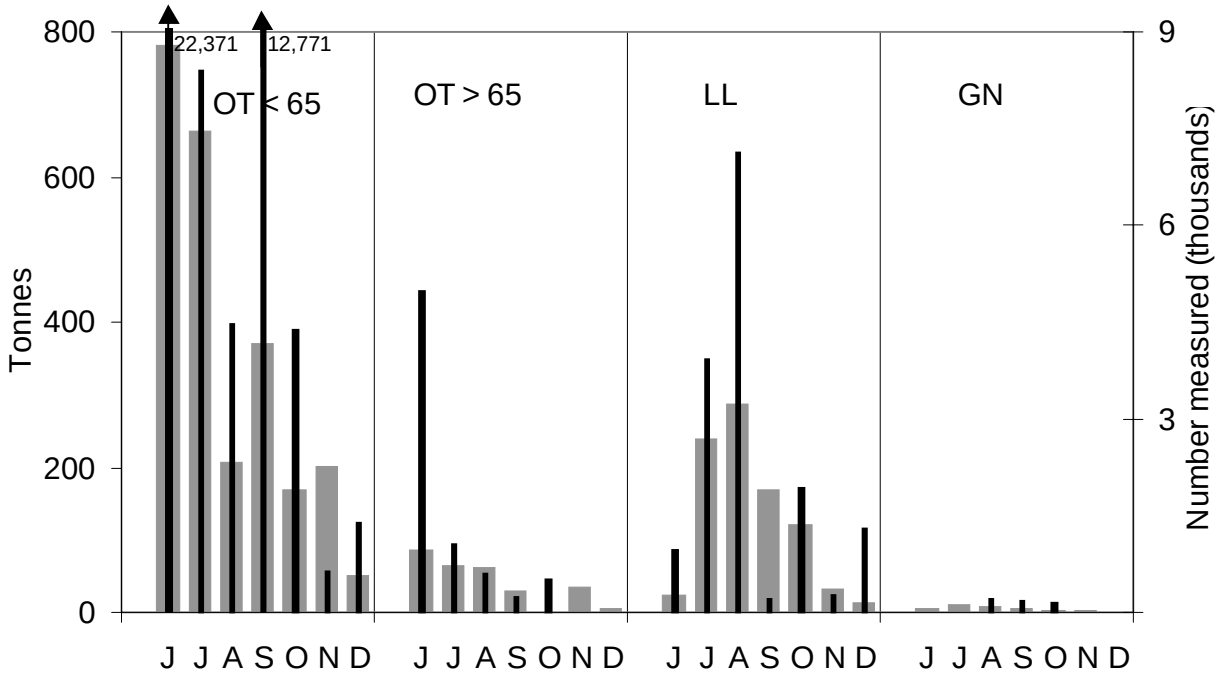

Figure 5. Haddock catches in 5Zjm by month and gear for the Canadian commercial fishery in 1999 (wide gray bars) with sampling levels (narrow black bars).

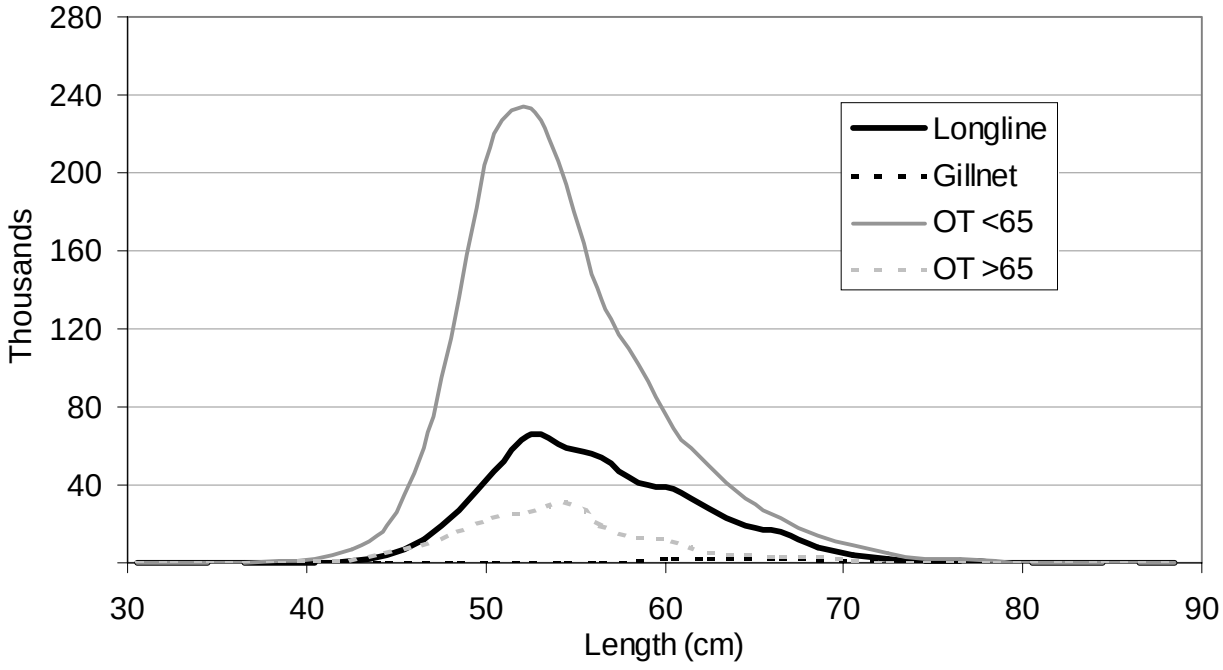

Figure 6. Catch at length by the principal Canadian 5Zjm commercial haddock fisheries in 1999.

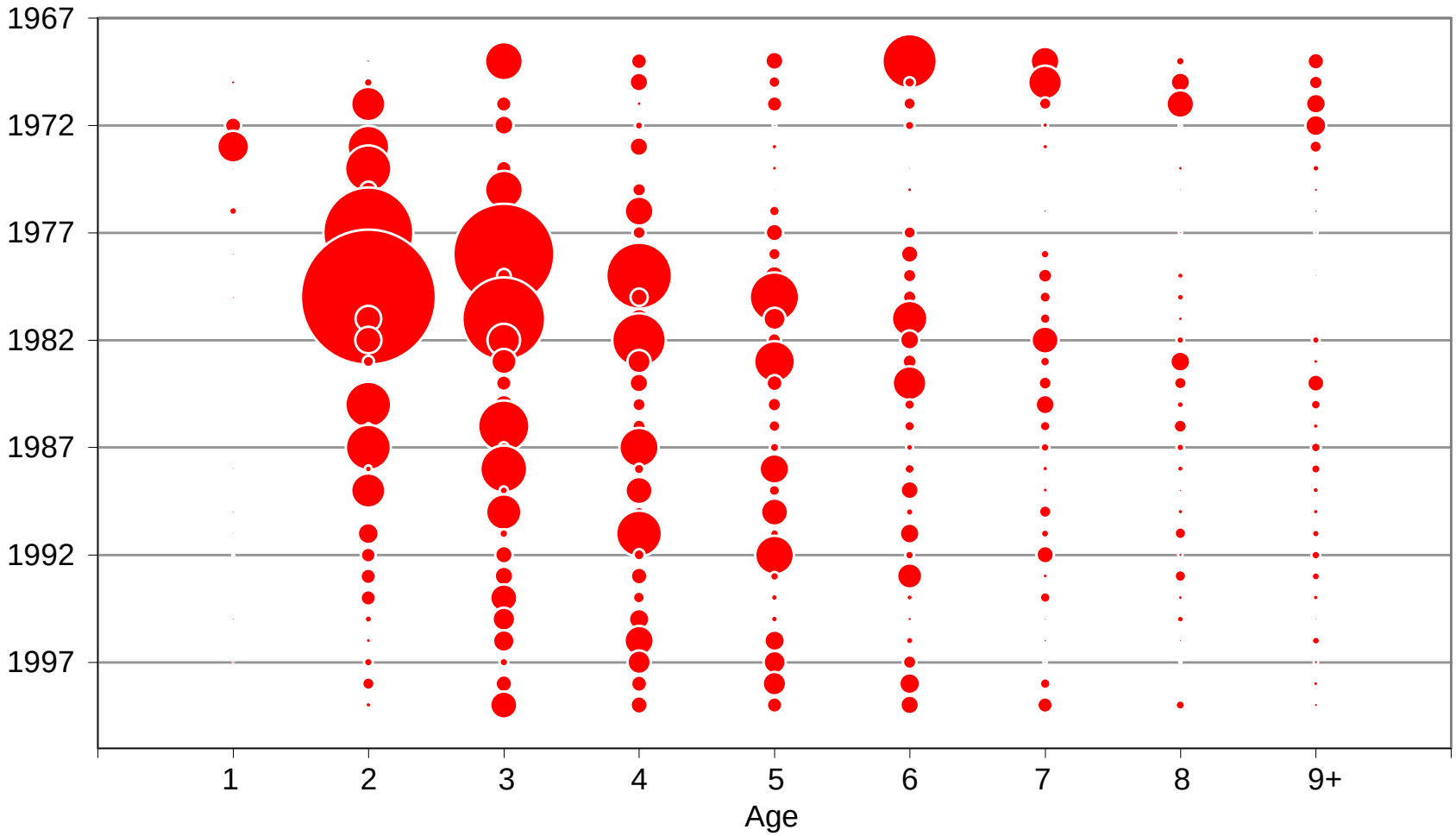

Figure 7. Total commercial catch at age (numbers) of haddock from unit areas 5Zjm. The bubble area is proportional to magnitude (see Table 9).

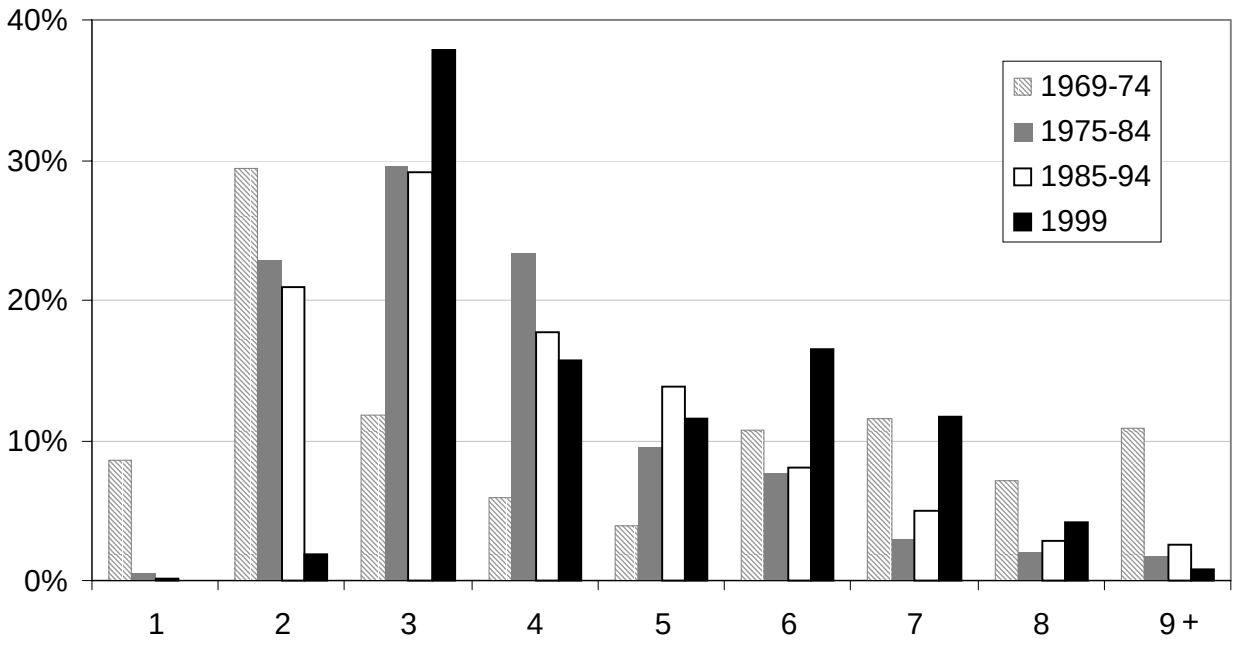

Figure 8. Age composition of the haddock catch for the Canadian 5Zjm commercial fishery in 1999 compared to the average age composition for the total catch of all fisheries during three earlier periods.

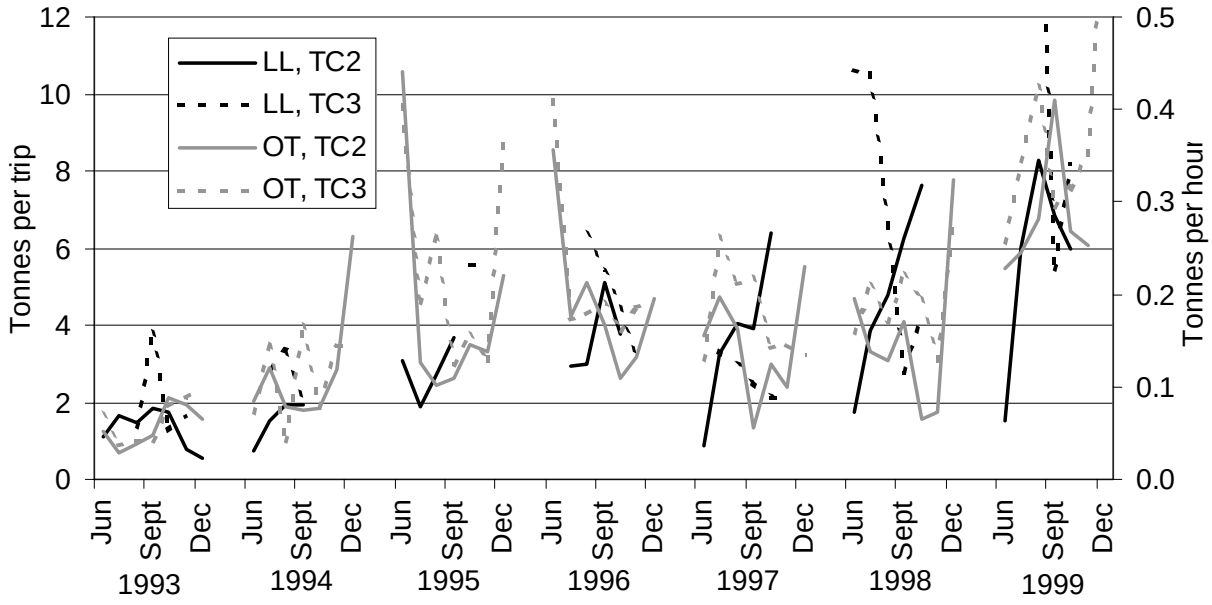

Figure 9. Catch rates for haddock from the Canadian commercial fishery in 5Zjm. (LL = longline, OT = otter trawl, TC = tonnage class).

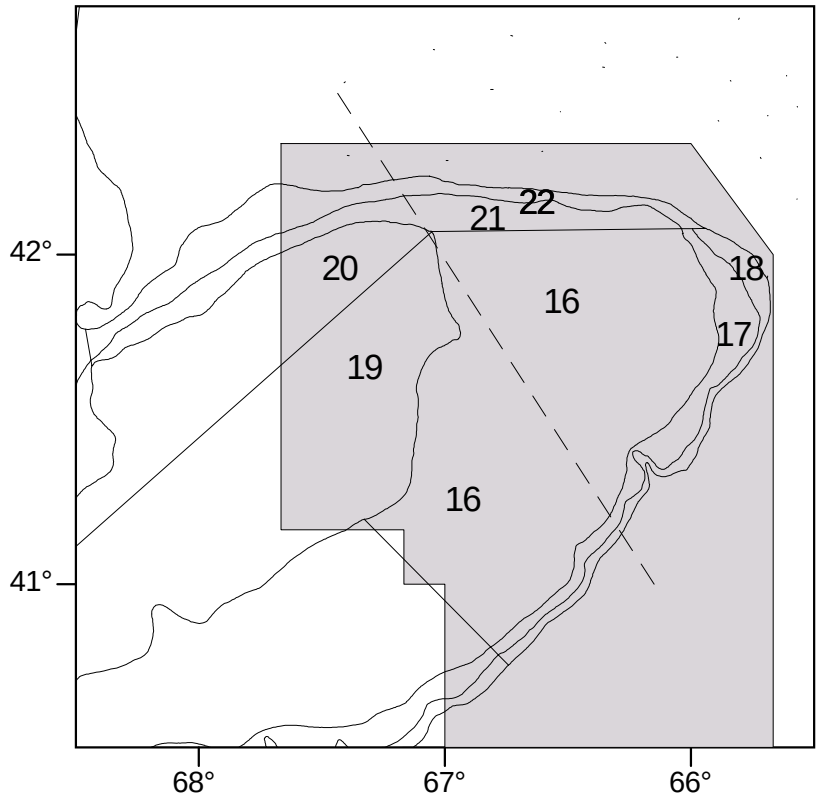

Figure 10. Stratification scheme used for NMFS surveys. The 5Zjm management area is indicated by shading.

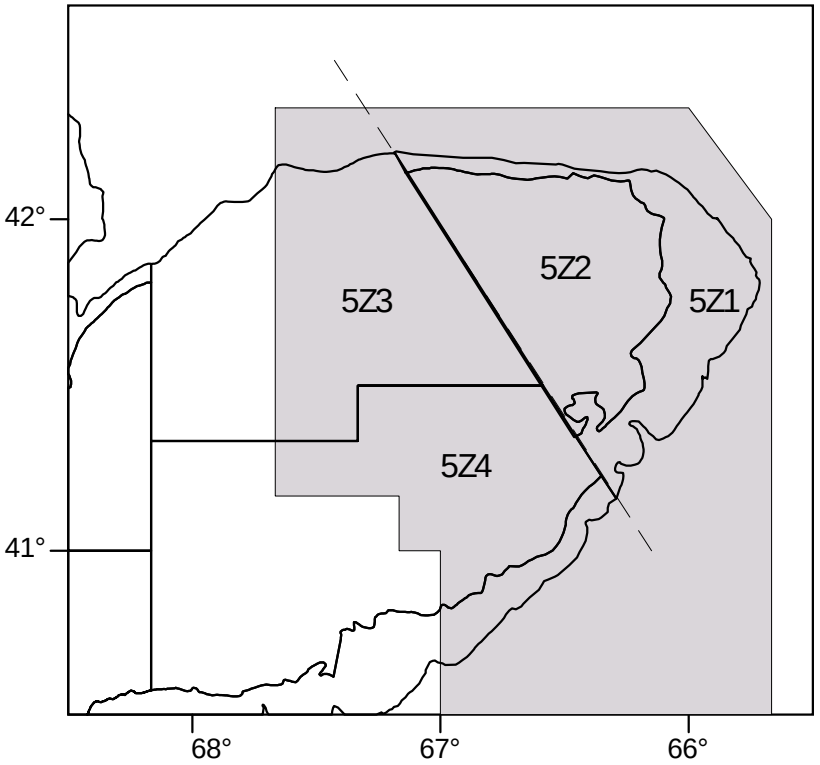

Figure 11. Stratification scheme used for the DFO survey. The 5Zjm management area is indicated by shading.

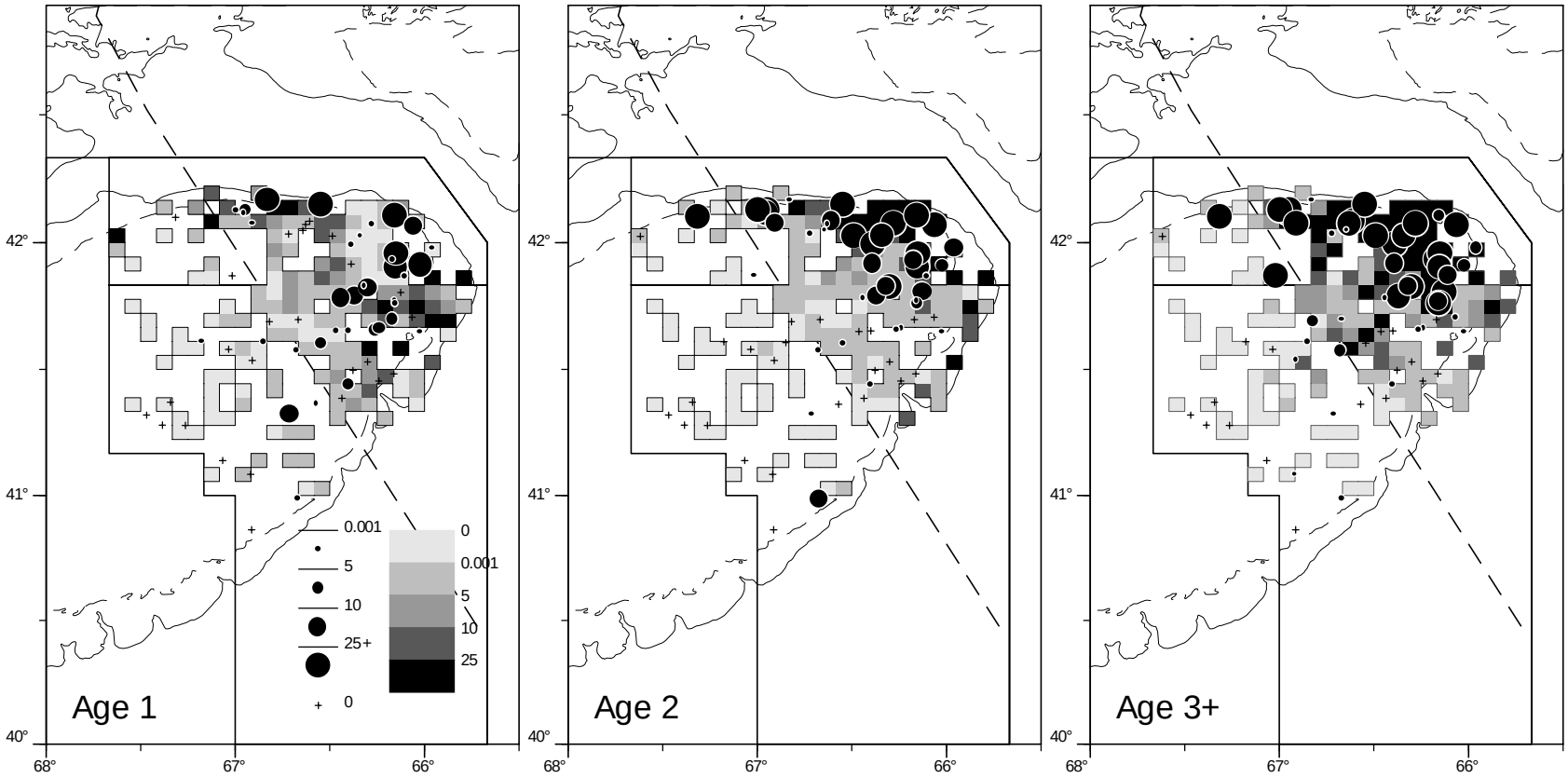

Figure 12. Distribution of 5Zjm haddock abundance (number/tow) as observed from the **DFO spring** survey. The squares are shaded relative to the average catch for 1995 to 1999. The expanding symbols represent the 2000 survey catches.

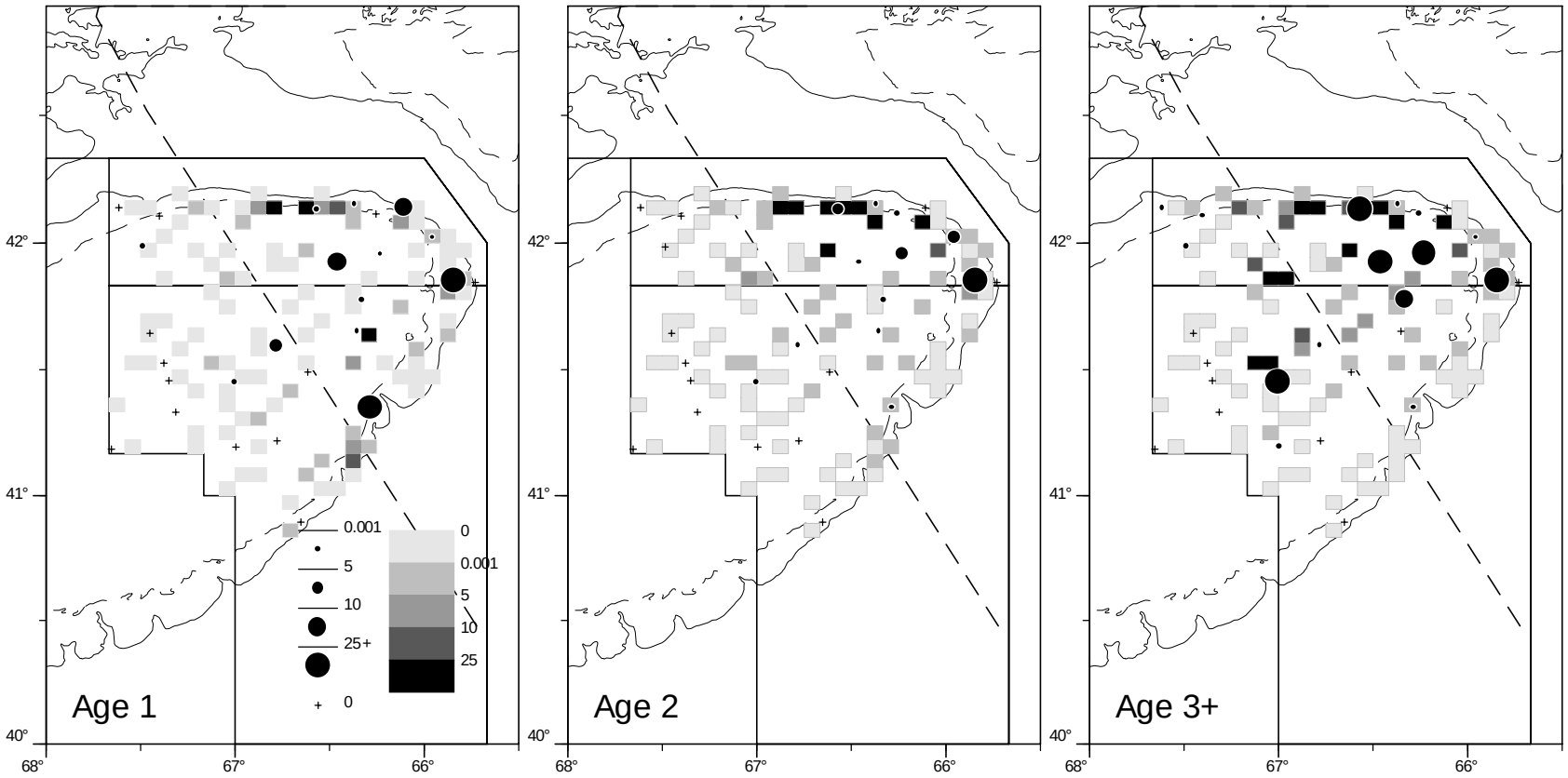

Figure 13. Distribution of 5Zjm haddock abundance (number/tow) as observed from the **NMFS spring** survey. The squares are shaded relative to the average catch for 1994 to 1998. The expanding symbols represent the 1999 survey catches.

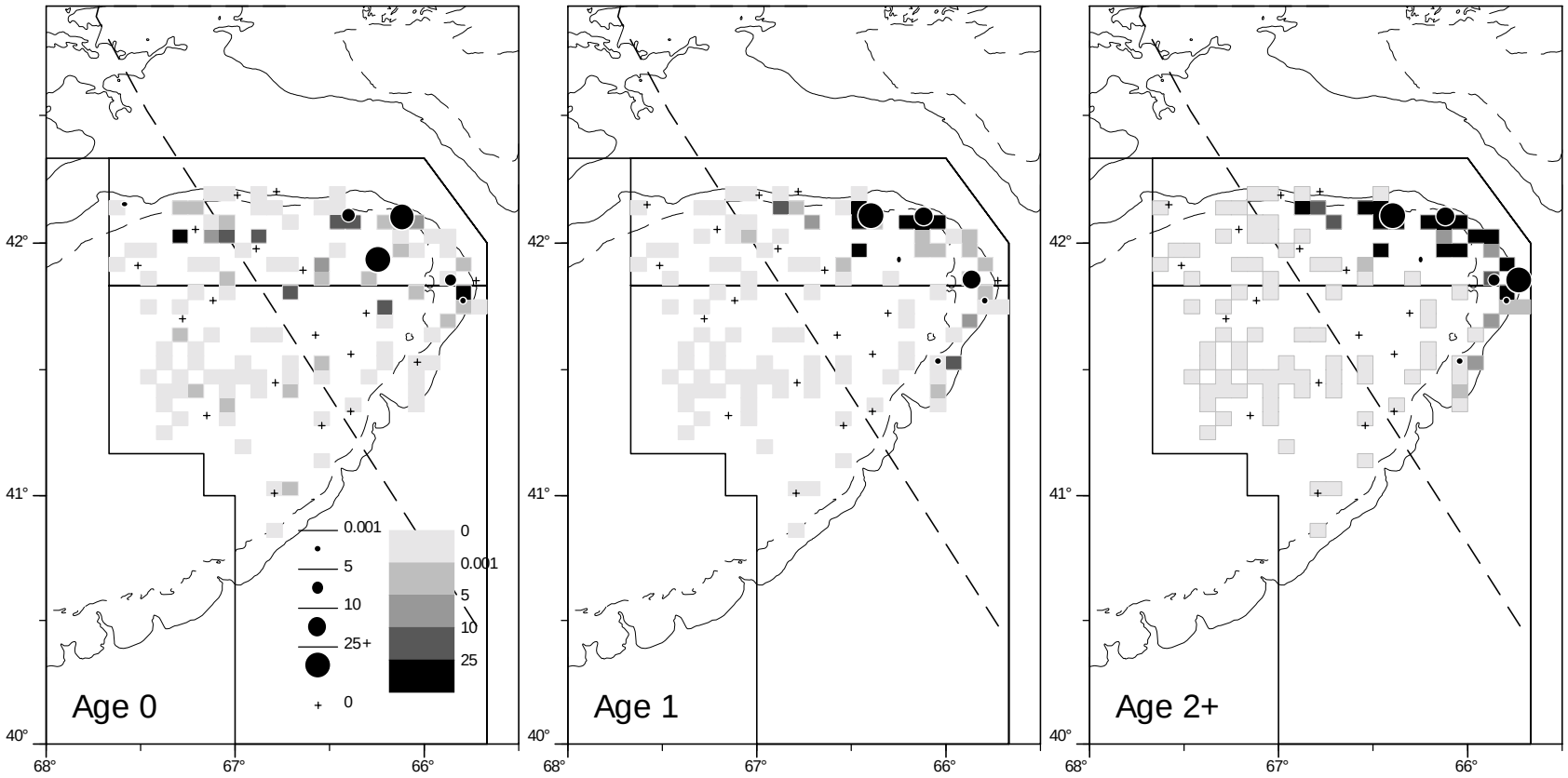

Figure 14. Distribution of 5Zjm haddock abundance (number/tow) as observed from the **NMFS fall** survey. The squares are shaded relative to the average catch for 1994 to 1998. The expanding symbols represent the 1999 survey catches.

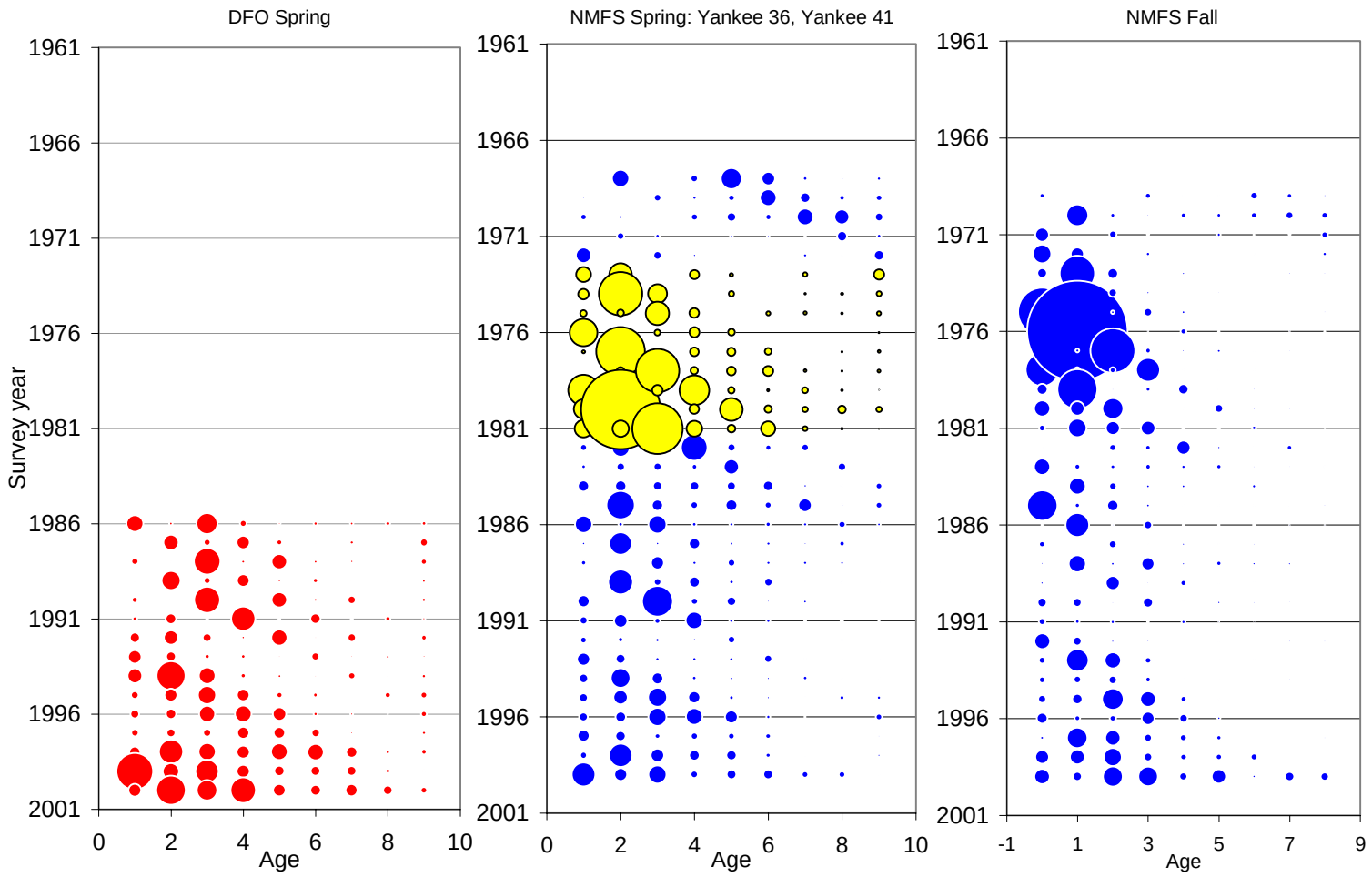

Figure 15. Estimated abundance at age (numbers in 000's) of haddock for the DFO and NMFS spring surveys and the NMFS fall survey. Bubble area is proportional to magnitude (see Tables 12-14). Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 1973-81, a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years. Symbol size has not been adjusted between surveys for the catcability of the survey.

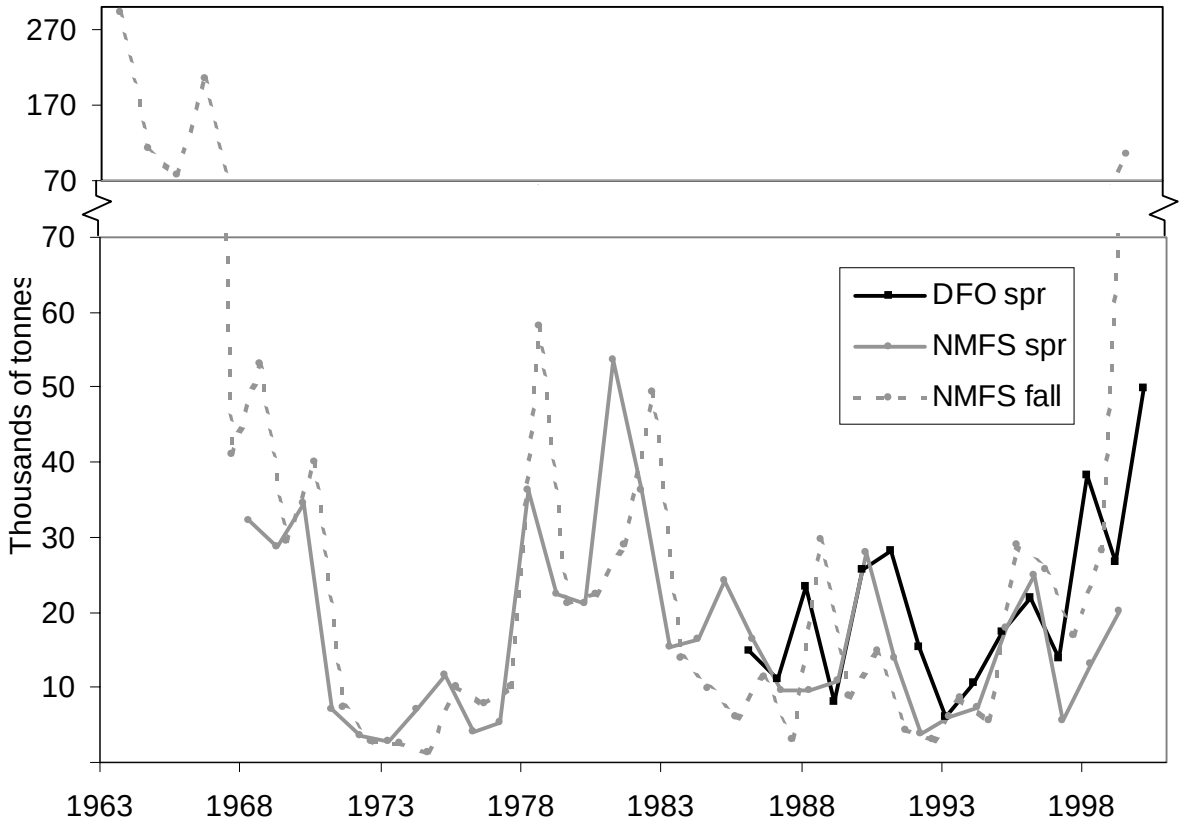

Figure 16. Biomass for ages 3-8 from the NMFS and DFO research surveys (adjusted by calibration constants) for haddock in unit areas 5Zjm..

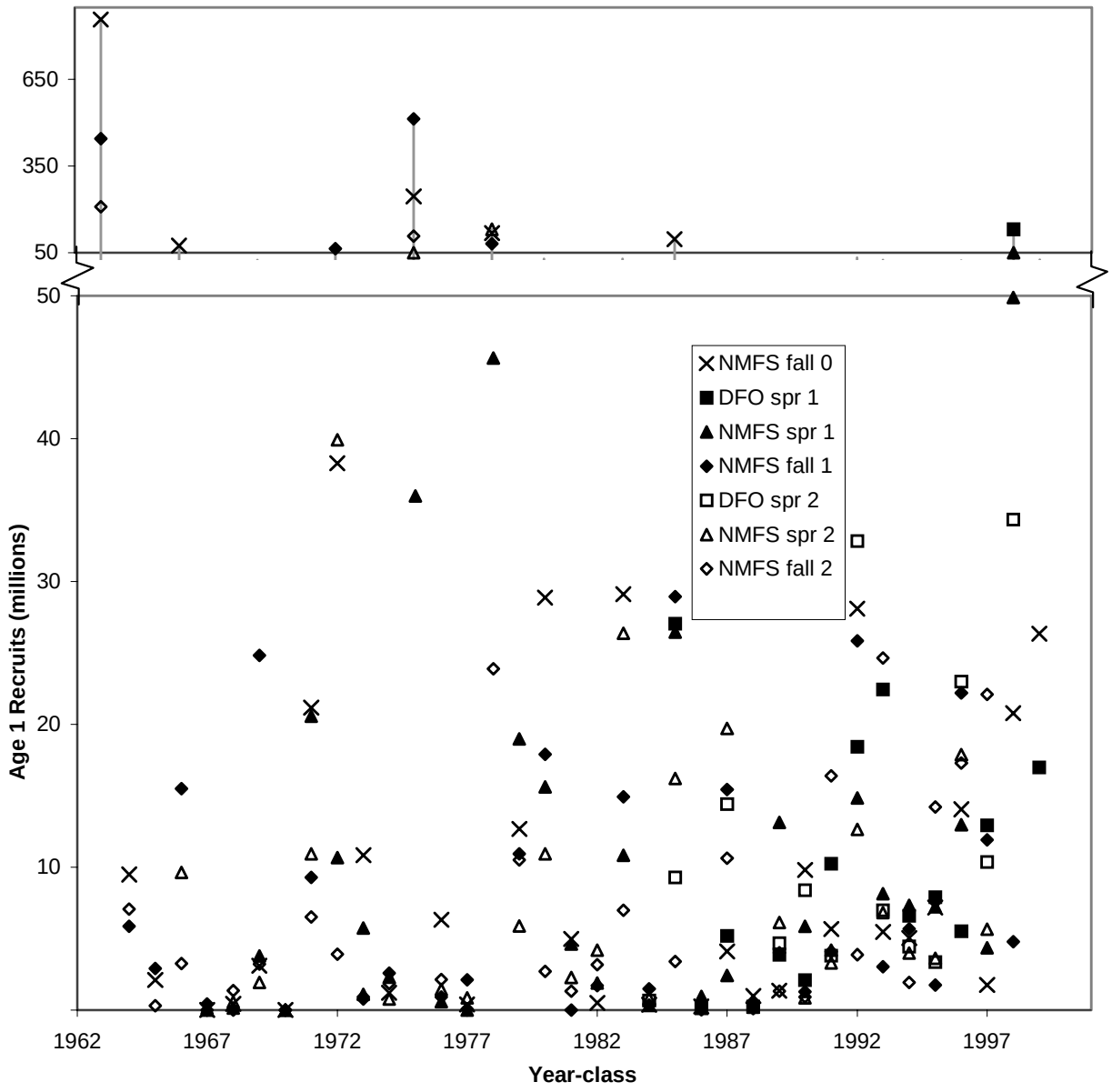

Figure 17. Year-class abundance for ages 0, 1 and 2 from the NMFS fall and ages 1 and 2 from the NMFS and DFO spring research surveys (adjusted by calibration constants) for haddock in unit areas 5Zjm.

Figure 18. Weight at age for haddock in unit areas 5Zjm derived from the DFO spring surveys.

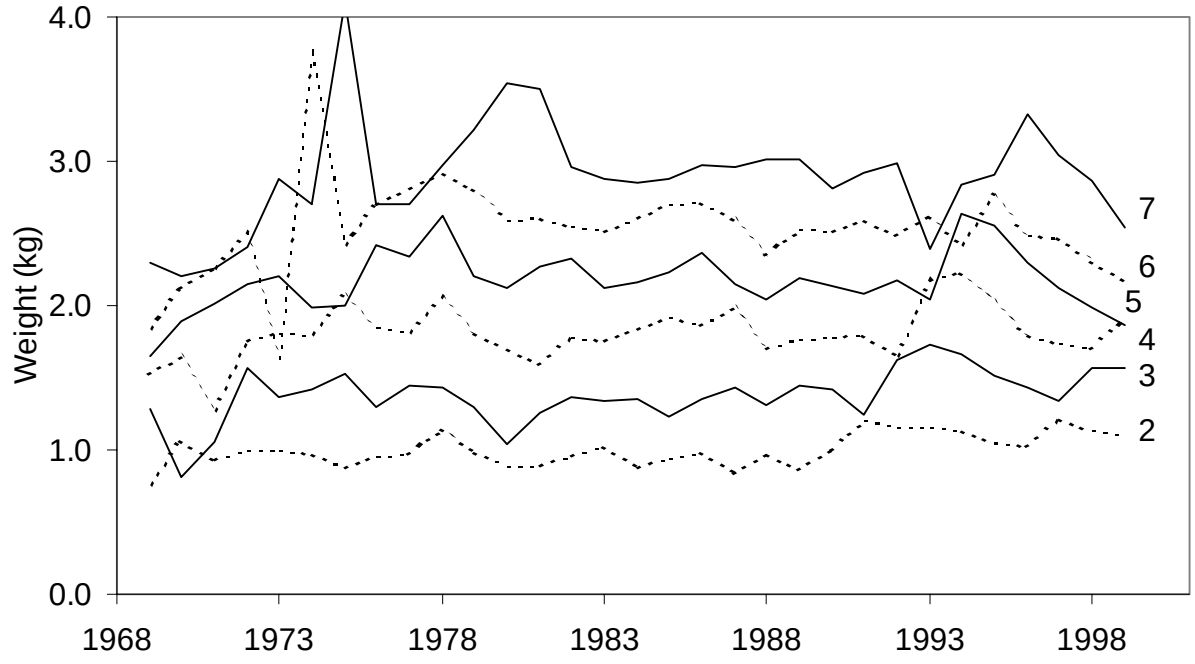

Figure 19. Weight at age for haddock in unit areas 5Zjm derived from the commercial fisheries.

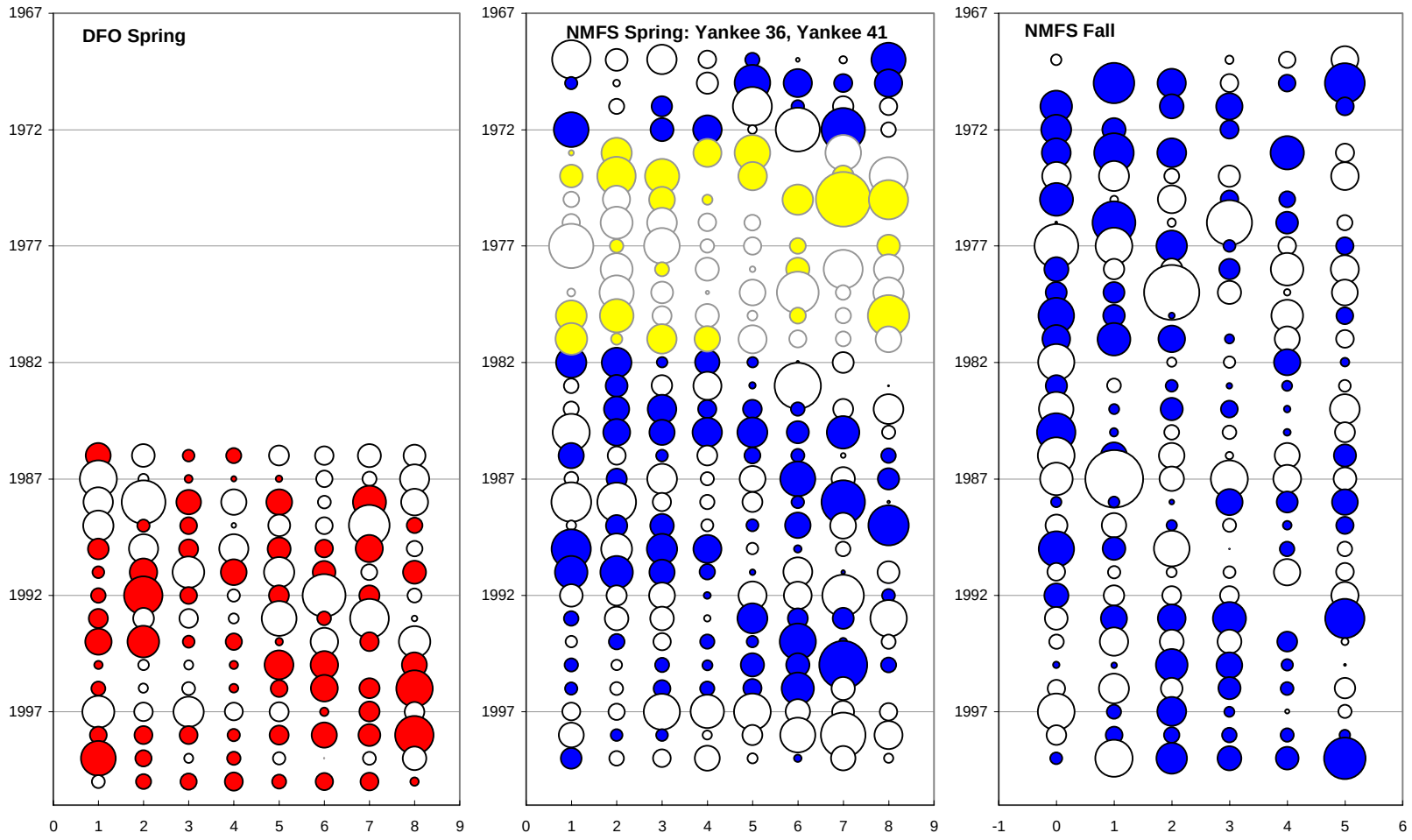

Figure 20. Residuals by year and age group for each research survey index. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude.

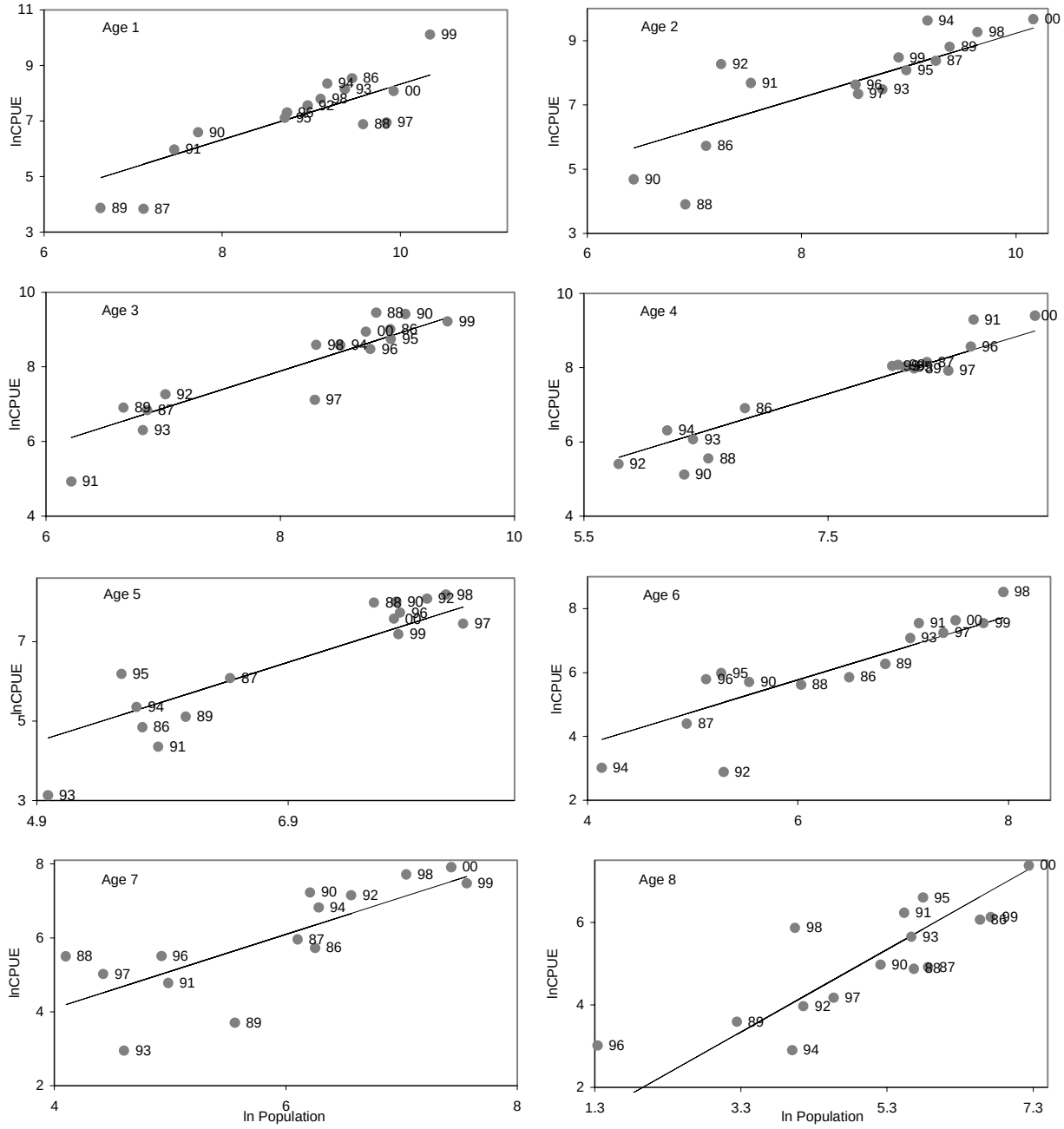

Figure 21. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **DFO spring** survey.

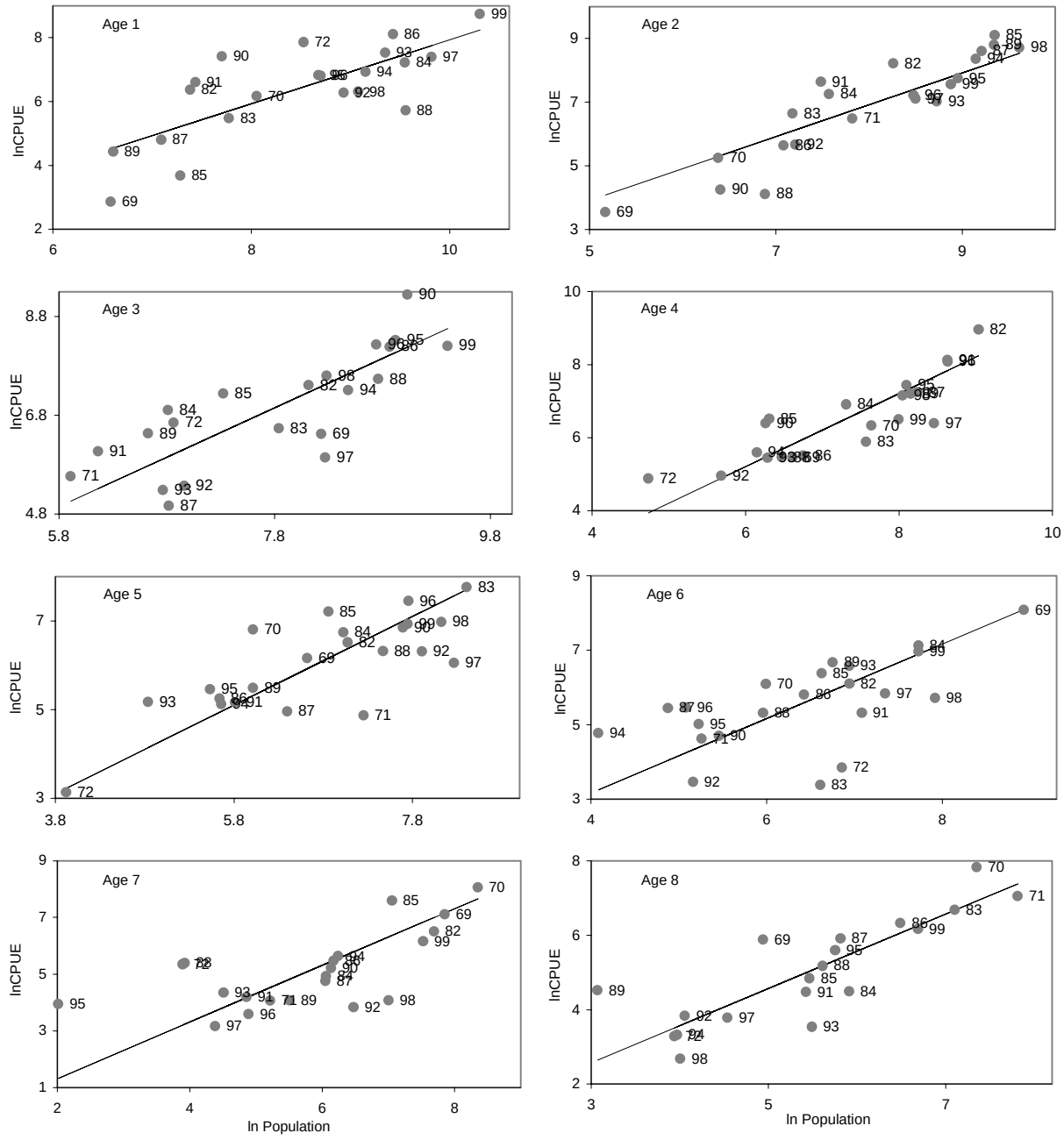

Figure 22. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **NMFS spring** survey with a Yankee 36 net.

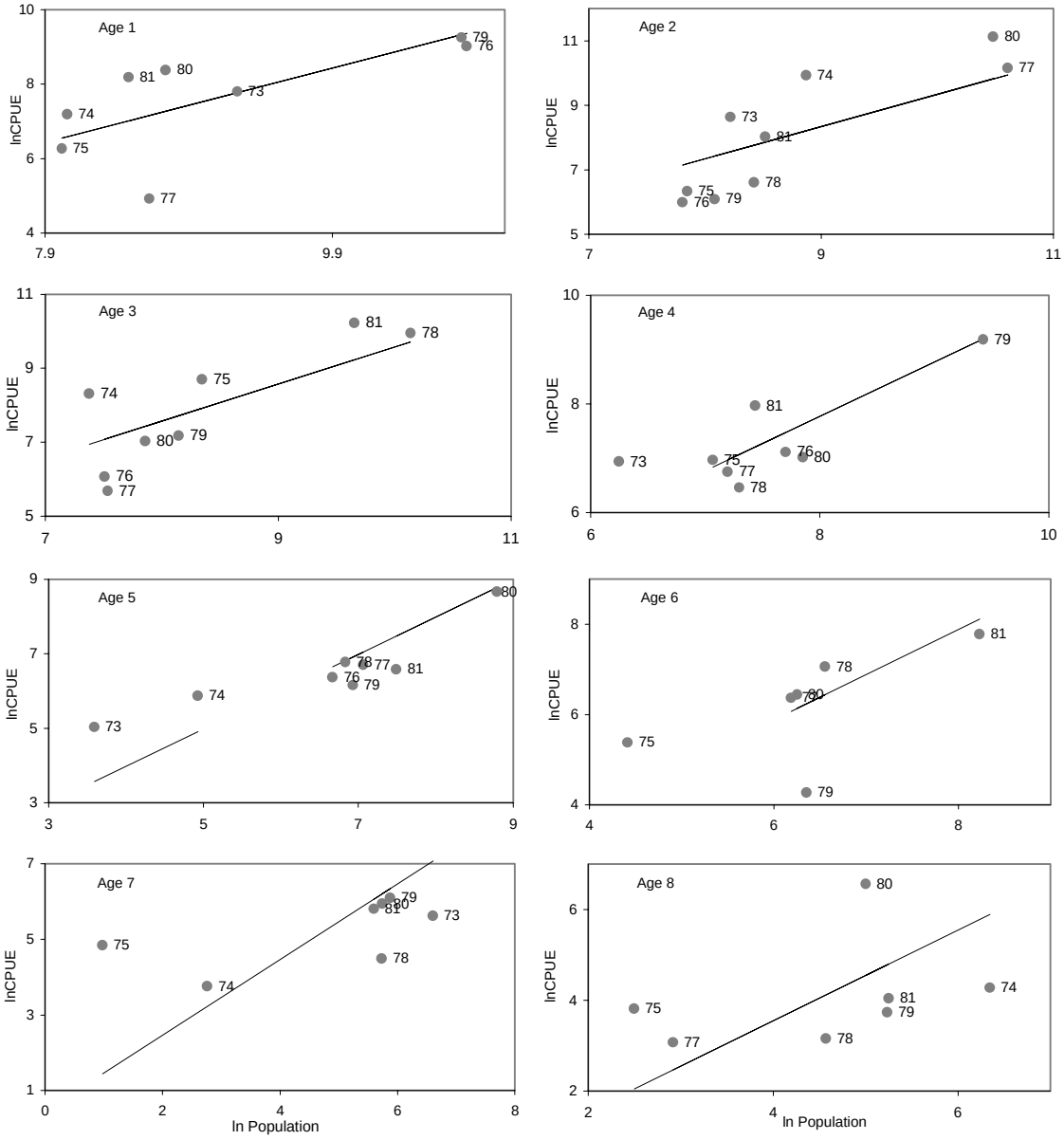

Figure 23. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **NMFS spring** survey with a Yankee 41 net.

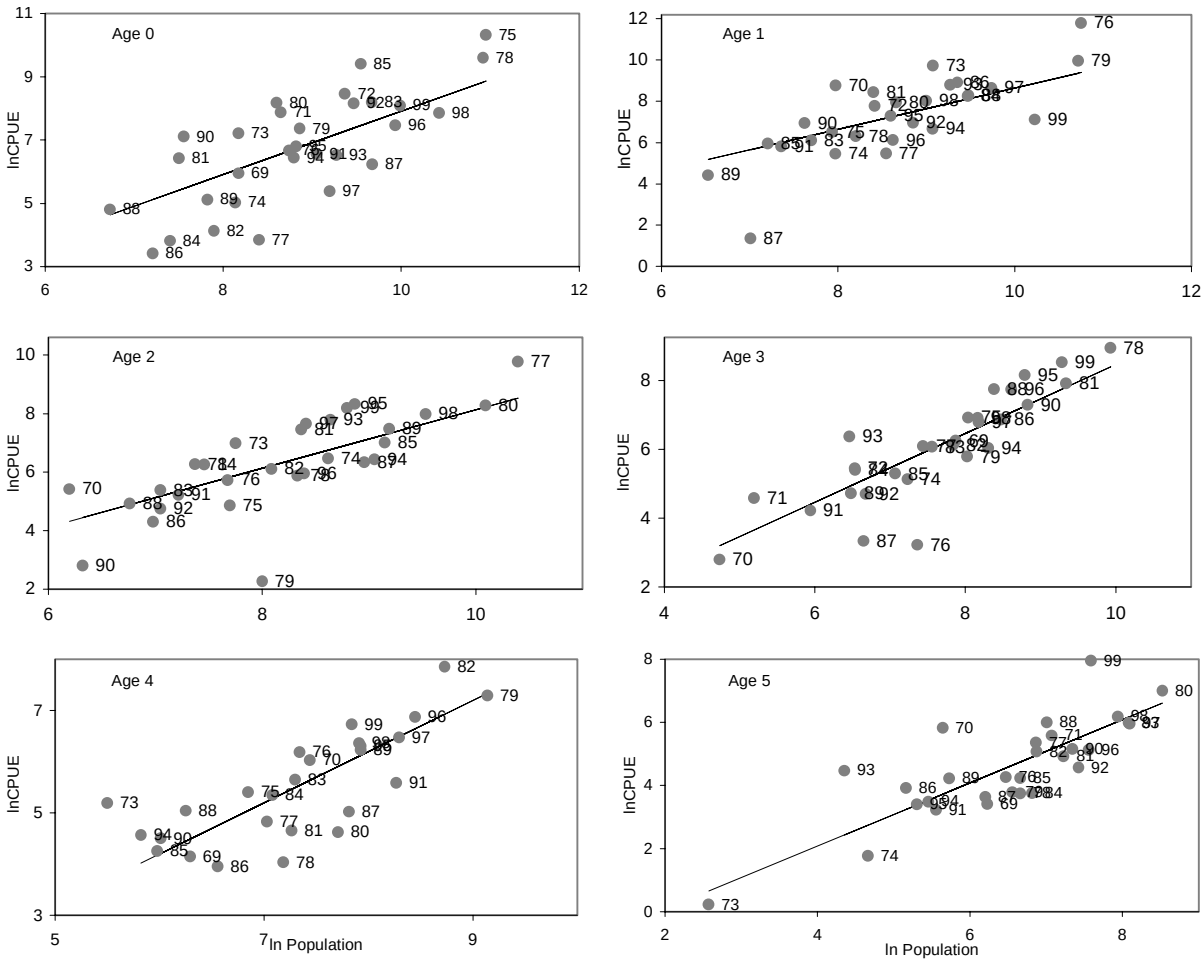

Figure 24. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **NMFS fall** survey.

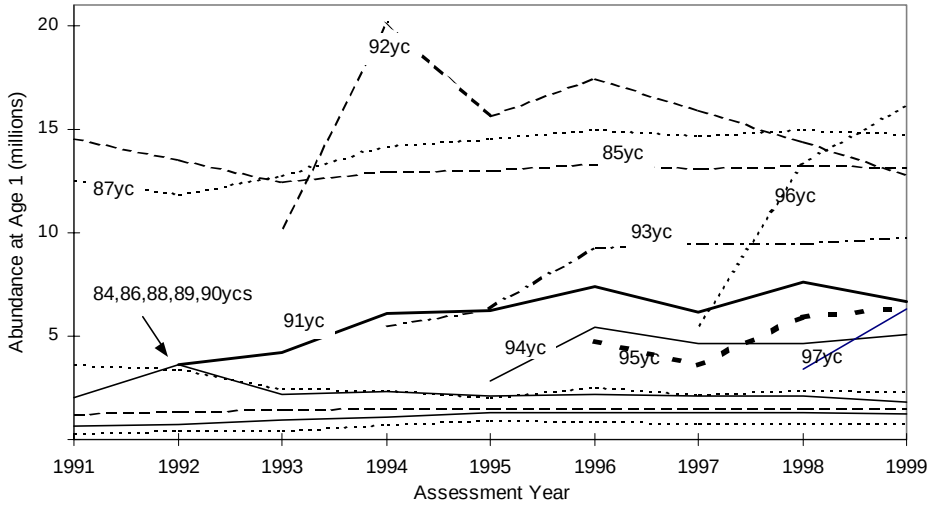

Figure 25. Successive estimates of year-class abundance as additional years of data were included in the assessment did not display any persistent trends.

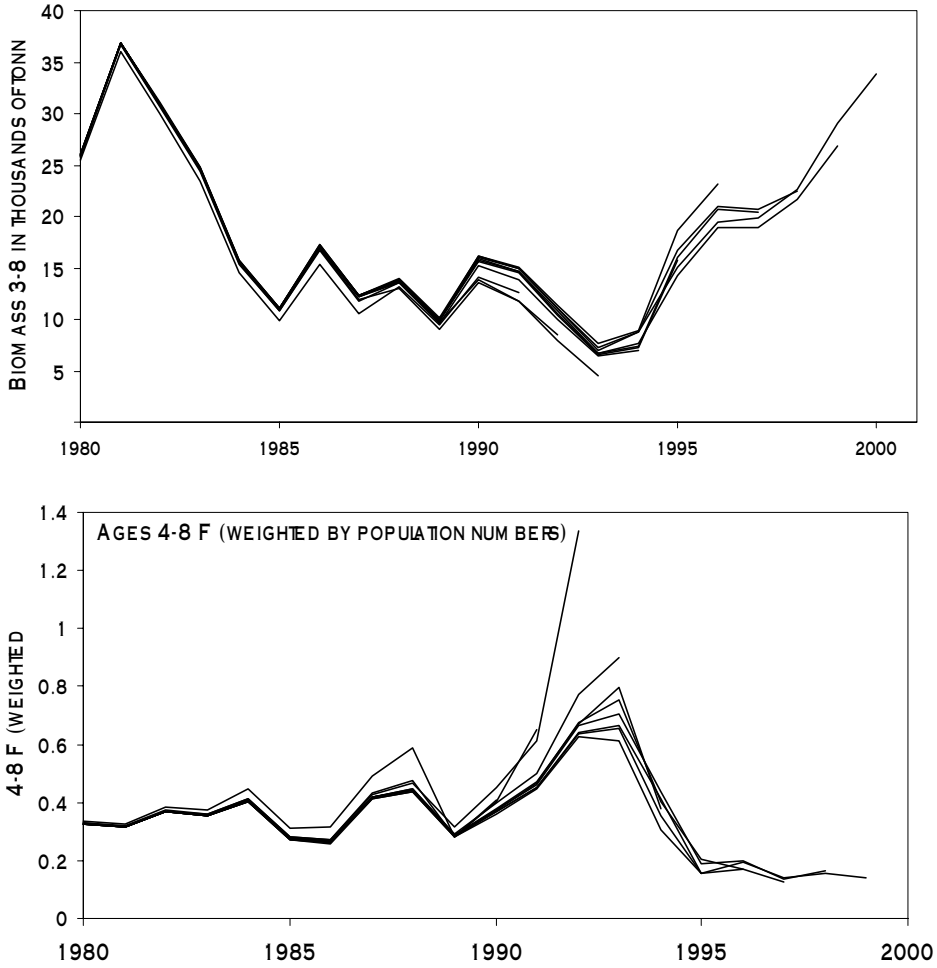

Figure 26. Retrospective estimates of biomass and fishing mortality did not display any persistent trends for over or under estimation as successive years of data were excluded in the assessment.

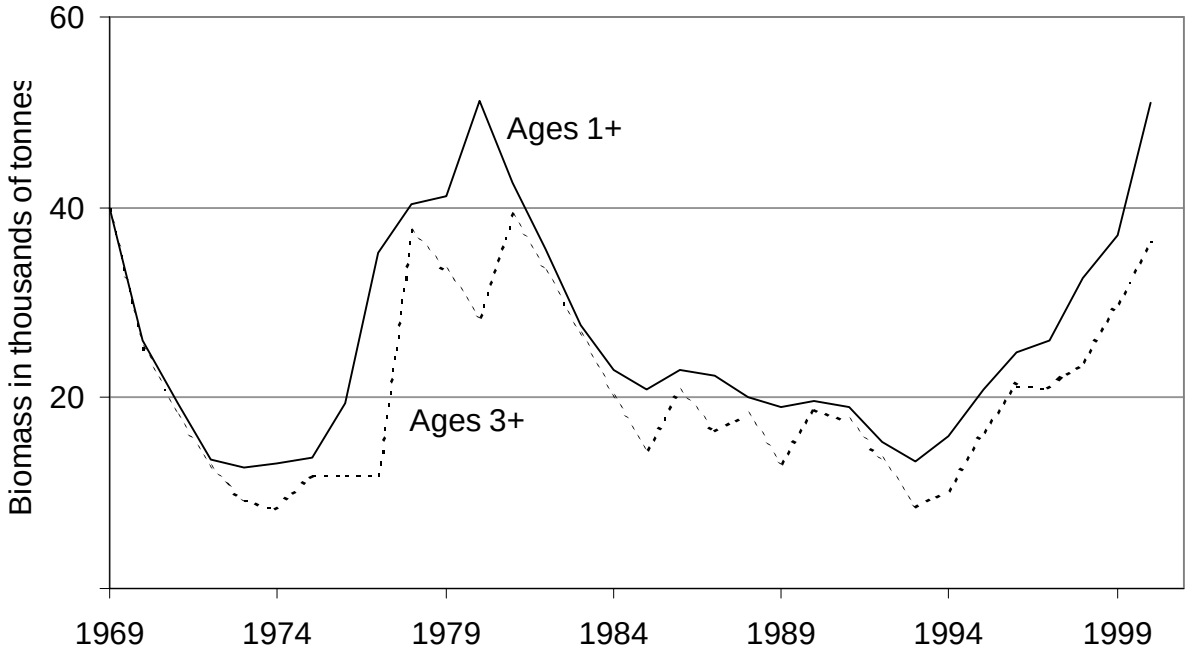

Figure 27. Beginning of year biomass for haddock in unit areas 5Zjm.

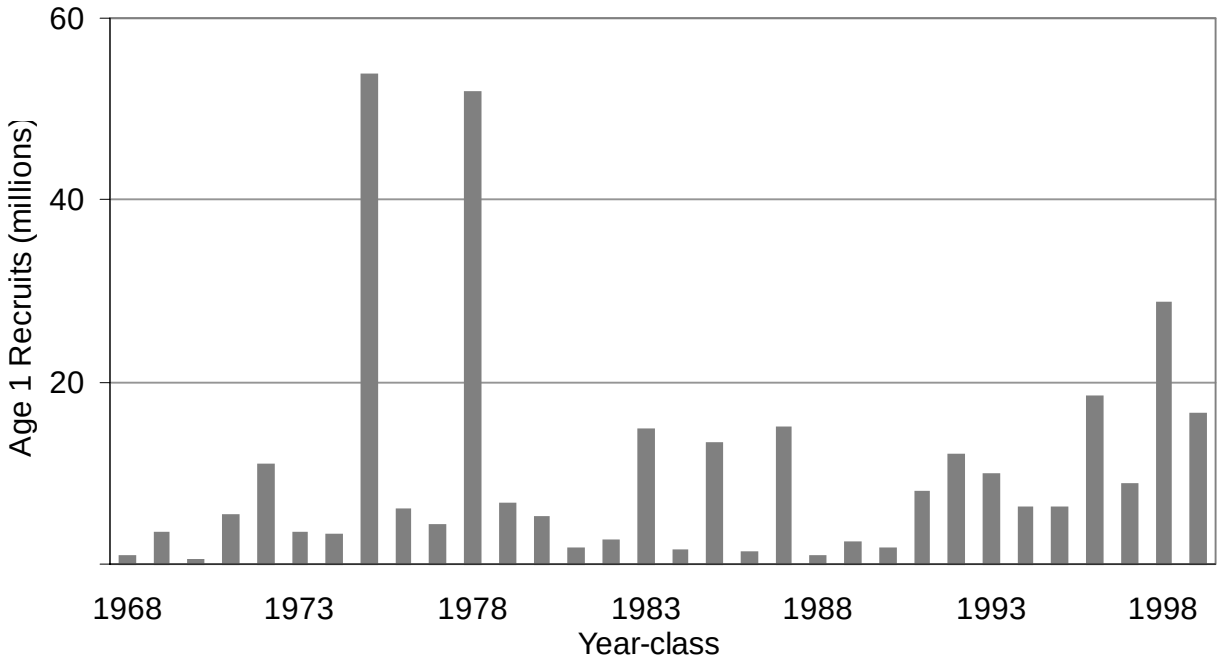

Figure 28. Number of age 1 recruits for haddock in unit areas 5Zjm.

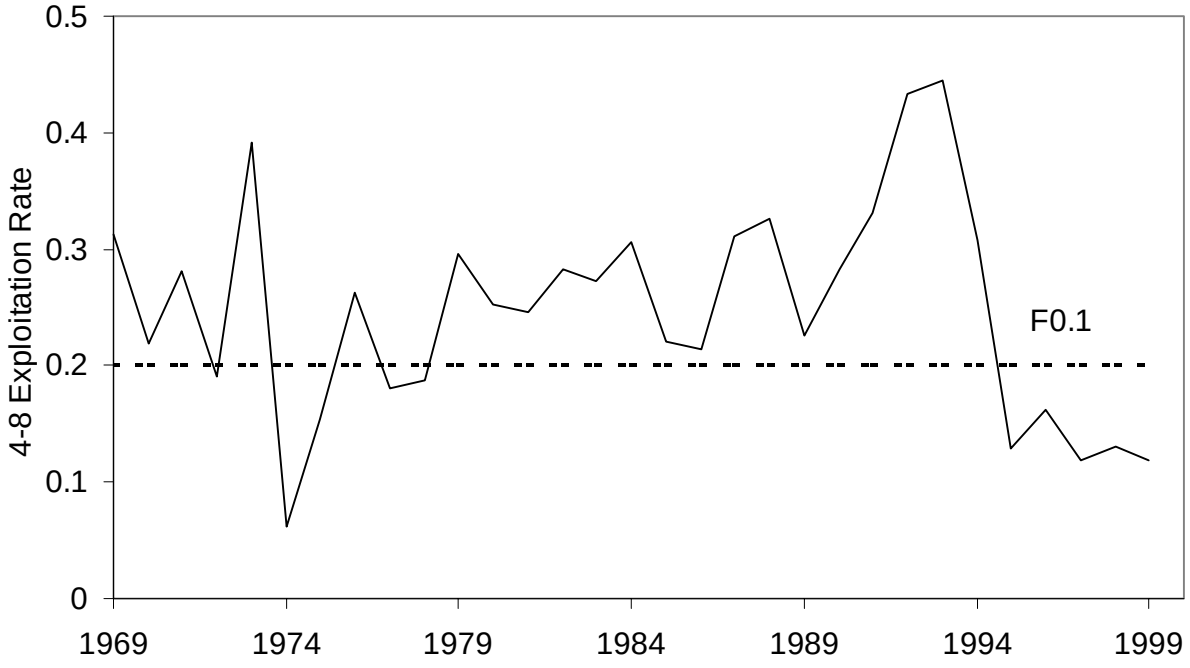

Figure 29. Exploitation rate for haddock ages 4 to 8 in unit areas 5Zjm.

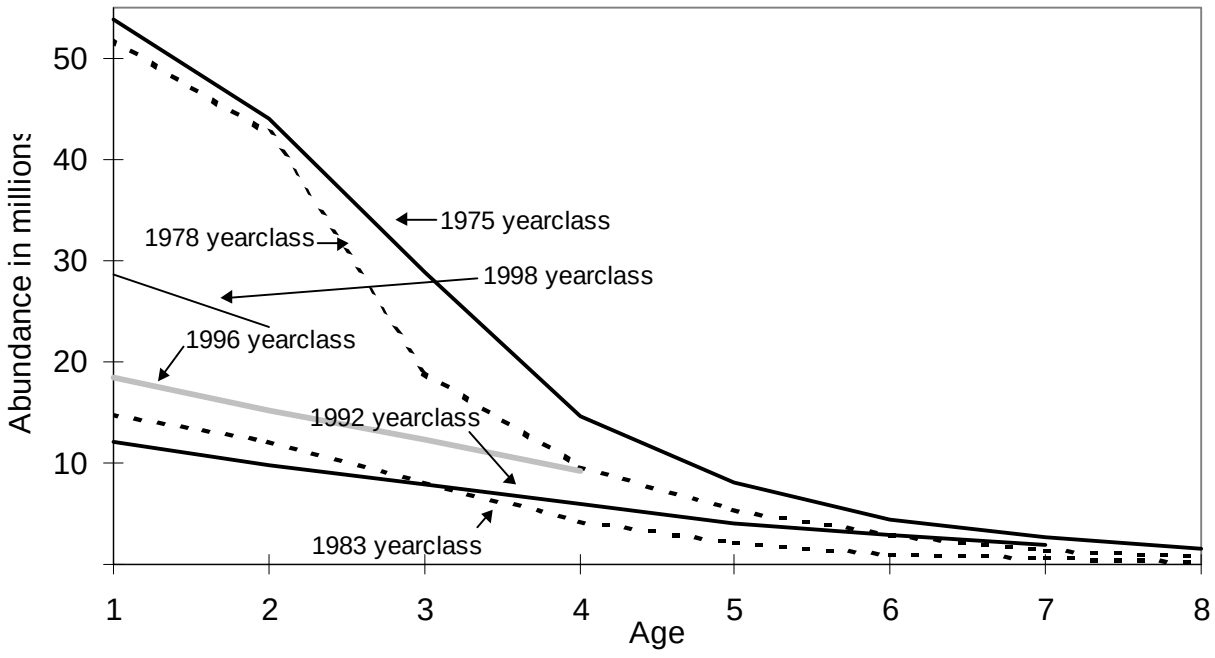

Figure 30. Decay of the 1992, 1996 and 1998 year-classes of the 5Zjm haddock population compared to the 1983, 1975 and 1978 as they progress through the fishery.

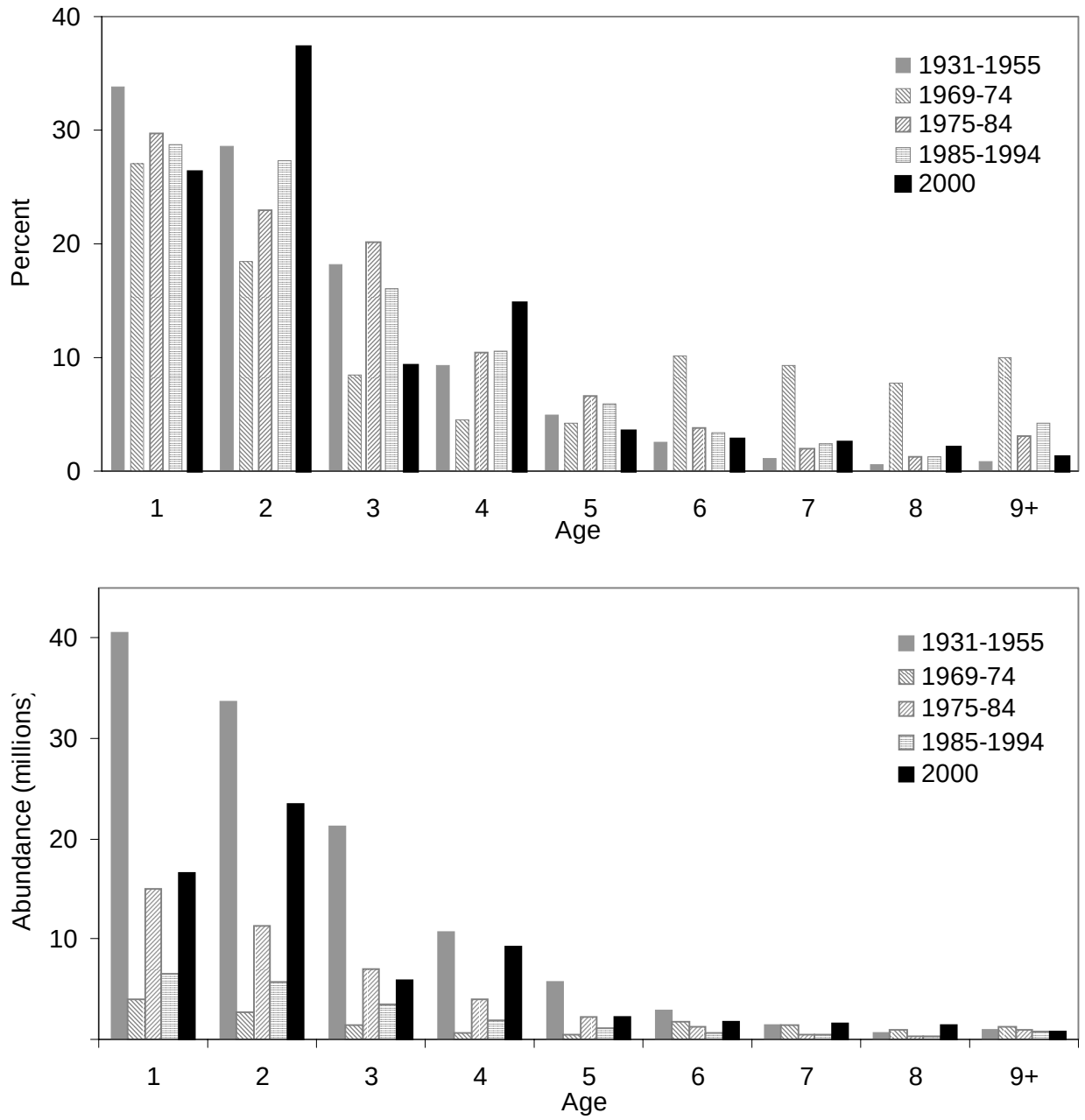

Figure 31. Comparison of age composition and absolute abundance of the 5Zjm haddock population in 2000 to earlier periods.

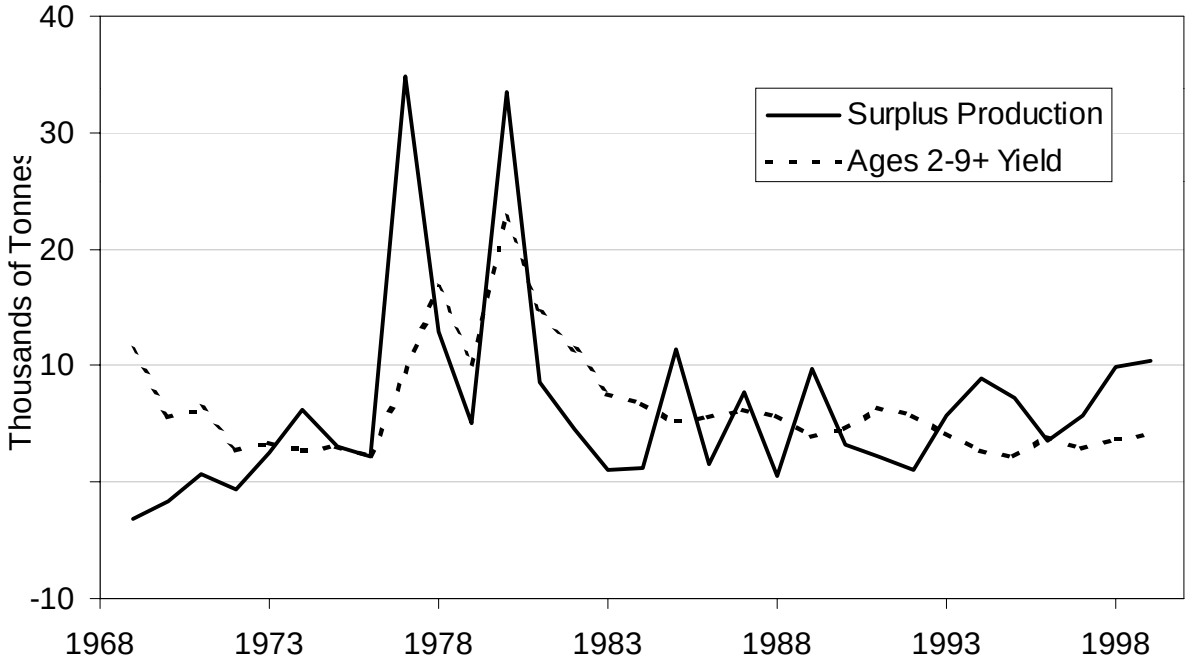

Figure 32. Surplus production of 5Zjm haddock available to the commercial fishery compared to amount actually harvested.

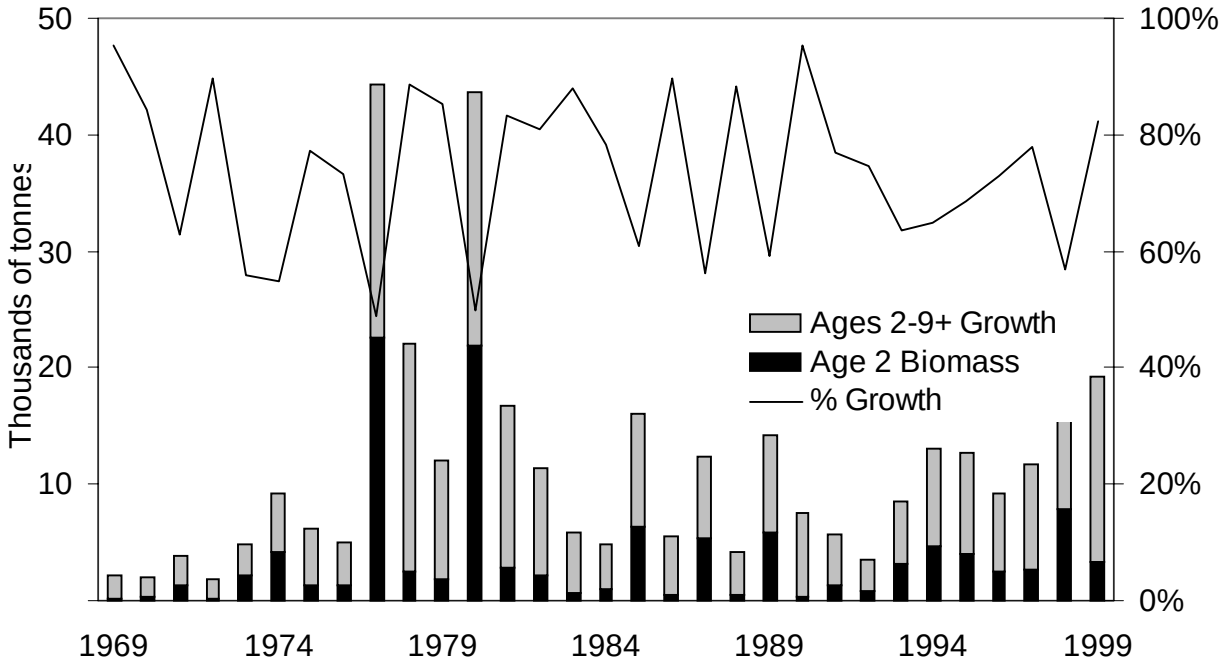

Figure 33. Amount of productivity attributible to growth of ages 2 to 8 5Zjm haddock and the amount contributed by recruitment of age 2 haddock.

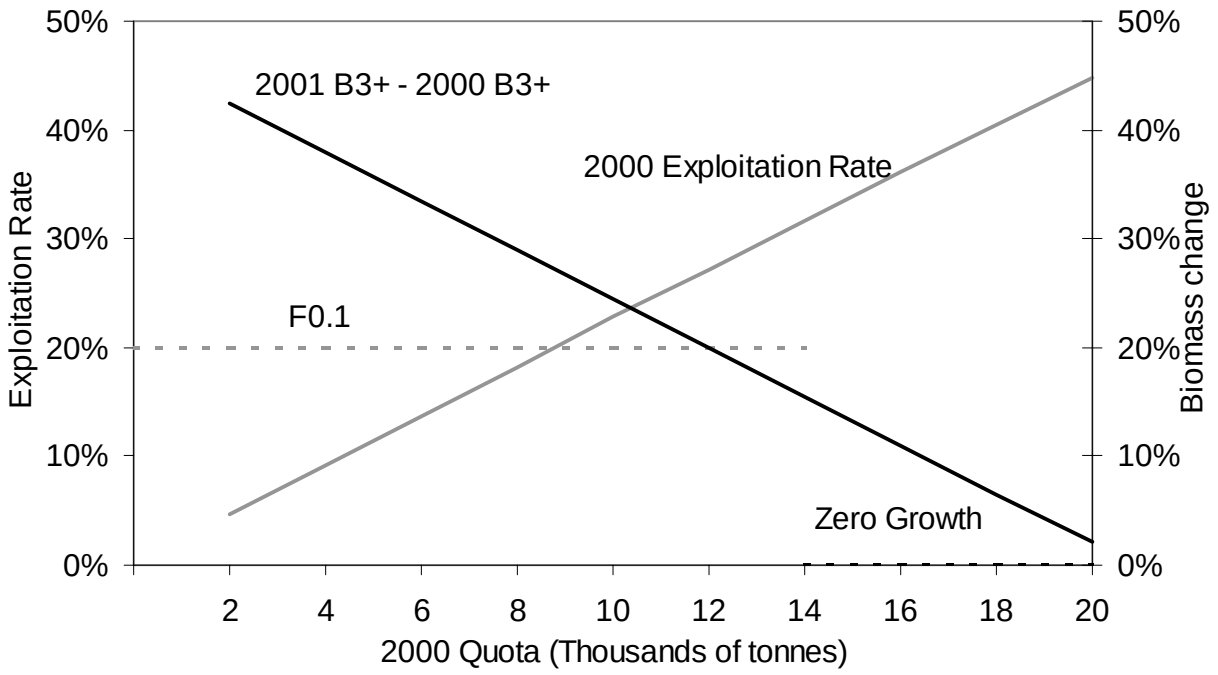

Figure 34. Expected exploitation rate in 2000 and expected change in biomass from 2000 to 2001 for 5Zjm haddock at various quotas.

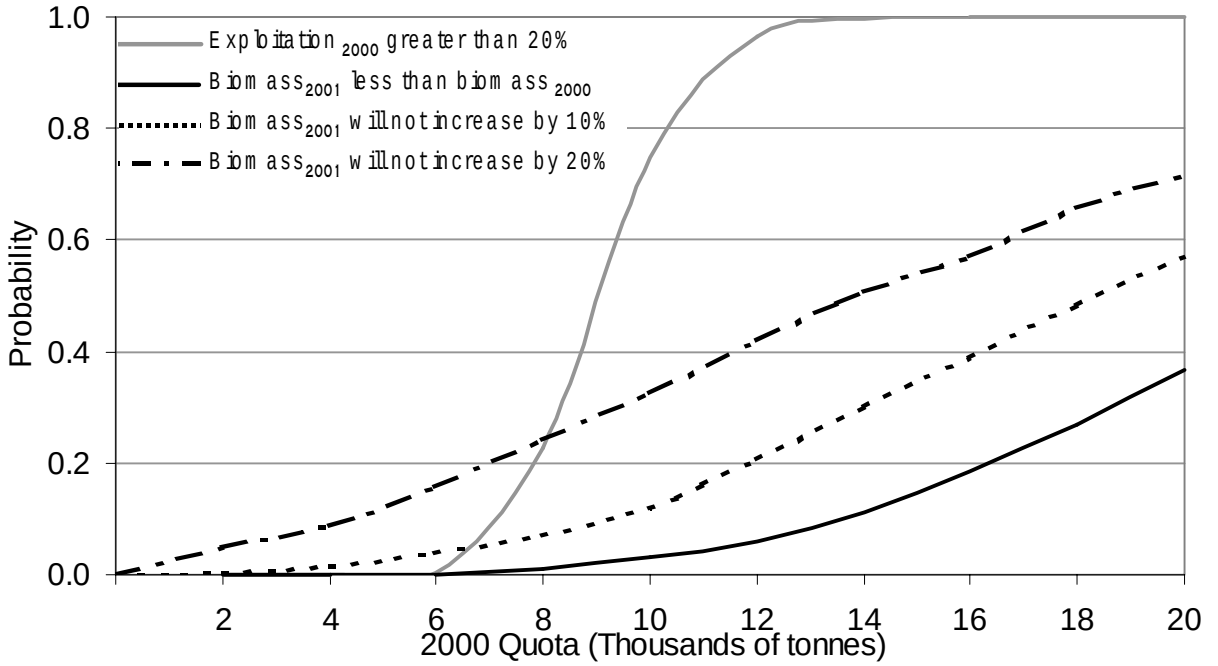

Figure 35. Probability of explopitation rate exceeding 20%, the $F_{0.1}$ reference level, and of the 2001 biomass being less than the 2000 biomass by 0%, 10% and 20% for 5Zjm haddock at various quotas.

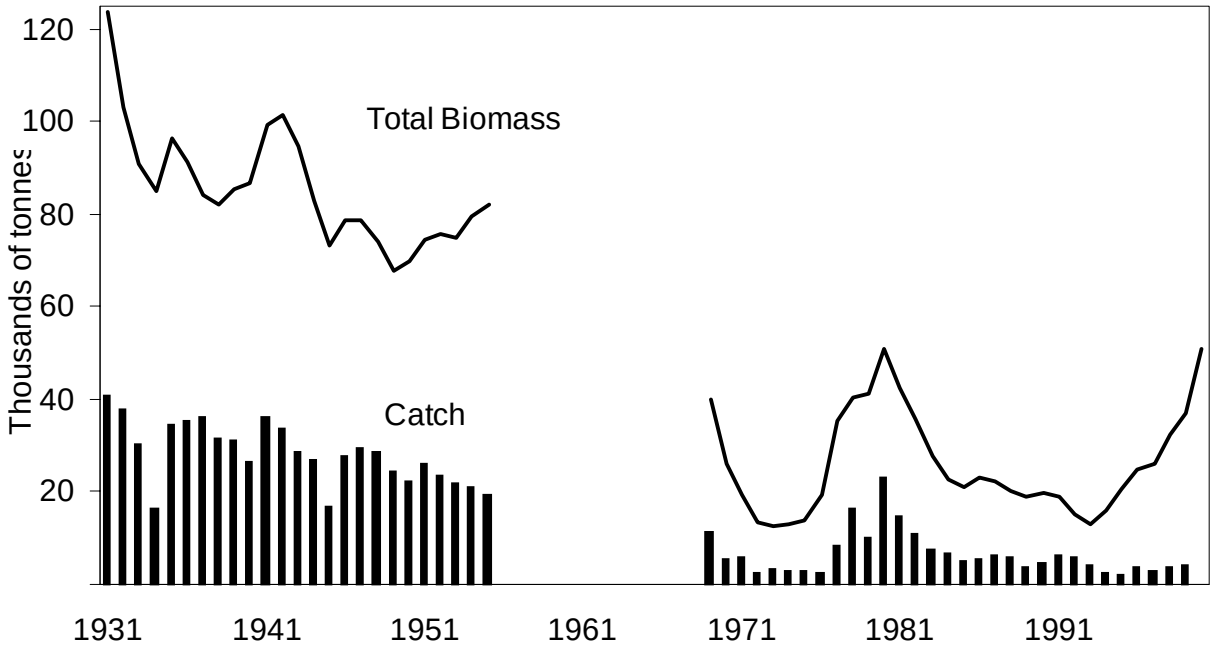

Figure 36. Historic catch and biomass of haddock in 5Zjm compared to recent catches and biomass.

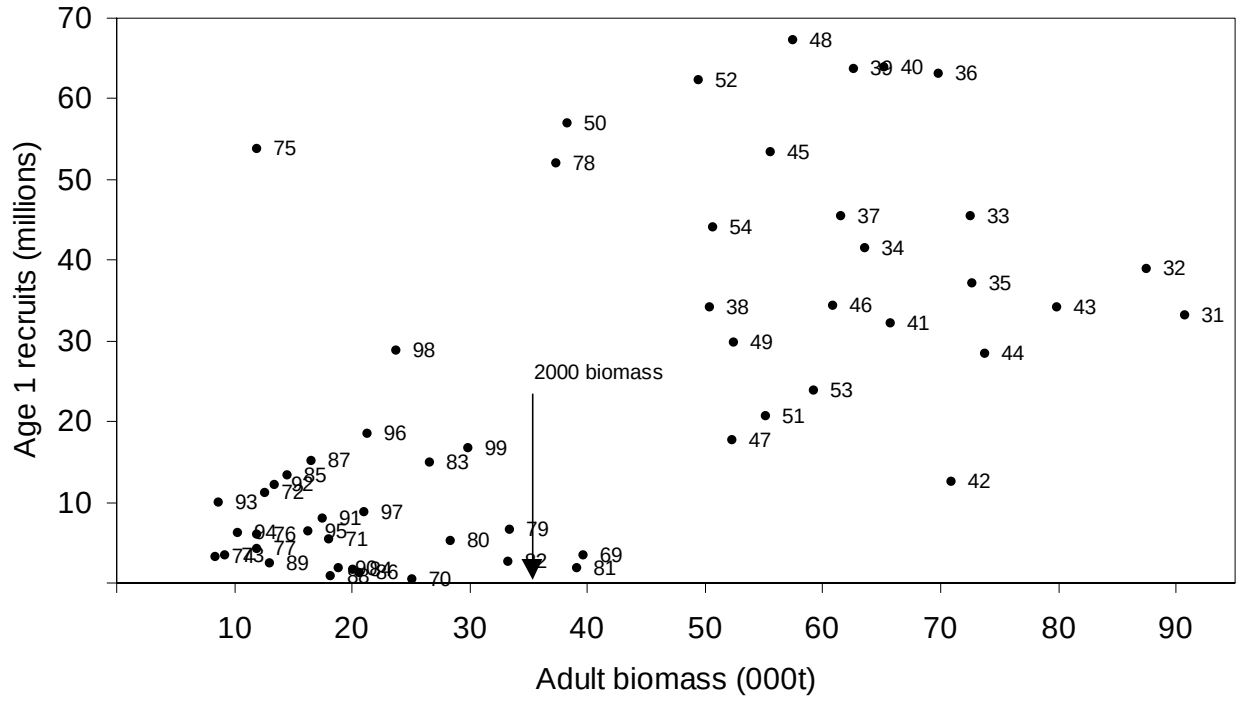

Figure 37. Relationship between mature (3+) 5Zjm haddock biomass and recruits at age 1 from 1931 to 1955 and 1969 to 2000.

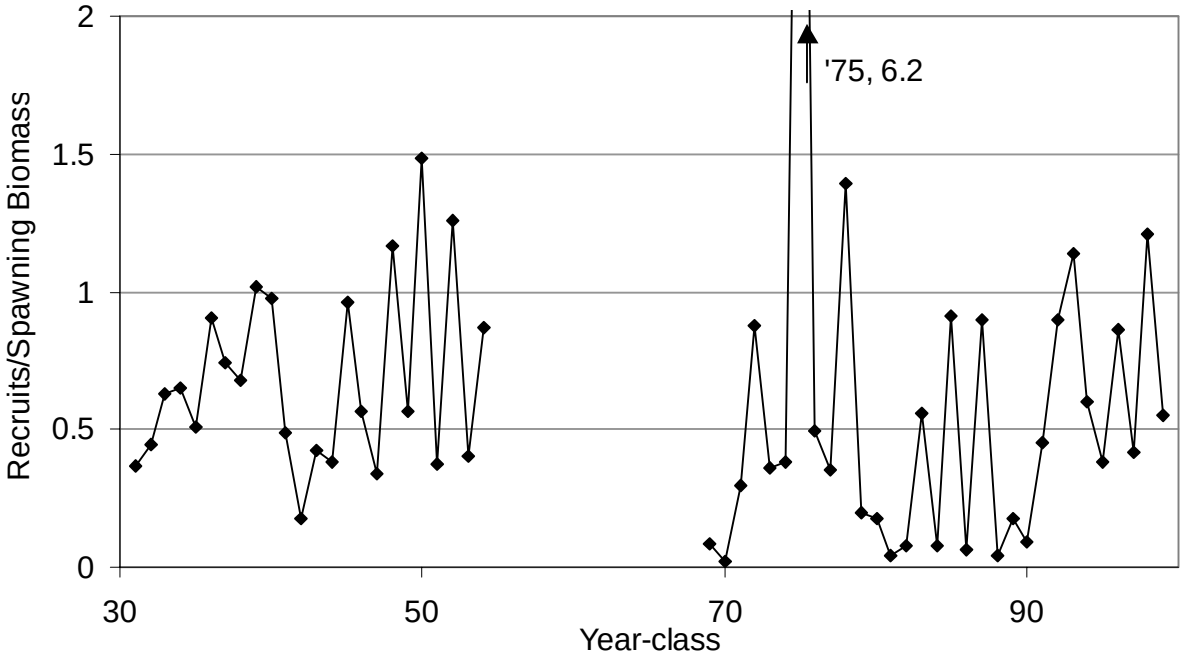

Figure 38. Ratio of recruits (numbers at age 1) per spawning biomass (kg) suggests that present survivorship appears comparable to that of the 1930s to 1950s.

Appendix A.

Inter and intra-reader agreement tests for L. Van Eeckhaute, the DFO reader, and N. Munroe, the NMFS reader are summarized in Table A1. The agreement matrices are given in Tables A2 to A5. There was evidence of bias in the inter-reader tests (Tables A4 and A5). In both cases the DFO reader was assigning higher ages than the NMFS reader. To try and resolve the discrepancies, annotated images of the otoliths with each readers interpretation were exchanged and the ageing material was also exchanged to determine whether the method of sectioning was causing the differences in interpretation. Results of these exchanges are pending.

Table A1. Summary of ageing tests and results for Georges Bank haddock.

Source	Test	No. of otoliths	% agreement	Comments
N165 1992 DFO Spring Survey	LVE vs LVE	98	99	Check for continuity over time
N871 1999 DFO Spring Survey	LVE vs LVE	98	96	
N871 1999 DFO Spring Survey	LVE vs NM	98	81	Evidence of bias
9804 1998 NMFS Fall Survey	LVE vs NM	50	80	Evidence of bias

Table A2. Inter-reader ageing agreement matrix for L. Van Eeckhaute for haddock ageing material from the 1992 DFO spring survey. This test was designed to ascertain whether a change in interpreting the otoliths had occurred over time.

DFO 1992 Georges Bank Sring Survey (N165)																		
First Reading	Second Reading																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
1	23																	23
2		21																21
3			8															8
4				2														2
5					21													21
6																		0
7							10	1										11
8																		0
9									6									6
10										1								1
11																		0
12																		0
13																		0
14														2				2
15																		0
16																		0
17																	1	1
Omitted				1	1													2
Total	23	21	8	3	22	0	10	1	6	1	0	0	0	2	0	0	1	98

Agreement = 99%

Note: omissions not included in calculation.

Table A3. Inter-reader ageing agreement matrix for L. Van Eeckhaute for haddock ageing material from the 1999 DFO spring survey.

DFO 1999 Georges Bank Spring Survey (N871)												
First Reading	Second Reading											
	1	2	3	4	5	6	7	8	9	12	Omitted	Total
1	27											27
2		15										15
3			14		1							15
4			1	4								5
5					4							4
6						3						3
7						1	13					14
8								8				8
9								1	3			4
12										1		1
Omitted					1						1	2
Total	27	15	15	4	6	4	13	9	3	1	1	98

Agreement = 92/96 = 96%
Note: The 3 vs 5 otolith is a clear 3, probably read wrong otolith.

Table A4. Ageing agreement matrix between N. Munroe, the NMFS reader, and L. Van Eeckhaute, the DFO Reader, for haddock ageing material from the 1999 DFO spring survey.

DFO 1999 Georges Bank Spring Survey (N871)													
DFO Reader	NMFS Reader												
	1	2	3	4	5	6	7	8	9	10	11	Omitted	Total
1	27												27
2		12	2									1	15
3			15										15
4				3	1								4
5			1	1	3							1	6
6						4							4
7						4	6	1				2	13
8							4	4		1			9
9								2	1				3
10													
11													
12											1		1
Omitted					1								1
Total	27	12	18	4	5	8	10	7	1	1	1	4	98

Agreement = 75/93 = 81%
Note that there is evidence of bias as the ratio of ages above and below the line of equality is 5:13.

Table A5. Ageing agreement matrix between N. Munroe, the NMF reader, and L. Van Eeckhaute, the DFO reader, for haddock ageing material from the 1998 NMFS fall survey.

NMFS 1998 Fall Survey (9804)							
DFO Reader	NMFS Reader						
	1	2	3	4	5	6	Total
1	1						1
2		14					14
3		2	9				11
4			2	6			8
5				2	4	1	7
6					1	6	7
7						2	2
Total	1	16	11	8	5	9	50

Agreement = 40/50 = 80%
Note that there is evidence of bias as the ratio of ages above and below the line of equality is 1:9.

Appendix B.

At the 1999 TRAC, April 20-22, 1999, the assessment team was asked to investigate an apparent inconsistency between survey and fishery weights at age. The text from the TRAC proceedings to describe the problem is reproduced below:

"An inconsistency between the population mean weights at age and the fishery mean weights at age was discussed. It was noted that, in some cases, the mean weight at age in the catch was larger than the population mean weight at age at the beginning of the following year for the same cohort."

This effect is most apparent when comparing the weight at age values used in the projection (Gavaris and Van Eeckhaute 1999):

Age	1	2	3	4	5	6	7	8
Weight at beginning of year used for population (kg)								
2000	0.13	0.50	0.91	1.25	1.61	2.14	2.52	2.87
Average weight at age for catch (kg)								
1999	0.66	1.11	1.46	1.82	2.24	2.51	3.03	2.95

Except for one instance, the average weight at age of the catch is higher than the population weight at the beginning of the next year. It was thought that this might be due to the difference in which the weights at age are calculated. The survey weights at age are derived from the observed weights while the fishery weights are derived from a length weight equation applied to the lengths. A comparison of the survey and fishery lengths at age was undertaken to determine whether the same trend was seen in the lengths (Fig. B1).

Table B1 follows the lengths at age by year classes. Stronger year classes, which are sampled more reliably than weak, have fewer drops in length from fishery to survey than weak year classes. This effect is more evident before the change in gear in 1993/94. As year classes age, lower population numbers increase this effect. After the switch to larger square mesh gear, drops in length from fishery to survey are frequently observed at the younger ages

The projection for the 1999 fishery was done with weight data for the most recent 4 years to estimate beginning year weights and fishery weights, i.e., 1996 to 1999 for survey data and 1995 to 1998 for fishery data. Fig. B1-A shows the data used in the projection while B shows data previous to the 4 most recent years. The fishery lengths at ages 1, 2, 3 and 4 are higher than the population lengths (survey) the following spring indicating selectivity by the fishing gear and that haddock in this fishery are fully recruited only at age 5 and older. Fig. B1-B shows that haddock were fully recruiting to the fishery by age 3 before 1995. Most of the catch in recent years in the Canadian fishery is mobile gear so this change in partial recruitment is consistent with the change in mobile gear to a larger mesh size and a switch to square mesh from diamond which occurred in 1993/1994.

The length weight equation used to estimate average weight at age for the Canadian fishery is as follows:

$$\text{weight} = .0000158 \times \text{length}^{2.91612}$$

where weight is in kg and length is in cm (Waiwood and Neilson, 1985). This equation is derived from 245 5Ze gutted haddock weights collected by Canadian port samplers from 1982 to 1984 from October to December over the length range of 35 to 79 cm. A conversion factor of 1.2 was used to convert gutted weights to round weights before the length weight relationship was determined. In Fig. B2 survey and fishery weights at age used in the projection are compared to corresponding lengths. The survey weights are estimated from direct observations while the fishery weights are derived from fishery lengths using the relationship described above in which a conversion factor of 1.2 has been used to convert gutted to round weights. This magnifies the gear selectivity effect so that it appears that haddock beyond age 5 are not fully recruited to the fishery.

The USA uses a conversion factor of 1.14 to convert from gutted to round weight while Canada uses 1.2. A comparison of weights derived from length weight equations fitted to round and gutted data was possible using data gathered by Canadian port technicians from 1982 to 1985. Quarter 2 and 3 were available for comparison and conversion factors at length could be calculated for the 2 quarters (Table B2, Fig. B3). They range from 1.17 to 1.19 for quarter 2 and from 1.14 to 1.19 for quarter 3. The majority of the Canadian fishery catch has centered around 53 to 54 cm (for otter trawlers) where the conversion factors are 1.18 and 1.17 respectively. A portion of the Canadian catch is landed as gilled and gutted but it is not reported as such. A conversion factor for this form would be higher than the gutted only factor.

In conclusion, the length analysis is consistent with changes in gear that have taken place in recent times and the seeming inconsistencies are due to selectivity of the commercial bottom trawl gear. The more persistent discrepancies in weights at age between the fishery and survey the following year may be due to problems with the length weight equations and further efforts towards establishing appropriate conversion factors to use to convert from gutted length weight equations to round length weight equations is warranted.

Table B1. Average lengths at age of 5Zjm haddock year classes as observed from the Canadian spring survey and the commercial fishery. Bold type indicates a strong yearclass; shaded values indicate that the weight dropped from the value in the time period before it; the horizontal stepped line denotes the change from diamond mesh to square mesh by bottom trawl gear which occurred gradually in 1993/1994.

Year	Age 1		Age 2		Age 3		Age 4		Age 5		Age 6		Age 7		Age 8	
class	Survey	Fishery	Survey	Fishery	Survey	Fishery	Survey	Fishery	Survey	Fishery	Survey	Fishery	Survey	Fishery	Survey	Fishery
1977																65.8
1978														66.3	66.0	72.3
1979												63.6	67.8	68.7	65.7	68.2
1980										56.8	61.8	62.8	65.1	62.9	65.8	64.1
1981								56.1	63.6	63.4	61.0	60.2	62.4	64.1	64.4	64.1
1982						47.6	51.0	56.2	57.1	57.5	58.0	58.1	57.9	62.3	63.1	59.3
1983				**43.2**	**45.4**	**50.1**	**53.4**	**56.6**	**55.9**	**58.1**	**61.3**	**61.2**	**61.6**	**62.0**	**65.1**	**63.2**
1984			36.2	43.8	39.7	49.2	55.7	53.7	56.8	57.8	58.7	57.8	58.3	58.9	60.2	61.2
1985	**22.9**	**33.7**	**36.3**	**41.4**	**45.1**	**48.4**	**50.4**	**53.8**	**55.9**	**58.0**	**60.2**	**61.5**	**63.9**	**64.0**	**63.7**	**65.1**
1986	24.2		36.4	43.7	39.1	49.7	48.1	52.9	52.8	56.0	62.5	56.3	59.2	64.0	66.5	65.4
1987	**22.3**	**32.8**	**35.9**	**41.8**	**44.4**	**50.2**	**51.7**	**54.2**	**57.7**	**58.1**	**60.4**	**61.6**	**65.9**	**62.8**	**65.0**	**64.2**
1988	19.5		35.8	43.5	42.7	47.0	46.8	52.6	49.9	56.9	58.5	59.5	60.1	63.5	61.8	56.5
1989	24.7	37.9	40.8	47.0	47.7	52.6	55.5	58.1	57.6	61.6	62.5	62.4	66.2	66.6	63.6	66.9
1990	23.1	36.2	39.2	46.4	49.6	53.4	53.8	58.1	59.0	60.8	62.7	60.0	62.4	64.4	69.3	67.2
1991	23.2	35.7	36.6	46.4	45.8	52.6	52.7	56.2	56.9	58.6	59.5	60.2	62.5	63.3	63.7	
1992	**23.6**	**38.3**	**35.8**	**46.1**	**45.1**	**50.8**	**50.1**	**53.8**	**54.2**	**57.0**	**57.2**	**58.7**	**58.8**			
1993	22.3	32.5	36.3	45.0	44.4	50.0	48.9	53.4	53.0	55.7	56.1					
1994	20.2	40.2	36.2	44.5	42.1	48.8	47.3	52.8	48.9							
1995	24.2	36.4	37.1	47.2	46.4	51.6	49.8									
1996	**23.7**	**38.6**	**37.6**	**46.1**	**44.8**											
1997	21.7	36.5	35.9													
1998	23.7															

Table B2. Conversion factors calculated from gutted and round length weight relationships for 5Ze haddock for quarters 2 and 3. Data was collected by Canadian port technicians from 1982 to 1985.

Length (cm)	Q2			Q3		
	Round[1] n = 181	Gutted[2] n = 96	Conversion Factor	Round[3] n = 96	Gutted[4] n = 209	Conversion Factor
32	0.358	0.307	1.165	0.375	0.330	1.135
33	0.392	0.337	1.166	0.410	0.360	1.137
34	0.429	0.368	1.166	0.447	0.393	1.139
35	0.468	0.401	1.167	0.487	0.427	1.141
36	0.509	0.436	1.168	0.528	0.462	1.143
37	0.553	0.473	1.169	0.572	0.500	1.145
38	0.599	0.512	1.169	0.619	0.540	1.146
39	0.648	0.553	1.170	0.668	0.581	1.148
40	0.699	0.597	1.171	0.719	0.625	1.150
41	0.752	0.642	1.171	0.772	0.671	1.151
42	0.809	0.690	1.172	0.829	0.719	1.153
43	0.868	0.740	1.173	0.888	0.769	1.154
44	0.930	0.792	1.173	0.949	0.821	1.156
45	0.994	0.847	1.174	1.014	0.876	1.157
46	1.062	0.904	1.174	1.081	0.933	1.159
47	1.133	0.964	1.175	1.151	0.992	1.160
48	1.207	1.027	1.175	1.224	1.054	1.162
49	1.284	1.091	1.176	1.300	1.118	1.163
50	1.364	1.159	1.177	1.379	1.184	1.164
51	1.447	1.229	1.177	1.461	1.253	1.166
52	1.534	1.303	1.178	1.546	1.325	1.167
53	1.624	1.379	1.178	1.635	1.399	1.168
54	1.718	1.457	1.179	1.726	1.476	1.169
55	1.815	1.539	1.179	1.821	1.556	1.171
56	1.916	1.624	1.180	1.920	1.638	1.172
57	2.020	1.712	1.180	2.021	1.723	1.173
58	2.128	1.803	1.180	2.127	1.811	1.174
59	2.240	1.897	1.181	2.236	1.902	1.175
60	2.356	1.994	1.181	2.348	1.996	1.176
61	2.475	2.095	1.182	2.464	2.093	1.178
62	2.599	2.198	1.182	2.584	2.192	1.179
63	2.727	2.306	1.183	2.707	2.295	1.180
64	2.859	2.416	1.183	2.835	2.401	1.181
65	2.995	2.530	1.183	2.966	2.510	1.182
66	3.135	2.648	1.184	3.101	2.622	1.183
67	3.279	2.769	1.184	3.241	2.737	1.184
68	3.428	2.894	1.185	3.384	2.856	1.185
69	3.582	3.022	1.185	3.531	2.978	1.186
70	3.739	3.155	1.185	3.683	3.103	1.187
71	3.902	3.291	1.186	3.838	3.232	1.188
72	4.069	3.430	1.186	3.998	3.364	1.189
73	4.241	3.574	1.187	4.163	3.499	1.190
74	4.417	3.722	1.187	4.331	3.638	1.191
75	4.599	3.874	1.187	4.505	3.781	1.191
76	4.785	4.029	1.188	4.682	3.927	1.192
77	4.976	4.189	1.188	4.864	4.077	1.193
78	5.173	4.353	1.188	5.051	4.230	1.194

[1] $W = 0.0000110\ L^{2.9979}$
[2] $W = 0.0000102\ L^{2.97564}$
[3] $W = 0.0000151\ L^{2.91973}$
[4] $W = 0.0000162\ L^{2.86287}$

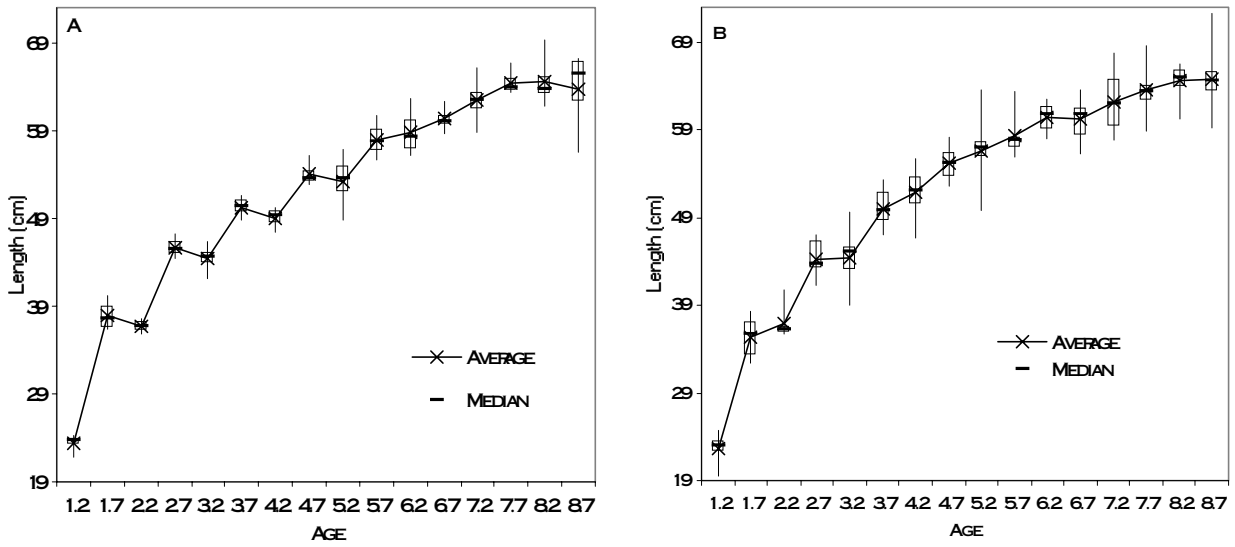

Fig. B1. Average, median, range and 25 and 75 percentiles of length at age of 5Zjm haddock from surveys and from the commercial fishery. A) Survey data is for 1996 to 1999 and fishery data is for 1995 to 1998. B) Survey data is for 1986 to 1995 and fishery data is for 1985 to 1994.

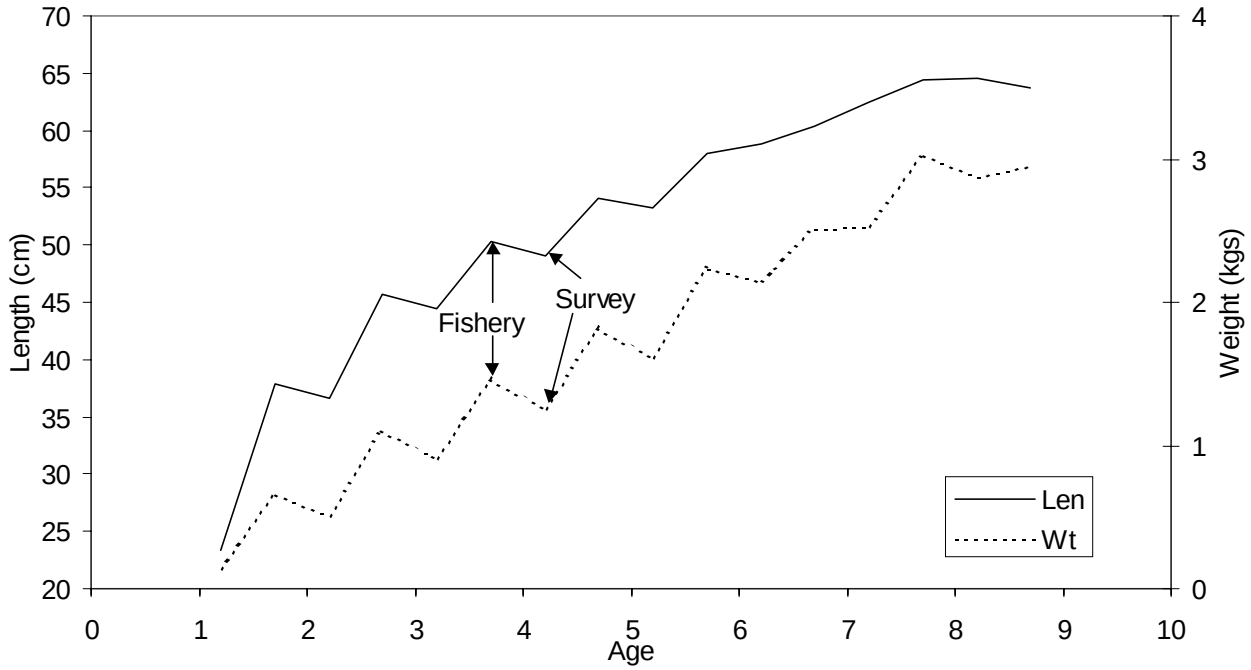

Fig. B2. Survey and fishery weights at age for 5Zjm haddock used to project beginning of year 2000 population biomass (from survey weights) and yield for the 1999 fishery (from fishery weights) compared to corresponding survey and fishery lengths at age. Survey lengths and weights are the average for 1996 to 1999 and those for the fishery are the average of 1995 to 1998. Fishery weights were calculated from lengths using a weight length relationship (see text) while survey weights are from observed values.

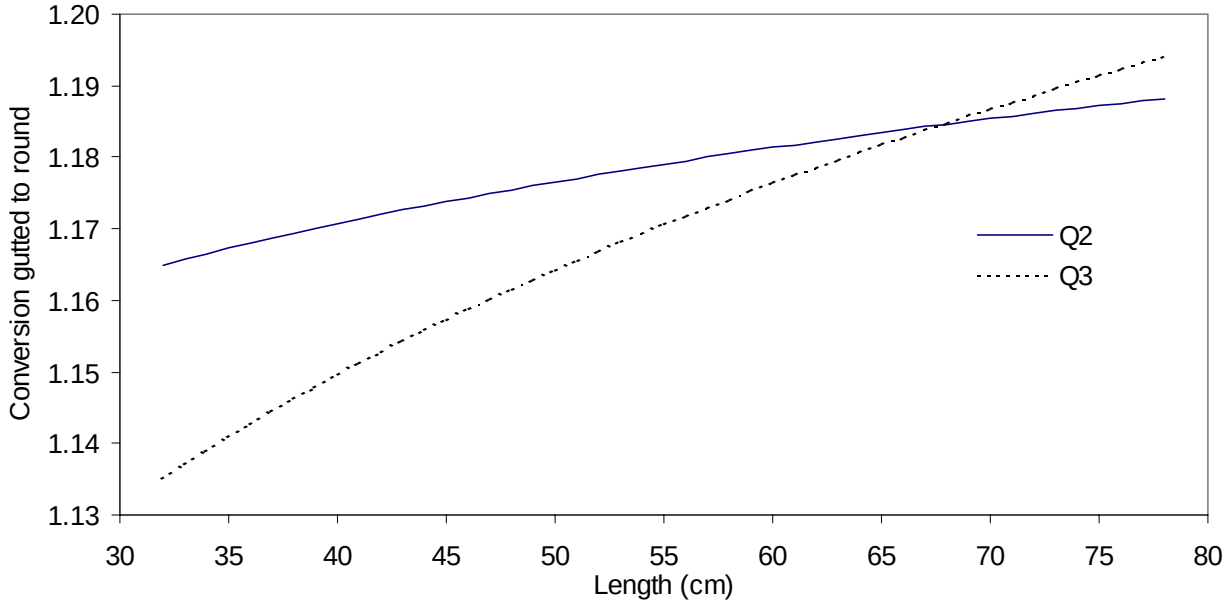

Fig. B3. Conversion factors for 5Zjm haddock from gutted to round derived from length weight equations for quarters 2 and 3. Data was gathered by Canadian port technicians from 1982 to 1985 (see Table 2).