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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 5,600 t.

Total population biomass has steadily increased from near historic low levels of about 13,000 t in 1993 to about 56,000 t at the beginning of 2001 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 four strongest year-classes since 1978. The exploitation rate for fully recruited ages 4+ has consistently been below the $F_{0.1}$ target of 20% 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 2001 would be about 9,700 t. While the adult biomass (3+) is not expected to decrease, the chance of a 10% increase is low. The population age structure shows good representation at all ages and a broad age range is expected to contribute to the 2001 catch.

Résumé

Suite à la mise en œuvre de mesures de gestion restrictives les prises d'aiglefin dans les eaux de l'est du banc Georges, qui atteignaient environ 5 000 t de 1985 à 1990 et plus de 6 400 t en 1991, ont chuté à environ 2 100 t en 1995 pour ensuite fluctuer entre environ 3 000 et 5 600 t.

La biomasse totale de la population a progressivement augmenté, passant d'un creux presque historique d'environ 13 000 t en 1993 à environ 56 000 t au début de 2001, mais elle demeure inférieure à la biomasse moyenne observée entre 1930 et 1955, lorsque la productivité était plus élevée. Cette récente augmentation est principalement le résultat d'un meilleur recrutement dans les années 90, qui a donné les quatre classes d'âge les plus abondantes depuis 1978. Le taux d'exploitation des sujets de 4 ans qui sont pleinement recrutés est, sans exception, inférieur au F0.1 cible de 20 % depuis 1995. Une mortalité par pêche moindre et la protection des juvéniles de la pêche au cours des dernières années se sont traduites par une survie accrue des nouvelles classes d'âge et une abondance plus élevée de sujets âgés.

Le rendement total projeté à F0,1 = 0,25 pour les pêcheurs canadiens et américains en 2001 se chiffre à environ 9 700 t. Bien que l'on ne s'attende pas à ce que la biomasse d'adultes (3 ans et plus) diminue, il est peu probable qu'elle augmente de 10 %. Tous les âges étant bien représentés dans la population, on s'attend à ce que cette diversité soit reflétée dans les prises en 2001

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 2000 Canadian and USA fisheries. Results from the Department of Fisheries and Oceans, Canada (DFO) survey in the spring of 2001 and the National Marine Fisheries Service, USA (NMFS) surveys in the spring and fall of 2000 were incorporated. Methods similar to those used in the last assessment were applied to the updated information.

The Fishery

Commercial Catches

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 5,600 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 around 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.

In 1995 to 1999, Canadian catches were below the quota due to closure of the fisheries when cod quotas were reached. The 2000 catch of 5,402 t was slightly above the Canadian quota of 5400 t. During 1994 to 2000, all Canadian groundfish fisheries on Georges Bank remained closed from January to early June to protect spawning concentrations.

Weight of all 2000 Canadian landings were monitored at dockside. At-sea monitoring by observers accounted for 15% of the 620 trips from which haddock was landed and 21% of the amount landed. In 2000, samples were collected by DFO at port, observers at sea and by two industry groups, Scotia Fundy Mobile Gear Fishermen's Association (SFMGFA) and High Liner Foods (HLF). Comparison of samples from all sources indicated that there was little discarding or highgrading (Fig. 4). Discarding and misreporting have been considered negligible since 1992.

In recent years, the Canadian fishery has been primarily conducted by vessels using otter trawls and longlines with some handlines and gillnets. During 2000, 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. The catches by otter trawlers peaked in June (Table 4, Figure 5), while longline catches peaked in September. Longline catches were low in June due to a late start for that gear type. The Canadian fishery management plan allocations by fleet sector and reported landings are shown below:

Fishery Sector	1996		1997		1998		1999		2000	
	Quota	Catch	Quota	Catch	Quota	Catch	Quota	Catch	Quota	Catch
Fixed gear <65’	1085	919	754	714	915	856	928	902	1271	1193
Mobile gear <65'	2280	1713	1625	1451	1984	1997	1972	1964	2743	2796
Fixed gear 65'-100'	45	49	32	36	39	39	39	8	54	51
Mobile gear 65'-100'	189	181	32	35	94	93	188	186	54	224
Vessels >100'	921	513	757	573	868	386	773	590	1278	1137
Totals	4500	3375	3200	2809	3900	3371	3900	3650	5400	5402

Source: Quota reports (will not match statistics exactly)

USA catches for 2000 were derived from logbooks coupled with dealer reports, as was done for 1994-99. 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. However, the trip limit resulted in an increase in the discard rate. The trip limit has been adjusted periodically and in September 1998 it was established at 3,000 lb/day, with a maximum of 30,000 lb/trip through to April 1999, 2,000 lb/day, with a maximum of 20,000 lbs/trip during May through October and raised to 5,000 lb/day, with a maximum of 50,000 lbs/trip in November 1999. In October 2000 the haddock trip limit was suspended through April 2001 with the trip limit of 50,000 lbs remaining in effect. 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 2000, landings from 5Zjm, which come exclusively from tonnage classes 3 and 4 otter trawlers (Table 5), decreased from 355 t in 1999 to 187 t in 2000 and, as in 1999, discards again were low because the day and trip possession limits remained high. Catches by month were not available for recent years (Table 6).

Size and Age Composition

The size and age composition of the 2000 Canadian fishery was characterised using DFO at port, at sea and industry samples from all principle gears and all seasons. Comparison of length frequencies from these sources did not reveal any persistent differences (Figure 4), therefore, all data was combined (Table 7, Figure 5). The size composition of the catch in the 2000 Canadian fisheries peaked at 55 cm (21 in) for otter trawlers and at 57 cm (22 in) for longliners (Figure 6). Gill-netters caught few haddock but they were larger. No samples have been available for discards of groundfish by-catch in the Canadian scallop fishery since 1995 when observer coverage was discontinued, though in previous years the amount caught has not been large.

USA port samples and ageing data from eastern Georges Bank were used to characterise the size and age composition of the USA fishery catch from eastern Georges Bank.

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 (Gavaris and Van Eeckhaute 2000) which is being investigated, however these are not considered substantial enough to seriously compromise analyses (Appendix A).

The 2000 catch at age by quarter for Canada and the USA (Table 8) was used to augment the 1969-99 results (Gavaris and Van Eeckhaute, 1997; Gavaris and Van Eeckhaute, 2000). Combined Canada/USA annual catch at age and average fishery weights at age are summarized in Tables 9 and 10 and Figure 7. As in 1999, the 1996 year-class (now age 4) dominated the combined Canada/USA fishery catch in 2000. In comparison to the age composition of the catch during the late 1970s to early 1990s when year-classes were quickly fished down, the older age groups continue to contribute significantly to the 2000 catch (Figure 8). The age composition during the 1969 to 1974 period was dominated by the outstanding 1992 and 1993 year-classes which continued to contribute substantially as older fish. The percentage of age 2 and 3 fish in 2000 was below the historical averages but the contribution from age 2 was higher than it has been in recent years, suggesting a strong 1998 year-class. The low percentage of younger ages in the recent catches has been 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 (i.e., 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) for tonnage classes 2 and 3 otter trawlers and longliners have increased from 1993 to 1995, remained relatively stable but variable from 1996 through 1998 and increased substantially in 1999 (Figure 9). In 2000, it increased again but not as much as in the previous year. 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, commercial catch rates were not used as indices of abundance.

Research Surveys

Surveys of Georges Bank have been conducted by NMFS each fall (October) since 1963 and each spring (April) since 1968, and by DFO each spring (February) since 1986. All surveys used 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. Vessel and door type 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. An abundance of age 1 haddock (2000 year-class) was observed on the southern flank during the DFO survey. In fall, adult haddock are more concentrated in the deeper waters along the slopes of the Northeast Peak and the Northern 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 in the table below (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, 1993 and 2000. For the NMFS spring surveys, generally conducted in April, the percentage on the Canadian side was typically lower but 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	41	100
2001	96	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, 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 (Figure 16). 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 late 1980s at about half the 1970s level. Biomass increased from 1992 to 1996, fluctuated somewhat and increased again after 1998. The NMFS fall survey biomass for 1999 appears to have been anomalously high as the 2000 biomass is more in line with previous observations. In 2000 the NMFS spring survey decreased slightly while the DFO spring survey increased and then decreased slightly in 2001.

Survey recruitment indices for ages 0, 1 and 2 indicate that the abundance of the 1998 year-class is the highest since the 1978 year-class (Figure 17). The 1996 and the 1999 year-classes were comparable to the moderate 1983, 1985, 1987 and 1992 year-classes. 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 DFO survey in 2001 indicates a

strong 2000 year-class in contrast to the age 0 observation from the NMFS fall survey which indicated only moderate abundance.

There were no persistent trends in weight at age derived from the DFO survey. Average weight at age of haddock from the 1989, 1990 and 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, which were used for beginning of year population weights, are given in Gavaris and Van Eeckhaute (1998) and were derived from weights observed during the survey, 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 feature was mostly attributable to bottom trawl gear changes which resulted in a change in partial recruitment since 1994 (Gavaris and Van Eeckhaute, 2000). 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.

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 - 8. 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…2000.75, 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…2000.16, 2001.0

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…2000.29

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…2000.69

Since forecast projections were required for the entire year 2001, the DFO spring survey in 2001 was designated as occurring at time 2001.0 instead of 2001.16. 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) as described in Gavaris and Van Eeckhaute (1998). 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+), estimated by the VPA, has steadily increased from near historic low levels of about 13,000 t in 1993 to about 56,000 t at the beginning of 2001 (Figure 27). The recent increase has been due to more consistent and improved recruitment and was enhanced by increased survivorship and reduced capture of small fish in the fisheries. Since the 1991 year-class, no year-classes have been below 5 million fish. Between the 1978 and 1991 year-classes, 7 of the 14 year-classes were below 5 million fish. The biomass increase is expected to be sustained by the 2000 year-class which appears at least as good as the 1998. The adult biomass (ages 3+) trend is similar to the ages 1+ trend, with a 25% increase from 2000 to 2001, due largely to recruitment of the 1998 year-class.

Population biomass during the late 1970s and early 1980s was about 50,000 t due to recruitment of the strong 1975 and 1978 year-classes, both of which were estimated to be around 50 million at age 1. 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.

Recruitment, estimated by the VPA, indicates the strength of the 1996 and 1999 year-classes to be about 17 million at age 1, comparable to the 1983, 1985 and 1987 year-classes, which were the strongest 3 year-classes over about a 20 year time span (Figure 28). Preliminary indications for the 2000 year-class indicate it is about equal to the 1998 year-class which is estimated to be relatively strong at about 25 million, making them the strongest since the 1978 year-class.

Exploitation rate on fully recruited ages 4+ 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 about 40%, the highest 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). Fishery avoidance of small fish has resulted in the number of fish of the 1998 year-class surviving to age 3 to be almost as many as survived to age 3 of the 1978 year-class which was twice as strong. In both absolute numbers and percent composition, the population structure displays a broad representation of age groups, reflecting improving 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, surplus production (biomass gains from growth and from recruitment, decremented by losses due to natural deaths) has exceeded the fishery harvest yield, 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 2001 beginning of year population abundance estimates. The abundance of the 2001 year-class was assumed to be 6 million at age 0. Partial recruitment to the fishery for ages 1, 2 and 3 and fishery weights at age were averaged over 1996 to 2000 and beginning of year population weights were averaged over 1997 to 2001 for use in the 2001 forecasts (Table 20). Projected total Canada/USA yield at an exploitation rate of 20% corresponding to $F_{0.1} = 0.25$ in 2001 would be about 9,700 t (Figure 34). If fished at that rate in 2001, the adult biomass is projected to increase somewhat from 46,500 t to 48,000 t by the beginning of 2002. As in 2000, the 1996 year-class (age 5) is expected to comprise the highest proportion of the total 2001 yield with ages 4 and 3 (1997 and 1998 year-classes) each contributing slightly lower yields and amounting to a combined proportion of 64%. Ages 6, 7 and 8 will contribute equally at 7% each and the 9+ group will contribute slightly more at 11%.

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 2001 results in about 11% probability that fishing mortality rate will exceed $F_{0.1}$ and a low probability that the adult biomass will decrease (Figure 35). At this yield there is a high probability of about 60% of not achieving 10% biomass increase and a higher probability of 86% of not achieving 20% biomass increase. A catch corresponding to $F_{0.1}$ in 2001 results in a probability of about 25% that the adult biomass will decrease.

These uncertainties are dependent on the set of model assumptions and data used in the analyses. Though these assumptions were deemed most suitable, there may be other plausible assumptions. These calculations do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting or the possibility that the model may not reflect the stock dynamics closely enough. The risk profiles provide a general sense of the associated uncertainties and can assist in assessing the consequences of alternative actions.

Management Considerations

The Canadian quota of 5,400 t in 2000 was expected to result in a negligible chance of exceeding $F_{0.1}$ and about an 85% chance of getting 20% growth in the stock. The Canadian catch in 2000 was very near the quota and resulted in a exploitation rate of about 14% and an increase in adult biomass of about 25%.

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. Although biomass has been increasing and is the highest it has been in about 30 years, it remains below the average biomass during 1930-55 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 year-classes have been above the average abundance of year-classes observed during the period 1930-55. 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.

Exploitation rate and biomass 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. While conditions have improved, considering all attributes, 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	3681	355			4036
2000	5402	187			5589

[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" (diamond is 6"). 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 to comply with Sustainable Fisheries Act.	Same as 1997 and 1998.
2000	October: Daily trip limit suspended to April 2001but retained max. trip limit of 50,000 lbs/trip.	Same as 1999.

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	2761	486	241	887	33	3680
2000	0	1313	2269	230	246	4146	619	258	1186	71	5402

[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	269	70	3681
2000	1	0	0	0	0	1368	1175	1026	848	658	175	150	5402

[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
2000			187	0	187

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
2000													187

Table 7. Sampling for catch at age for the 2000 5Zjm Canadian haddock fishery.

Country	Quarter	Aged	Month	Gear / TC	Measured	Landings
Canada	2	514	June	OT / 0-3	13901	1145
				OT / 4-6	3363	209
				LL	1113	8
				GN		7
	3	655	July	OT / 0-3	6989	831
				OT / 4-6		54
				LL	4159	259
				GN	609	29
			August	OT / 0-3	8720	667
				OT / 4-6		
				LL	3344	352
				GN	200	8
			September	OT / 0-3	7783	478
				OT / 4-6		
				LL	2925	365
				GN	177	6
	4	464	October	OT / 0-3	7767	371
				OT / 4-6	1363	120
				LL	200	160
				GN		6
			November	OT / 0-3	727	110
				OT / 4-6	399	33
				LL	2391	30
				GN		3
			December	OT / 0-3	705	72
				OT / 4-6	1634	67
				LL		11
				GN		1

OT=Otter Trawl Bottom, GN=Gill Net, LL=Longline (includes Handline) TC=Tonnage Class.

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											
2000	0	0	0	0	0	0	0	0	0	0	
2000.25	0	67830	101096	269328	87577	36258	53302	64009	26235	705636	
2000.5	0	186058	259983	716635	108791	116162	105330	84507	26456	1603923	
2000.75	88	52750	68277	235804	34583	33500	41056	28129	10049	504236	2813794
USA											
2000	0	0	349	5234	6414	4423	2231	665	33	19349	
2000.25	0	0	3733	13979	5760	5007	4044	2123	531	35177	
2000.5	0	0	90	348	276	249	140	55	85	1243	
2000.75	0	2114	3884	4060	5174	4718	2461	2071	1765	26247	82016
USA Discards											
2000	0	0	0	0	0	0	0	0	0	0	
2000.25	0	0	0	0	0	0	0	0	0	0	
2000.5	0	0	0	0	0	0	0	0	0	0	
2000.75	0	0	0	0	0	0	0	0	0	0	0
Total											
2000	0	0	349	5234	6414	4423	2231	665	33	19349	
2000.25	0	67830	104829	283307	93337	41265	57346	66132	26766	740813	
2000.5	0	186058	260073	716983	109067	116411	105470	84562	26541	1605166	
2000.75	88	54864	72161	239864	39757	38218	43517	30200	11814	530483	2895810

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
2000	0	0	309	437	1245	249	200	209	182	65	2896

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
2000	0.664	1.103	1.470	1.920	2.242	2.098	2.497	2.816
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	0.993	1.392	1.801	2.154	2.516	2.882	3.131
Average	0.601	1.006	1.381	1.815	2.174	2.515	2.878	3.145

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
2000	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 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
2001	23026	3519	14633	4255	5608	1808	1426	1963	2299	58536

Table 13. Total estimated abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from 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
2000	2675	2131	3399	1624	636	564	438	305	165	11938

Table 14. Total estimated abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from 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
2000	1368	5284	6226	3712	622	229	0	146	97	17684

Table 15. Average weight at age (kg) from DFO spring surveys used to represent beginning of year weights.

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
2001	0.093	0.524	1.005	1.371	1.798	2.166	2.249	2.593	2.928
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	0.121	0.497	0.939	1.419	1.867	2.171	2.479	2.779	3.364
Average	0.117	0.514	0.934	1.429	1.875	2.247	2.591	2.864	3.332

Table 16. Statistical properties of estimates for beginning of 2001 population abundance (numbers in 000's) and survey calibration constants (unitless, survey:population) for haddock in unit areas 5Zjm obtained from a bootstrap with 1000 replications.

Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
		Population Abundance (000's)			
1	34225	45484	1.329	8624	0.252
2	14746	6639	0.450	1105	0.075
3	17393	5995	0.345	1175	0.068
4	5412	1663	0.307	225	0.042
5	5742	1583	0.276	125	0.022
6	1586	460	0.290	54	0.034
7	1251	366	0.292	37	0.030
8	1167	393	0.336	19	0.016
		Survey Calibration Constants			
DFO Spring Survey					
1	0.209	0.051	0.244	0.004	0.019
2	0.455	0.110	0.242	0.014	0.031
3	0.903	0.214	0.237	0.028	0.031
4	0.834	0.201	0.241	0.022	0.027
5	0.997	0.243	0.244	0.024	0.024
6	0.829	0.200	0.241	0.026	0.032
7	1.129	0.274	0.243	0.026	0.023
8	1.099	0.258	0.235	0.016	0.015
NMFS Spring Survey – Yankee 36 – 1969-72/1982-99					
1	0.129	0.027	0.205	0.003	0.021
2	0.323	0.064	0.197	0.005	0.016
3	0.440	0.088	0.199	0.008	0.019
4	0.442	0.087	0.198	0.008	0.019
5	0.543	0.108	0.199	0.014	0.026
6	0.439	0.087	0.198	0.007	0.017
7	0.499	0.096	0.193	0.009	0.019
8	0.641	0.130	0.202	0.005	0.009
NMFS Spring Survey – Yankee 41 – 1973-81					
1	0.230	0.079	0.345	0.013	0.059
2	0.516	0.171	0.330	0.032	0.062
3	0.653	0.225	0.345	0.035	0.054
4	0.797	0.274	0.344	0.030	0.038
5	0.984	0.334	0.339	0.048	0.048
6	0.892	0.380	0.426	0.074	0.083
7	1.627	0.576	0.354	0.082	0.050
8	0.650	0.239	0.367	0.039	0.060
NMFS Fall Survey					
0	0.121	0.021	0.178	0.002	0.013
1	0.263	0.045	0.170	0.004	0.013
2	0.234	0.040	0.171	0.003	0.011
3	0.226	0.038	0.168	0.003	0.015
4	0.164	0.029	0.180	0.001	0.008
5	0.148	0.025	0.171	0.002	0.015

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 2001.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	770	189	4139	850	894	8651	2890	180	781	19345	18575	18386
1970	3348	629	139	2102	463	439	4520	1638	460	13737	10389	9760
1971	462	2714	439	107	1412	247	246	2678	1226	9530	9068	6354
1972	5371	377	1128	138	61	935	62	61	2166	10300	4929	4551
1973	11034	4152	308	587	49	31	686	18	1431	18297	7262	3110
1974	3346	8120	1827	246	153	7	17	528	1035	15279	11933	3813
1975	3223	2719	4749	1279	201	99	4	14	1205	13492	10269	7550
1976	53873	2632	1972	2593	868	160	51	2	971	63122	9249	6617
1977	5916	43952	2021	1467	1403	599	131	25	782	56295	50379	6427
1978	4215	4832	28833	1598	1043	884	349	107	635	42496	38281	33449
1979	52024	3442	3680	14519	1159	703	457	213	590	76787	24763	21321
1980	6641	42493	2800	2831	8086	624	400	185	607	64668	58027	15534
1981	5128	5423	18947	1988	2051	4506	342	216	593	39193	34065	28643
1982	1714	4188	3832	9537	1279	1239	2605	176	628	25197	23483	19295
1983	2535	1400	2766	2194	5286	864	679	1487	546	17757	15222	13822
1984	14914	2070	1015	1674	1305	2882	522	462	1281	26126	11212	9142
1985	1551	12182	1625	607	1064	836	1370	264	1003	20503	18952	6770
1986	13220	1267	8035	984	338	702	574	795	889	26803	13583	12317
1987	1275	10794	1001	4293	654	150	466	368	1192	20194	18918	8125
1988	14998	1042	7035	706	2154	449	73	308	1117	27882	12884	11842
1989	788	12247	807	3823	469	990	271	28	1040	20463	19674	7427
1990	2336	644	8982	589	2466	268	524	195	816	16821	14485	13841
1991	1796	1907	521	6206	370	1351	159	283	753	13346	11550	9643
1992	7840	1463	1158	347	3227	223	756	67	663	15743	7904	6441
1993	11339	6399	986	666	171	1347	105	337	494	21844	10505	4106
1994	9907	9257	5001	494	297	65	541	56	482	26101	16194	6937
1995	5993	8091	7347	3404	268	193	8	328	377	26009	20016	11925
1996	6050	4894	6563	5528	2406	171	136	4	516	26268	20218	15324
1997	16627	4943	3975	4926	3729	1581	83	94	356	36315	19687	14745
1998	10282	13579	3968	3178	3528	2604	1115	56	331	38641	28359	14780
1999	24693	8397	10951	2981	2361	2385	1718	809	274	54569	29876	21479
2000	16701	20168	6834	8272	2150	1709	1638	1175	776	59424	42722	22554
2001	25601	13641	16218	5188	5616	1532	1214	1148	1371	71529	45928	32287

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 2001. 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	0.002	0.112	0.478	0.409	0.512	0.449	0.368	0.765	0.492	0.441	33
1970	0.010	0.159	0.058	0.198	0.428	0.380	0.323	0.277	0.586	0.308	24
1971	0.002	0.678	0.956	0.367	0.212	1.178	1.194	0.366	0.442	0.413	31
1972	0.058	0.004	0.453	0.832	0.467	0.110	1.030	0.321	0.240	0.248	20
1973	0.107	0.621	0.024	1.143	1.737	0.412	0.062	0.695	0.131	0.361	28
1974	0.008	0.336	0.156	0.002	0.242	0.492	0.004	0.060	0.060	0.068	6
1975	0.002	0.121	0.405	0.188	0.026	0.460	0.336	0.172	0.025	0.116	10
1976	0.004	0.064	0.096	0.414	0.171	0.002	0.522	0.000	0.019	0.273	22
1977	0.002	0.222	0.035	0.141	0.261	0.339	0.002	1.009	0.020	0.186	15
1978	0.003	0.072	0.486	0.121	0.194	0.460	0.293	0.107	0.015	0.201	17
1979	0.002	0.006	0.062	0.385	0.419	0.363	0.703	0.249	0.026	0.381	29
1980	0.003	0.608	0.142	0.122	0.385	0.402	0.416	0.346	0.022	0.310	24
1981	0.002	0.147	0.486	0.241	0.304	0.348	0.465	0.178	0.013	0.297	23
1982	0.002	0.215	0.358	0.390	0.192	0.401	0.361	0.481	0.117	0.360	28
1983	0.002	0.121	0.302	0.319	0.406	0.304	0.185	0.342	0.071	0.342	26
1984	0.002	0.042	0.314	0.253	0.246	0.544	0.481	0.486	0.308	0.392	30
1985	0.002	0.216	0.302	0.387	0.216	0.175	0.344	0.246	0.132	0.249	20
1986	0.003	0.035	0.427	0.208	0.610	0.209	0.246	0.263	0.051	0.223	18
1987	0.002	0.228	0.149	0.490	0.177	0.527	0.213	0.229	0.106	0.366	28
1988	0.003	0.056	0.410	0.209	0.577	0.305	0.759	0.174	0.101	0.364	28
1989	0.002	0.110	0.114	0.238	0.359	0.436	0.130	1.606	0.048	0.248	20
1990	0.003	0.013	0.170	0.265	0.402	0.321	0.416	0.269	0.058	0.319	25
1991	0.005	0.299	0.207	0.454	0.307	0.381	0.673	0.823	0.093	0.423	31
1992	0.003	0.195	0.352	0.507	0.674	0.555	0.609	0.540	0.161	0.582	40
1993	0.003	0.046	0.490	0.607	0.769	0.712	0.428	0.667	0.173	0.593	41
1994	0.002	0.031	0.185	0.414	0.231	1.879	0.301	0.884	0.096	0.338	26
1995	0.003	0.009	0.084	0.147	0.251	0.154	0.502	0.191	0.048	0.149	13
1996	0.002	0.008	0.087	0.194	0.220	0.522	0.163	2.039	0.172	0.206	17
1997	0.003	0.020	0.024	0.134	0.159	0.149	0.192	0.098	0.113	0.144	12
1998	0.002	0.015	0.086	0.097	0.192	0.216	0.121	0.268	0.124	0.161	13
1999	0.002	0.006	0.081	0.127	0.123	0.176	0.179	0.143	0.105	0.146	12
2000	0.002	0.018	0.076	0.187	0.138	0.142	0.155	0.190	0.101	0.168	14

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 2001.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	89	98	3870	1279	1780	20273	7755	526	2678	38347	38259	38161
1970	385	324	130	3162	921	1028	12128	4793	1576	24446	24061	23737
1971	53	1398	410	161	2811	579	659	7833	4203	18107	18054	16656
1972	618	194	1055	208	121	2191	167	178	7427	12159	11541	11346
1973	1269	2139	288	883	98	73	1840	53	4906	11550	10281	8142
1974	385	4183	1708	370	305	17	45	1543	3548	12105	11720	7537
1975	371	1401	4441	1924	400	231	10	40	4130	12947	12576	11176
1976	6198	1356	1844	3899	1727	375	137	6	3330	18872	12674	11319
1977	681	22641	1890	2206	2793	1403	351	72	2680	34717	34037	11396
1978	485	2489	26960	2404	2076	2072	937	313	2176	39912	39427	36938
1979	5985	1773	3441	21837	2308	1647	1227	624	2024	40865	34880	33107
1980	764	21889	2618	4258	16101	1463	1074	542	2081	50790	50026	28137
1981	590	2793	17716	2990	4083	10559	917	632	2034	42315	41726	38932
1982	197	2157	3583	14344	2547	2903	6990	514	2151	35387	35190	33033
1983	292	721	2587	3300	10525	2025	1822	4349	1872	27492	27201	26479
1984	1716	1066	949	2518	2599	6755	1400	1351	4390	22745	21029	19963
1985	178	6275	1520	913	2119	1958	3676	772	3440	20852	20674	14398
1986	1780	572	7829	1422	1026	1996	2066	2681	3481	22852	21072	20500
1987	192	5392	717	7178	1316	383	1469	1157	4326	22129	21937	16545
1988	1458	484	6547	1267	3912	860	197	1008	4324	20056	18598	18115
1989	49	5807	524	5322	936	2503	584	78	3081	18883	18834	13027
1990	348	339	8303	698	4594	556	1314	549	2831	19532	19184	18844
1991	216	1314	417	9374	624	3280	335	885	2585	19030	18814	17500
1992	959	881	1295	367	6707	482	2048	152	2285	15177	14218	13336
1993	1383	3078	1209	1202	217	3143	245	922	1628	13028	11645	8567
1994	1057	4343	5235	801	573	140	1707	150	1486	15492	14435	10092
1995	517	3992	7076	5298	595	473	19	981	1202	20152	19635	15643
1996	838	2422	6032	7298	4648	436	393	10	1853	23930	23092	20670
1997	2198	2504	3107	5936	6204	3443	203	244	1127	24965	22767	20263
1998	1091	7021	4144	3777	5567	5091	2910	199	1144	30944	29853	22832
1999	3197	3977	9975	3841	2969	4458	3643	2202	819	35079	31882	27906
2000	1932	10972	6479	12230	4022	3058	3766	2948	2253	47660	45728	34755
2001	2390	7142	16303	7111	10096	3319	2729	2977	4013	56082	53692	46549

Table 20. Deterministic projection results for haddock in unit areas 5Zjm for 2001 at $F_{0.1}$ using the bootstrap bias adjusted population abundance at the beginning of 2001.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
Beginning of Year Population Numbers (000s)												
2001	25601	13641	16218	5188	5616	1532	1214	1148	1371			
2002	4912	20960	10947	12015	3308	3581	977	774	1606			
Partial Recruitment to the Fishery[1]												
2001	0.00	0.08	0.40	1.00	1.00	1.00	1.00	1.00	1.00			
Fishing Mortality												
2001	0.000	0.020	0.100	0.250	0.250	0.250	0.250	0.250	0.250			
Weight at beginning of year for population (kg)[2]												
2002	0.12	0.51	0.94	1.31	1.63	1.99	2.35	2.79	3.09			
Beginning of Year Projected Population Biomass (t)												
2002	567	10751	10269	15694	5403	7131	2292	2162	4959	59229	58663	47911
Projected Catch Numbers (000s)												
2001	0	245	1401	1044	1131	309	244	231	276			
Average weight at age for catch (kg)[1]												
2001	0.63	1.11	1.48	1.81	2.1	2.31	2.85	2.88	3.8			
Projected Yield (t)												
2001	0	273	2070	1894	2375	713	697	665	1048	9734		

[1]Average of 1996 – 2000.
[2]Average of 1997 – 2001.

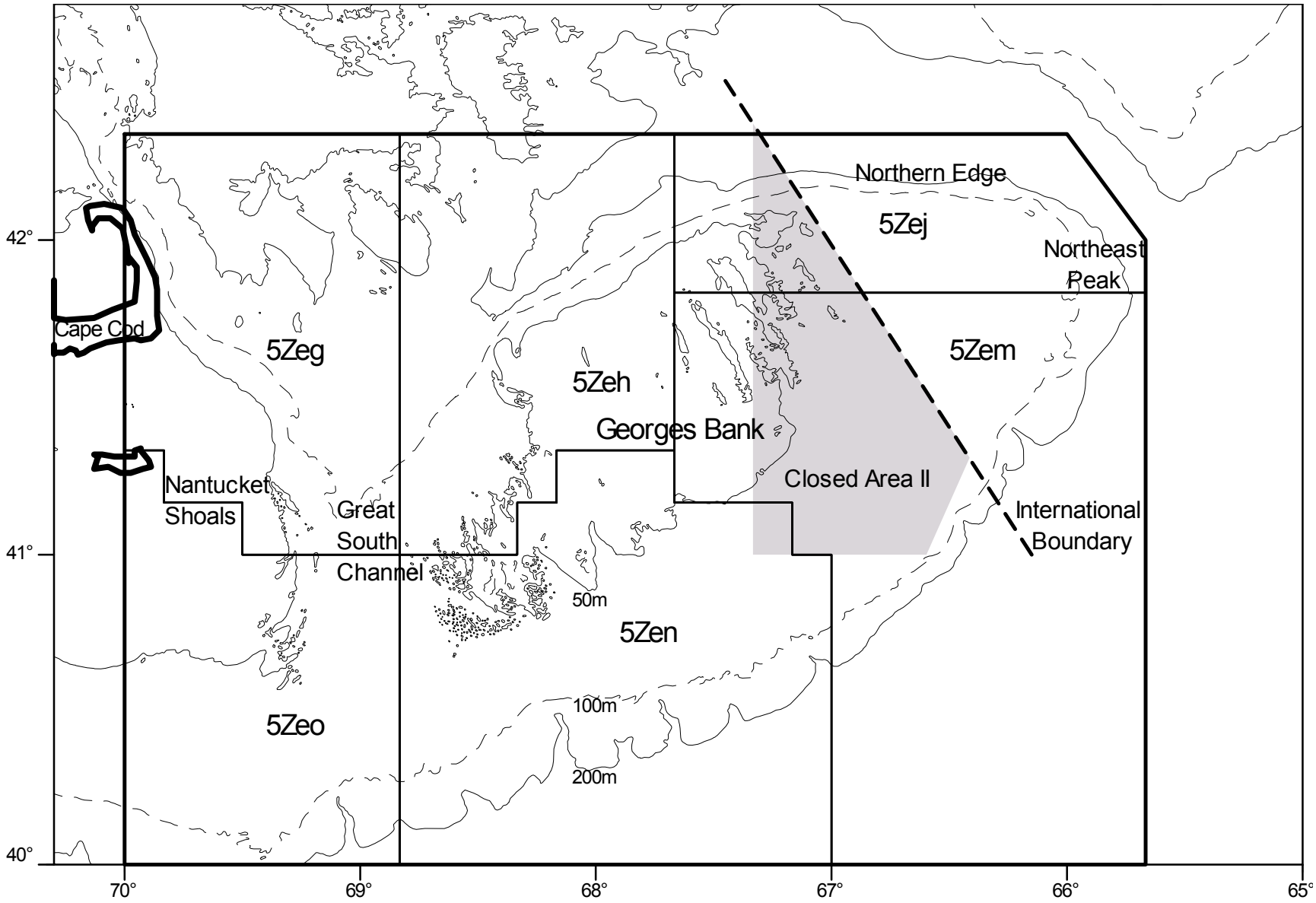

Figure 1. Fisheries statistical unit areas in NAFO Subdivision 5Ze.

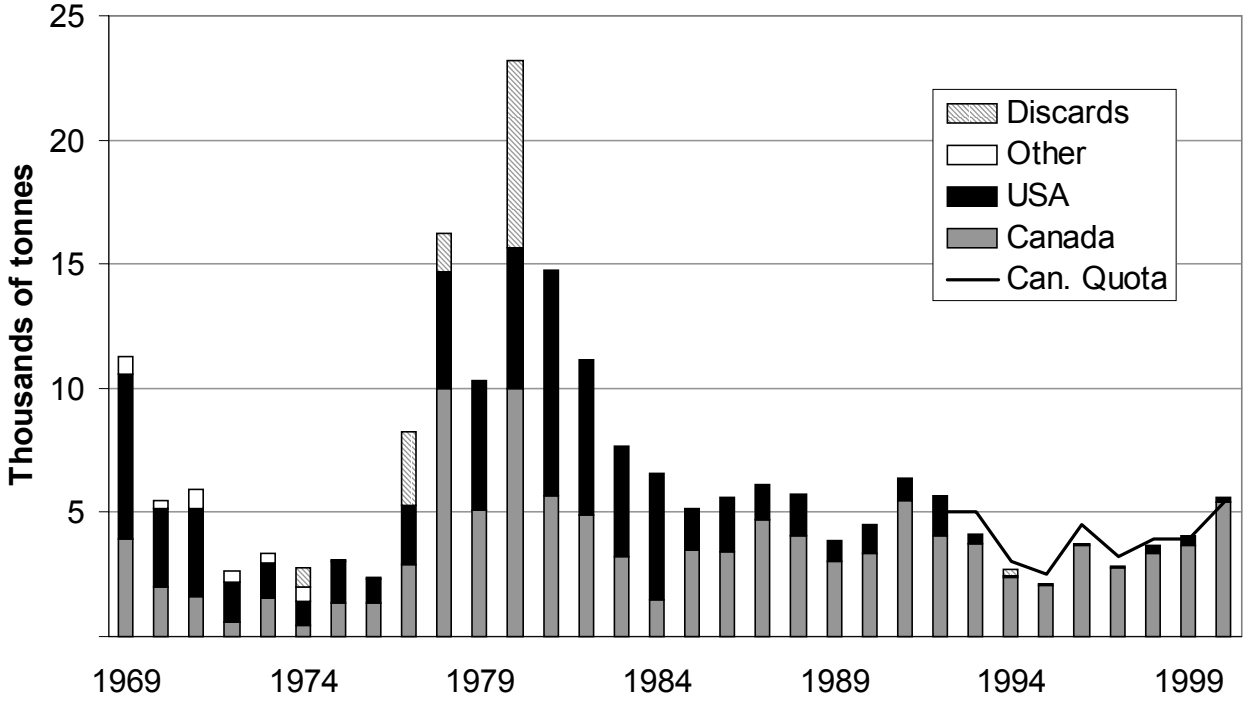

Figure 2. Nominal catch of haddock in unit areas 5Zjm.

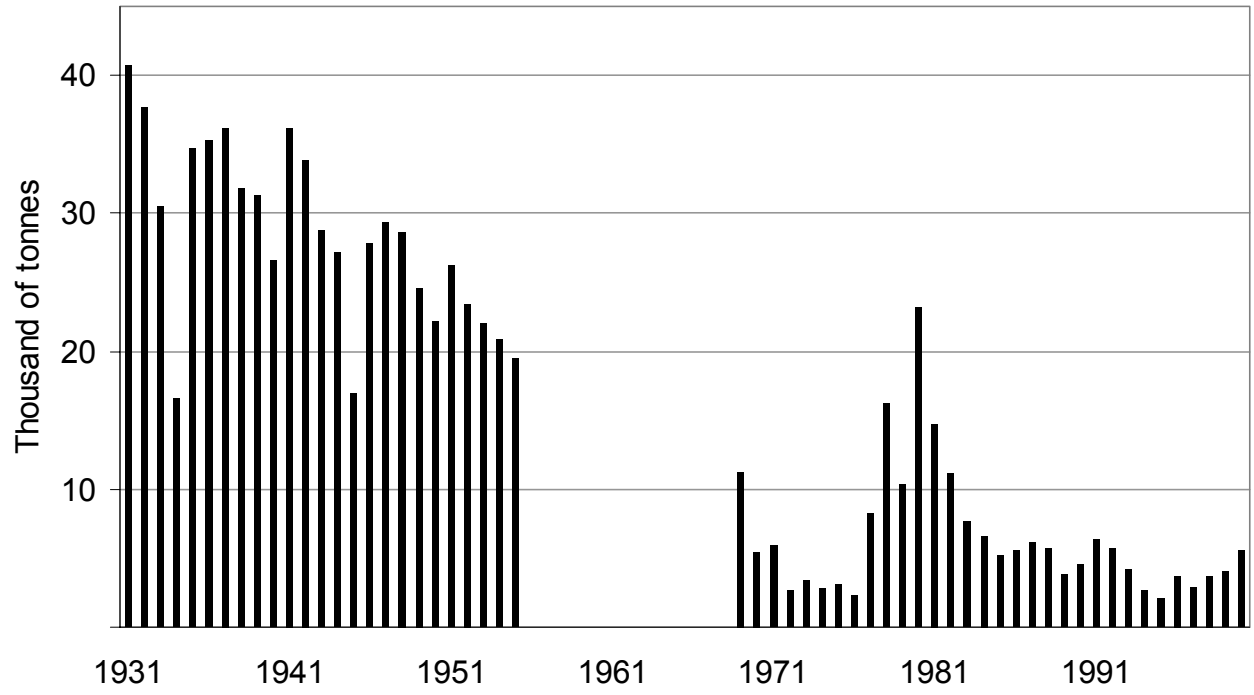

Figure 3. Historic catch of haddock in 5Zjm compared to recent catches.

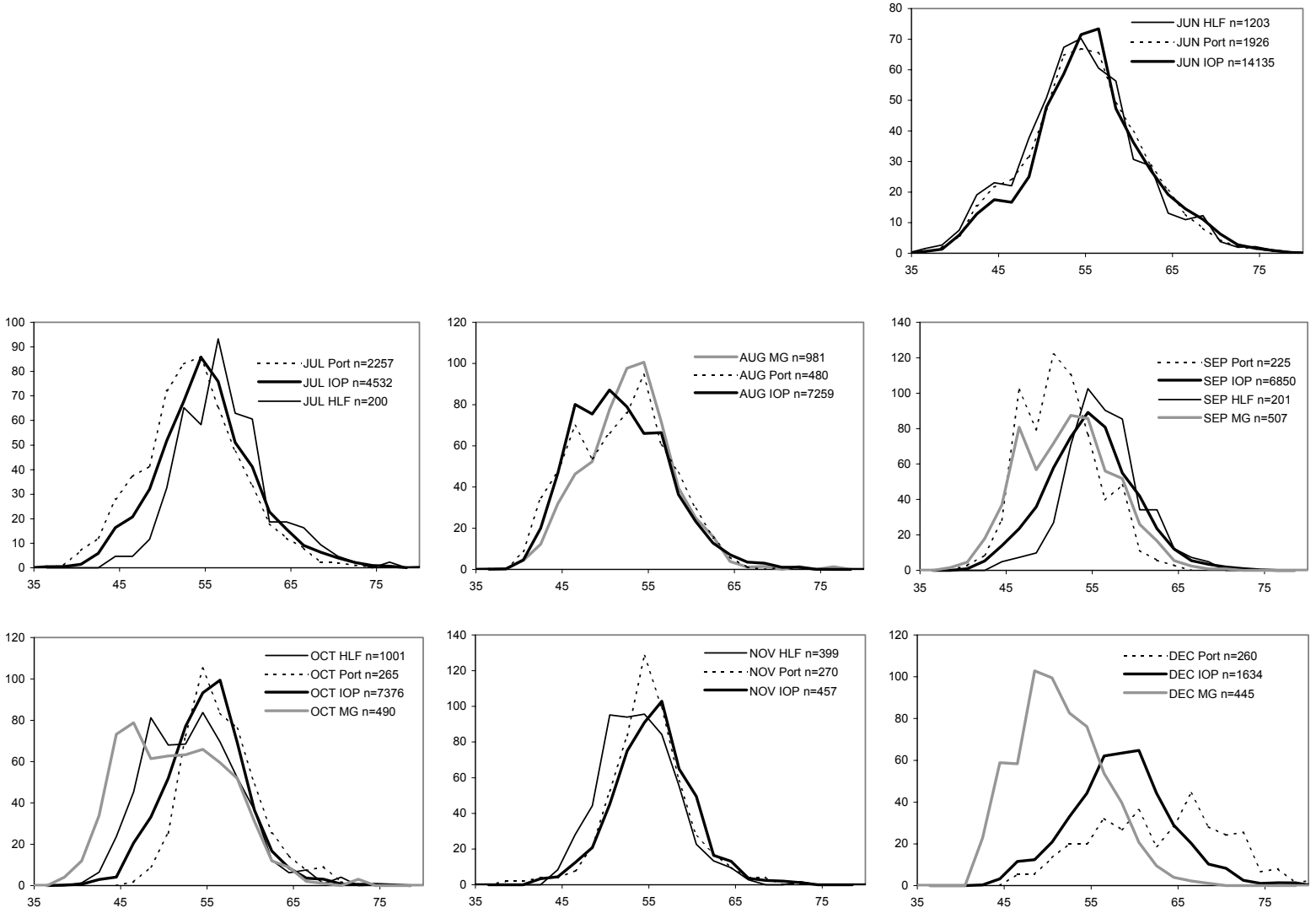

Figure 4. Comparison of bottom trawl length frequencies obtained by DFO port samplers (Port), observers (IOP), Scotia Fundy Mobile Gear Fishermen's Association (MG) and High Liner Foods (HLF) from the Georges Bank commerical fishery in 2000.

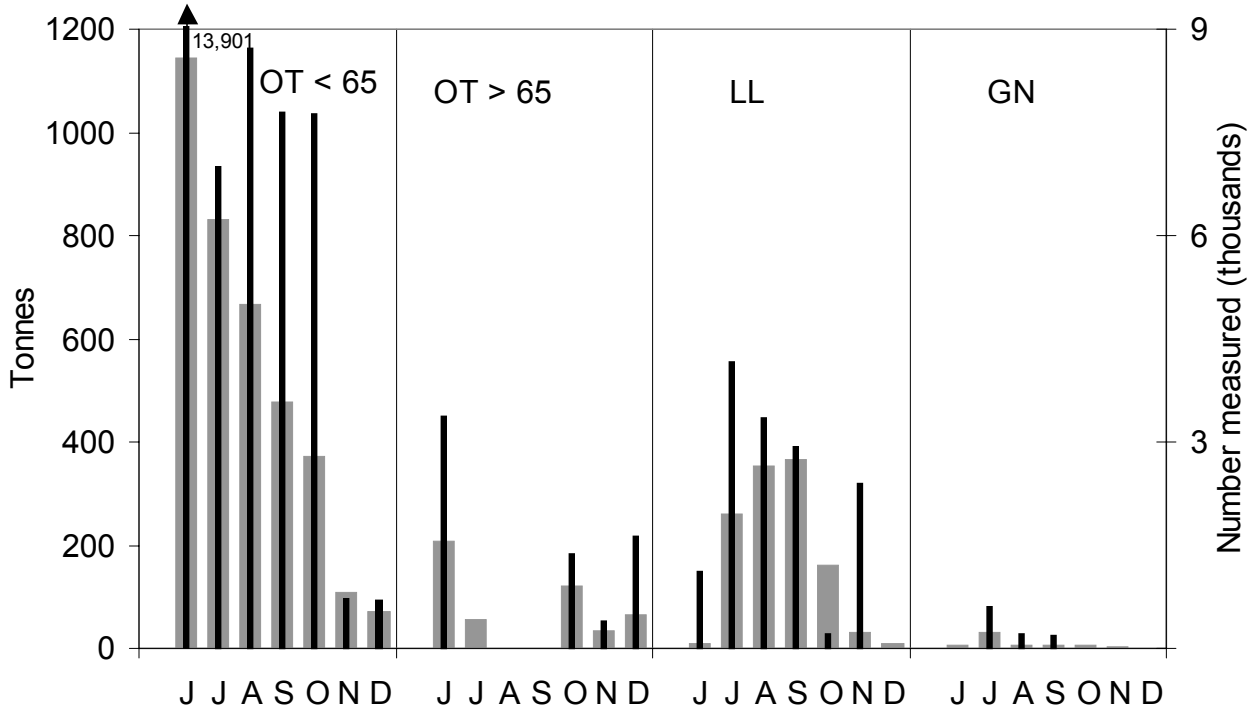

Figure 5. Haddock catches in 5Zjm by month and gear for the Canadian commercial fishery in 2000 (wide gray bars) with sampling levels (narrow black bars).

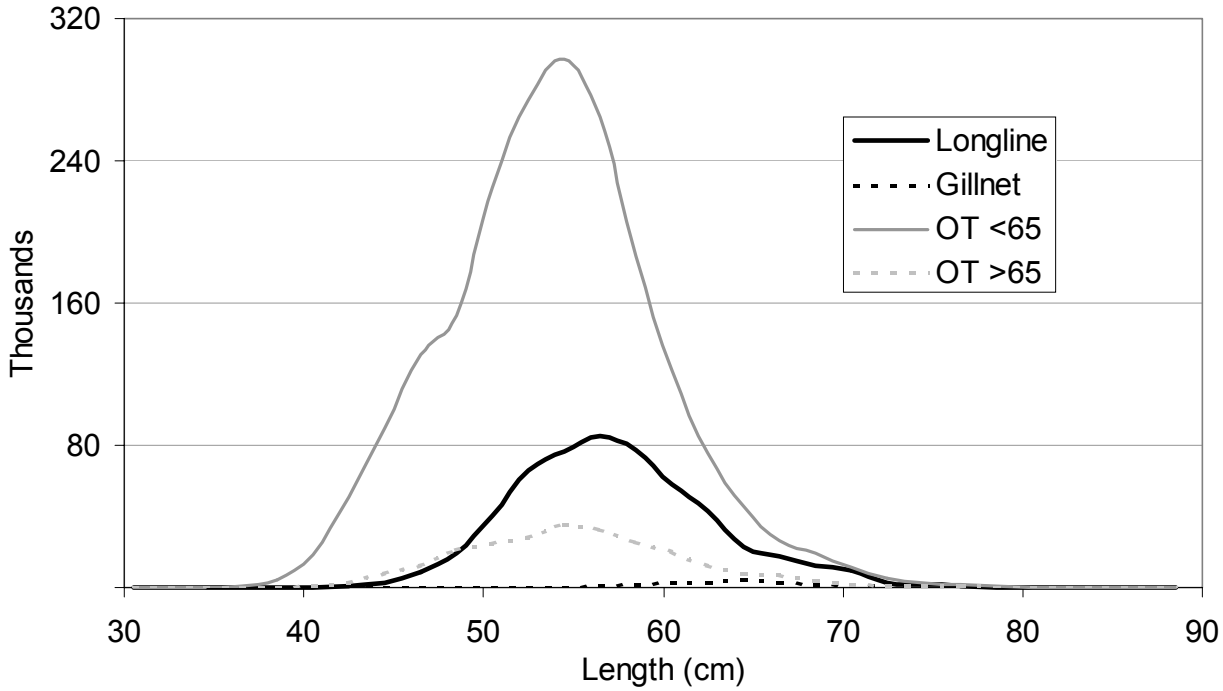

Figure 6. Catch at length by the principal Canadian 5Zjm commercial haddock fisheries in 2000.

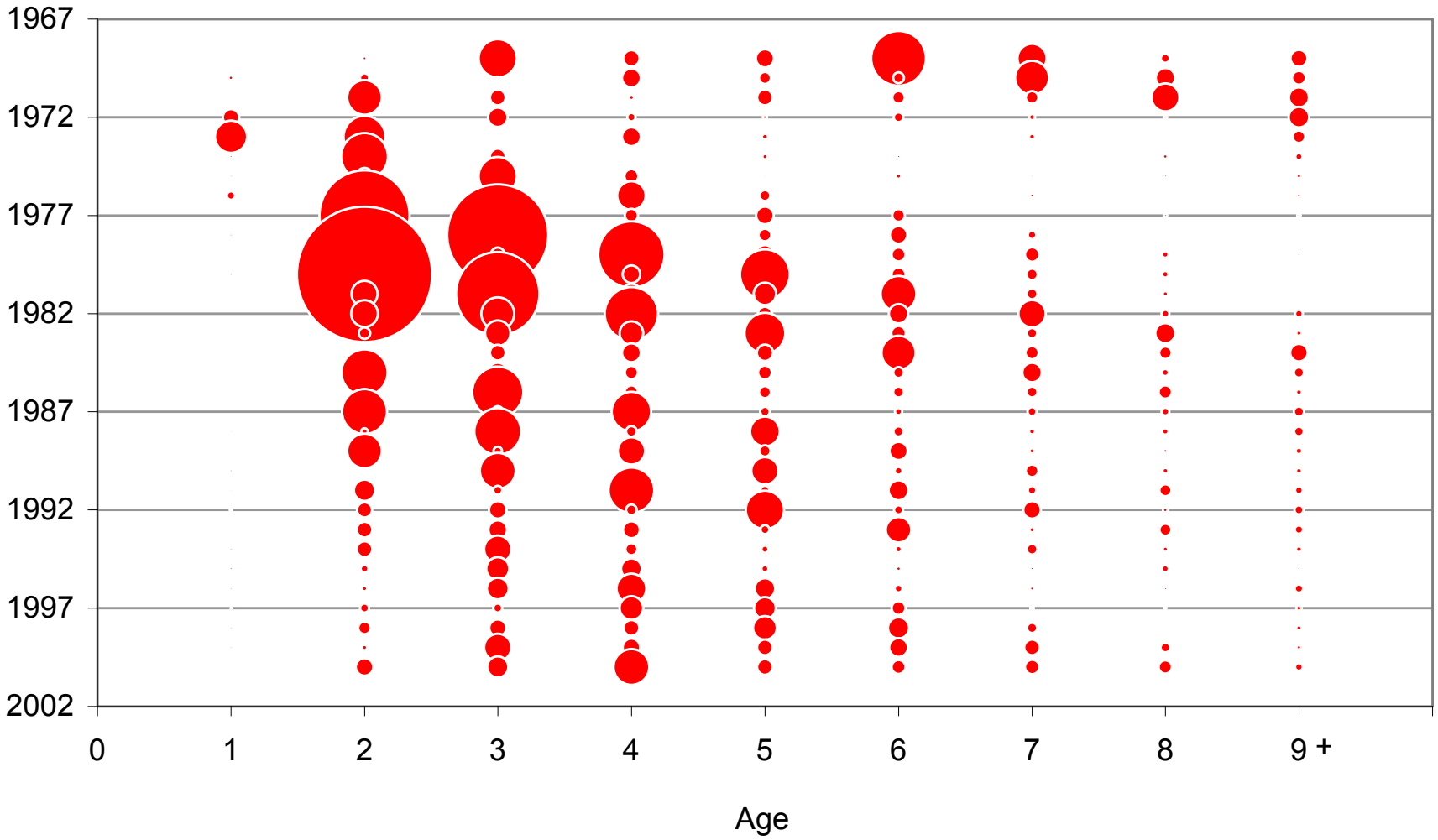

Figure 7. Total commercial catch at age (numbers) of haddock from unit areas 5Zjm. The bubble area is proportional to magnitude (see Table 9).

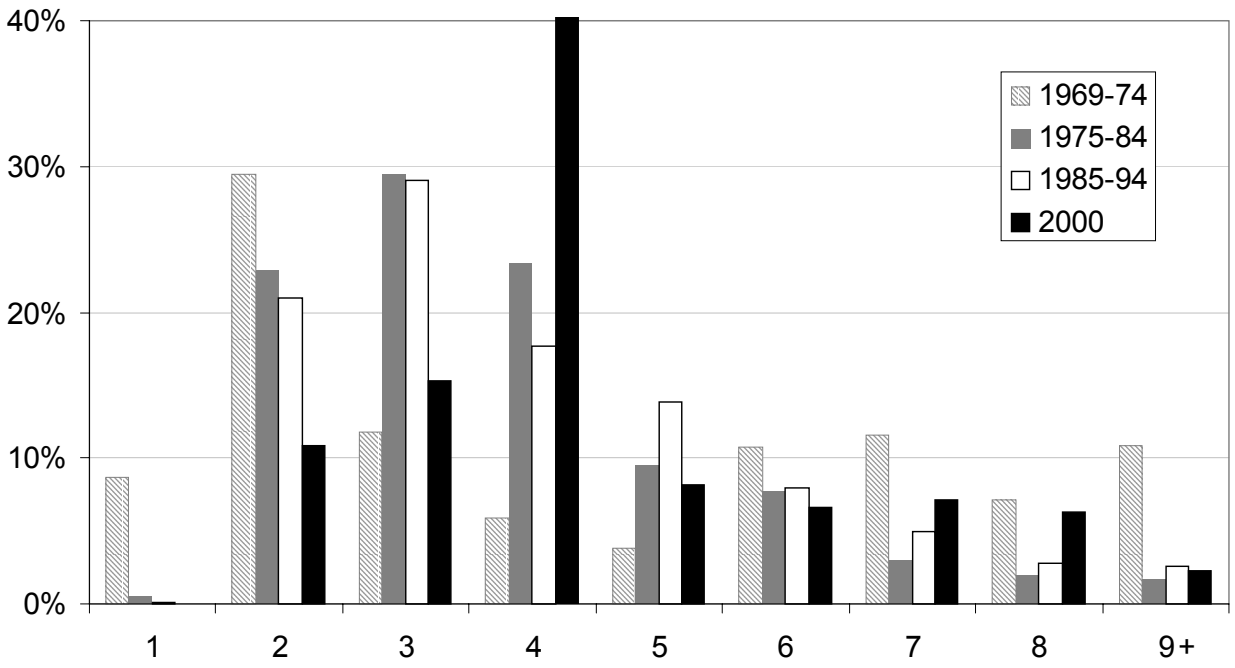

Figure 8. Age composition of the haddock catch for the Canadian 5Zjm commercial fishery in 2000 compared to the average age composition for the total catch of all fisheries during three earlier periods.

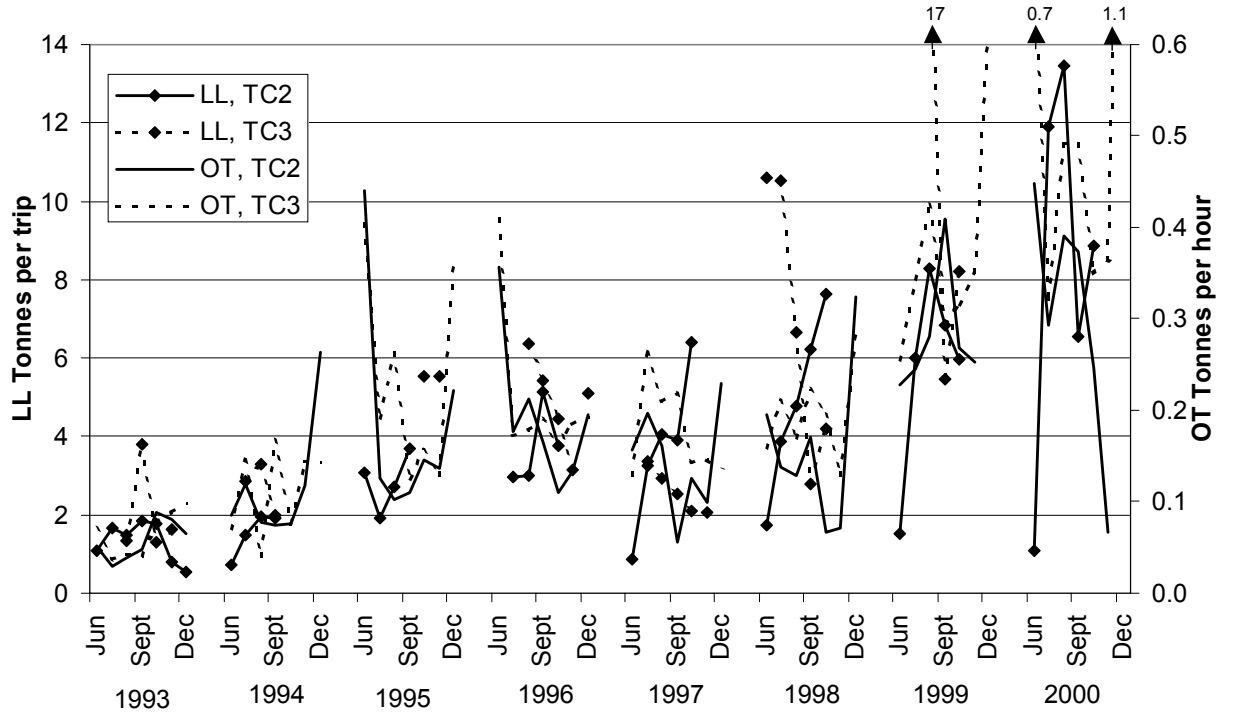

Figure 9. Catch rates for haddock from the Canadian commercial fishery in 5Zjm. (LL = longline, OT = otter trawl, TC = tonnage class).

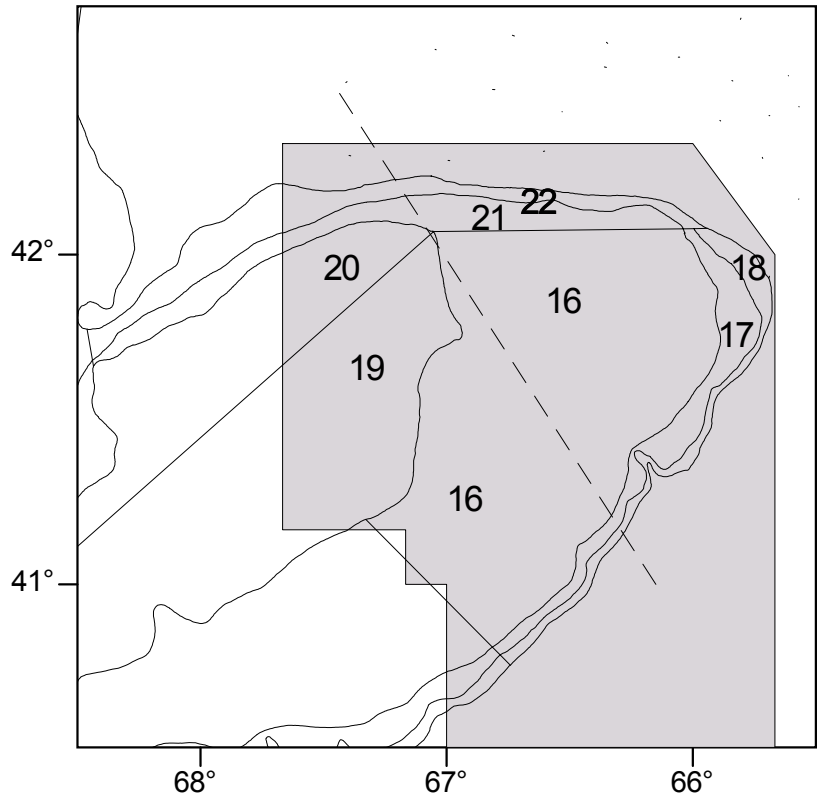

Figure 10. Stratification scheme used for NMFS surveys. The 5Zjm management area is indicated by shading.

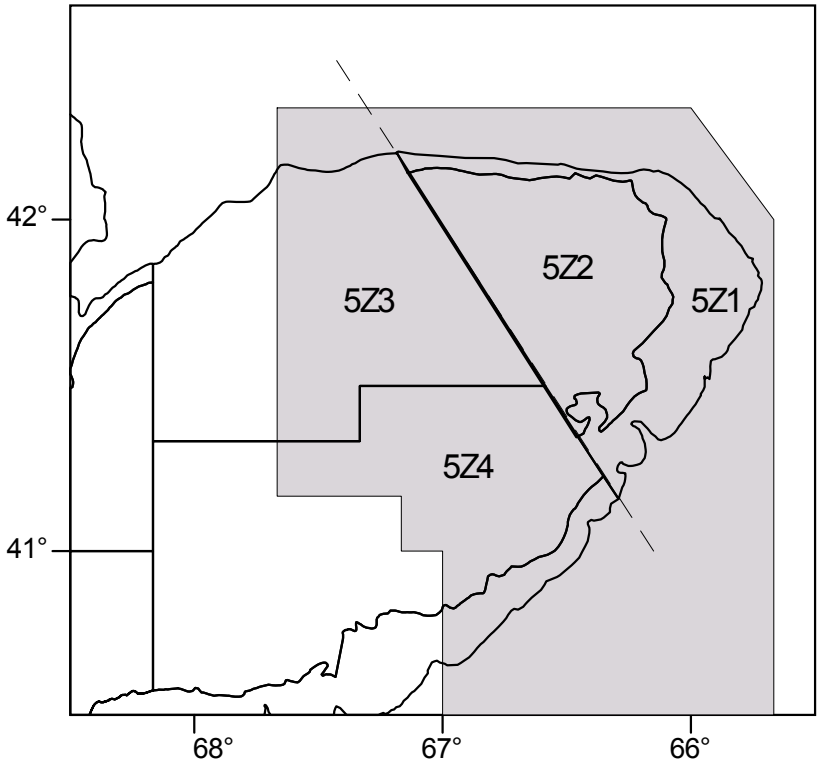

Figure 11. Stratification scheme used for the DFO survey. The 5Zjm management area is indicated by shading.

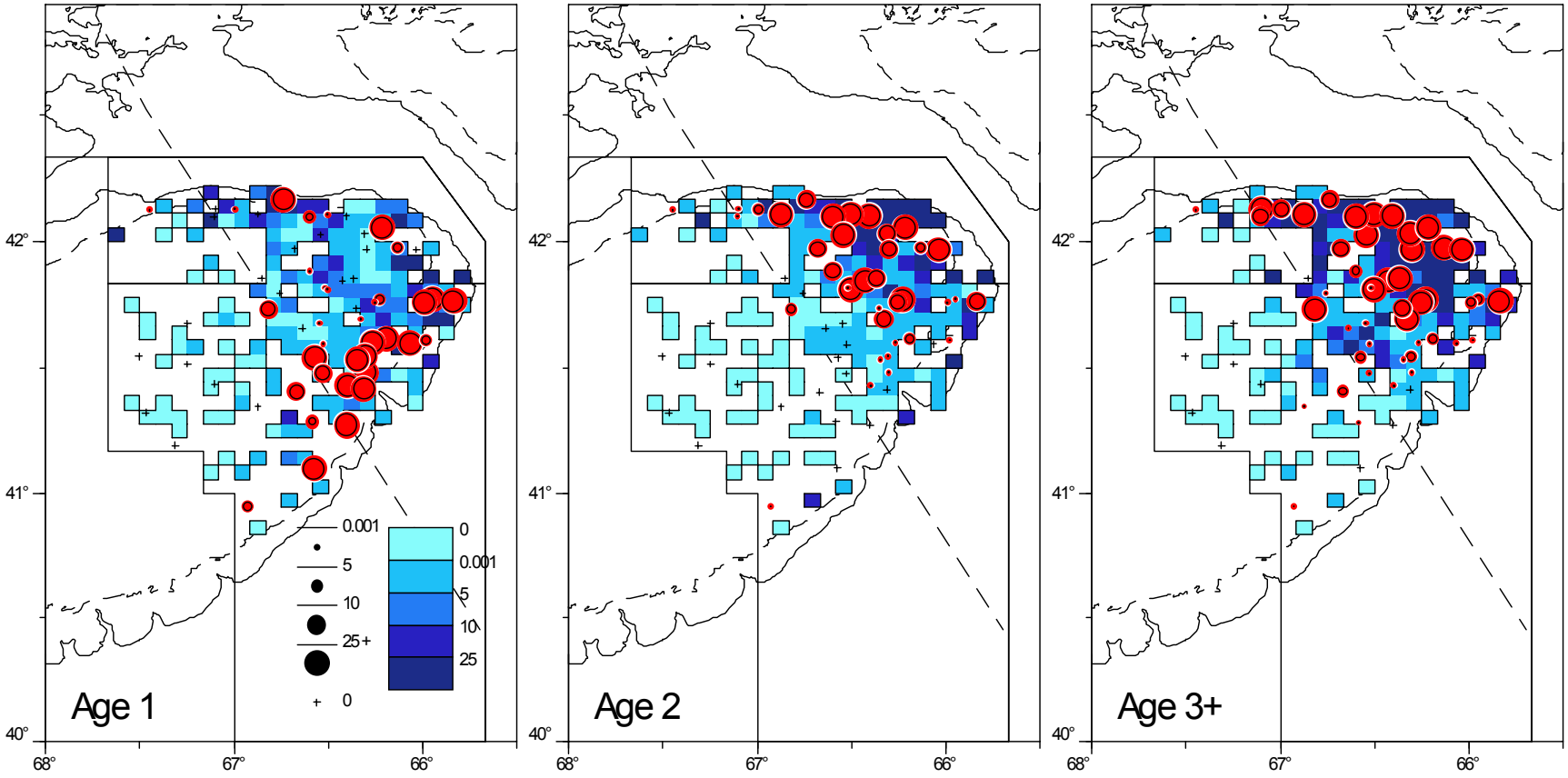

Figure 12. Distribution of 5Zjm haddock abundance (number/tow) as observed from the **DFO spring** survey. The squares are shaded relative to the average catch for 1996 to 2000. The expanding symbols represent the 2001 survey catches.

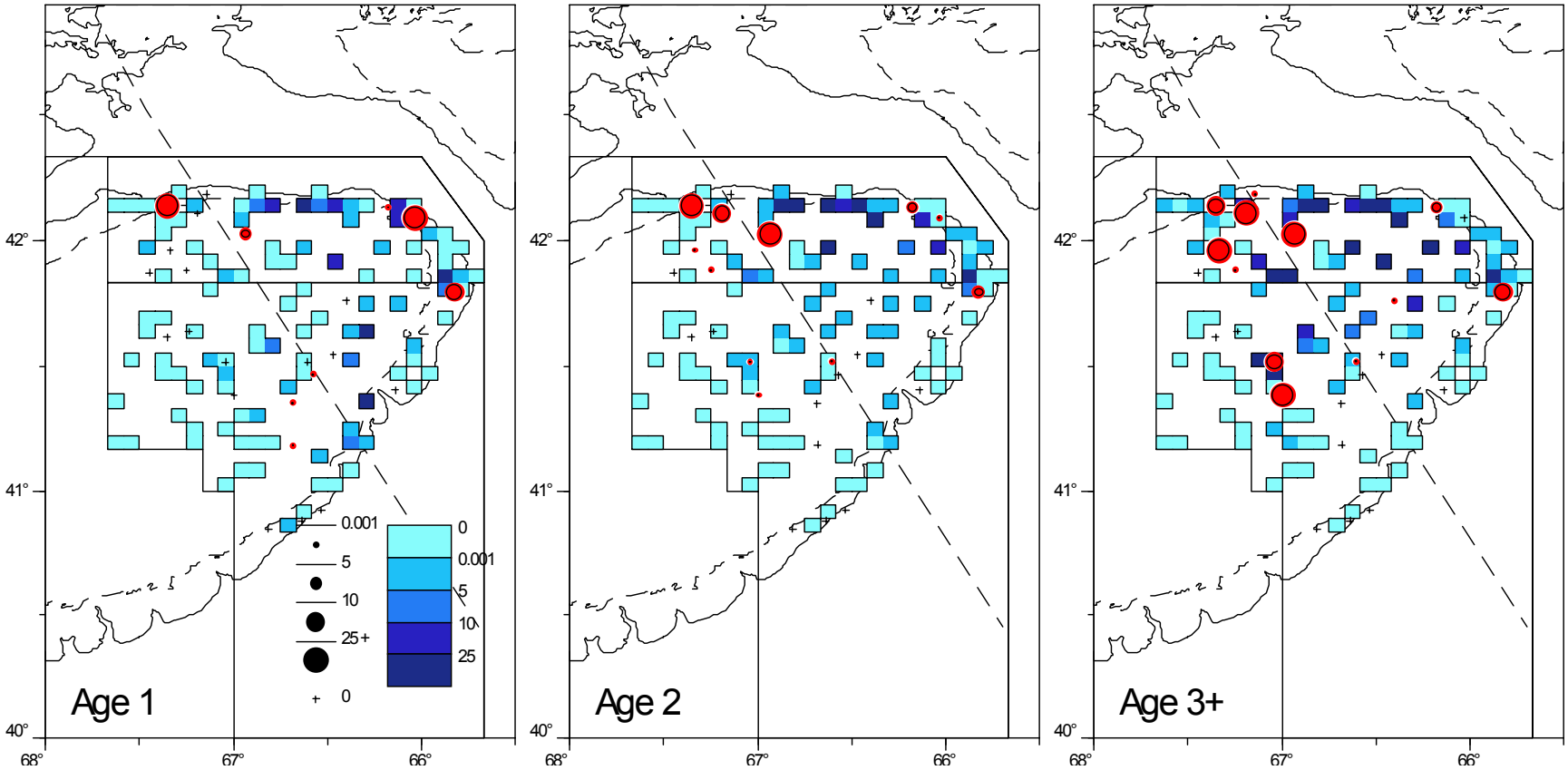

Figure 13. Distribution of 5Zjm haddock abundance (number/tow) as observed from the **NMFS spring** survey. The squares are shaded relative to the average catch for 1995 to 1999. The expanding symbols represent the 2000 survey catches.

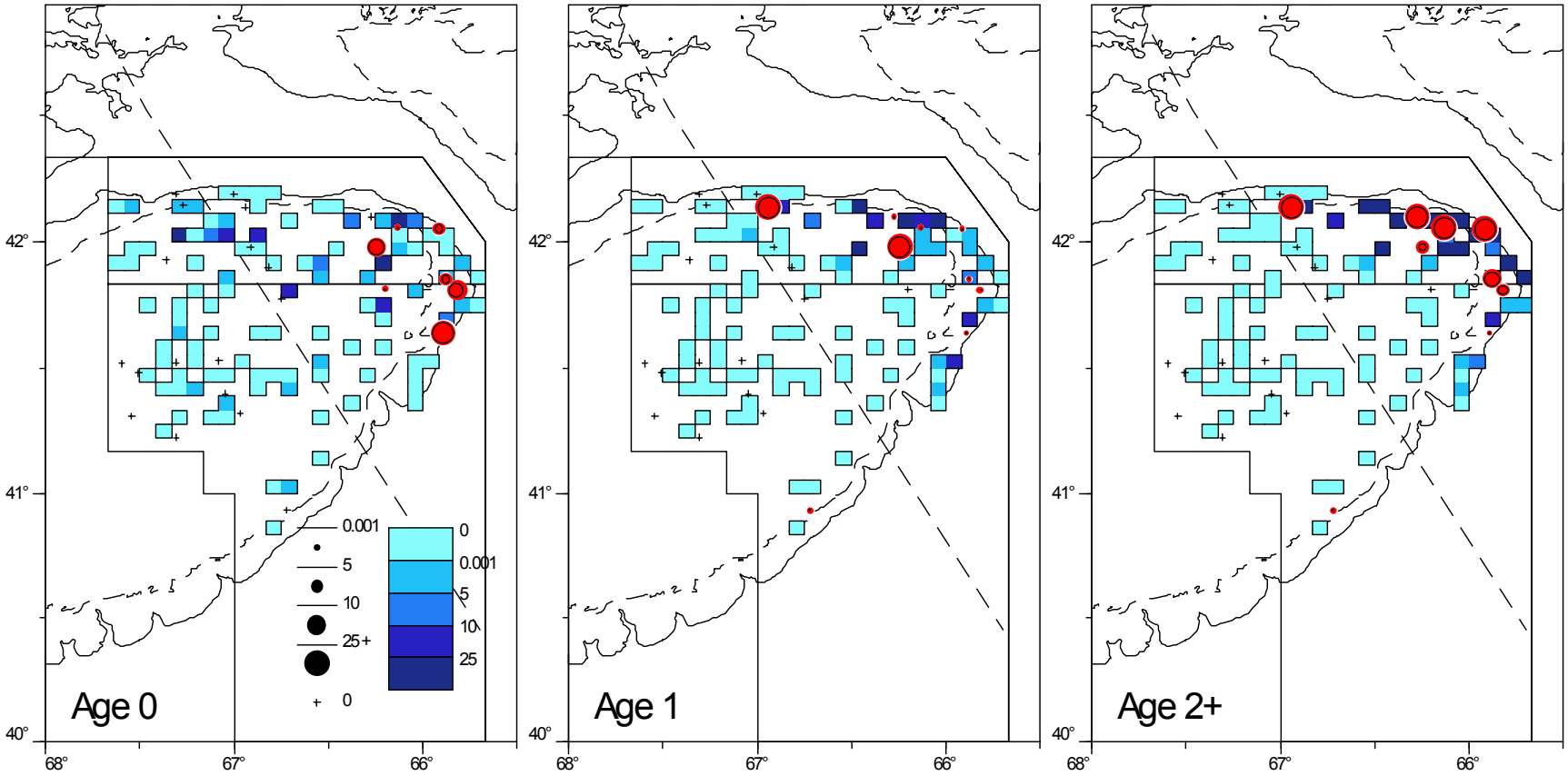

Figure 14. Distribution of 5Zjm haddock abundance (number/tow) as observed from the **NMFS fall** survey. The squares are shaded relative to the average catch for 1995 to 1999. The expanding symbols represent the 2000 survey catches.

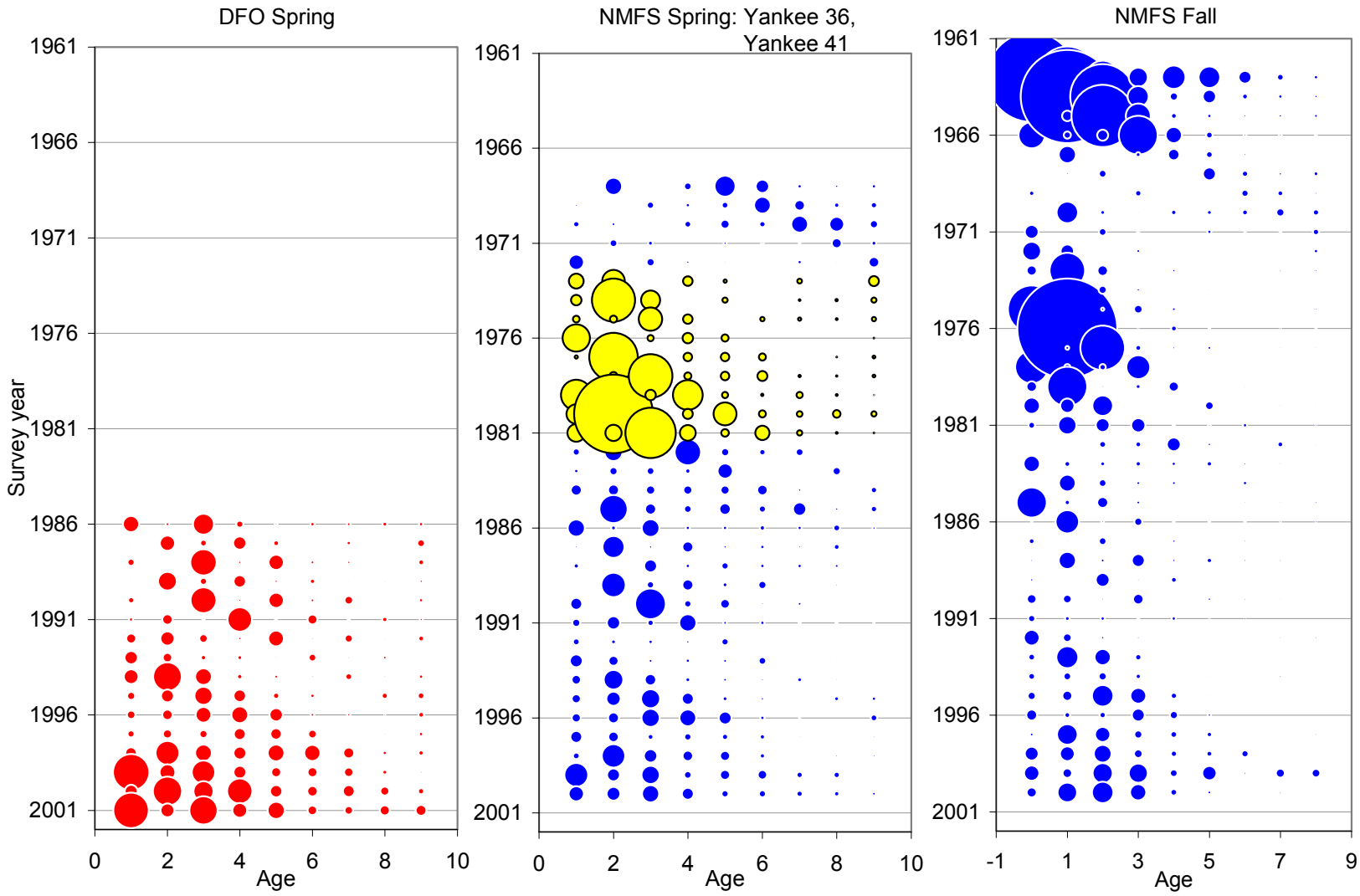

Figure 15. Estimated abundance at age (numbers in 000's) of haddock for the DFO and NMFS spring surveys and the NMFS fall survey. Bubble area is proportional to magnitude (see Tables 12-14). Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 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.

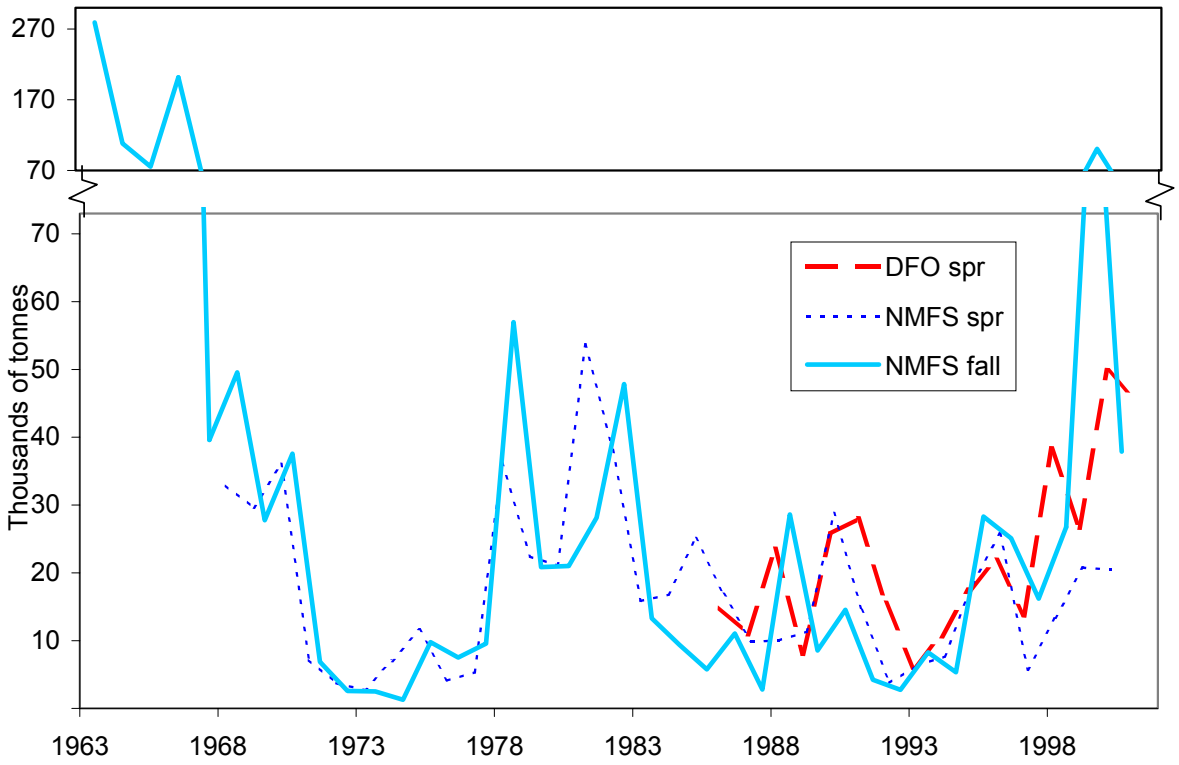

Figure 16. Biomass for ages 3-8 from NMFS and DFO research surveys (adjusted by calibration constants) for haddock in unit areas 5Zjm..

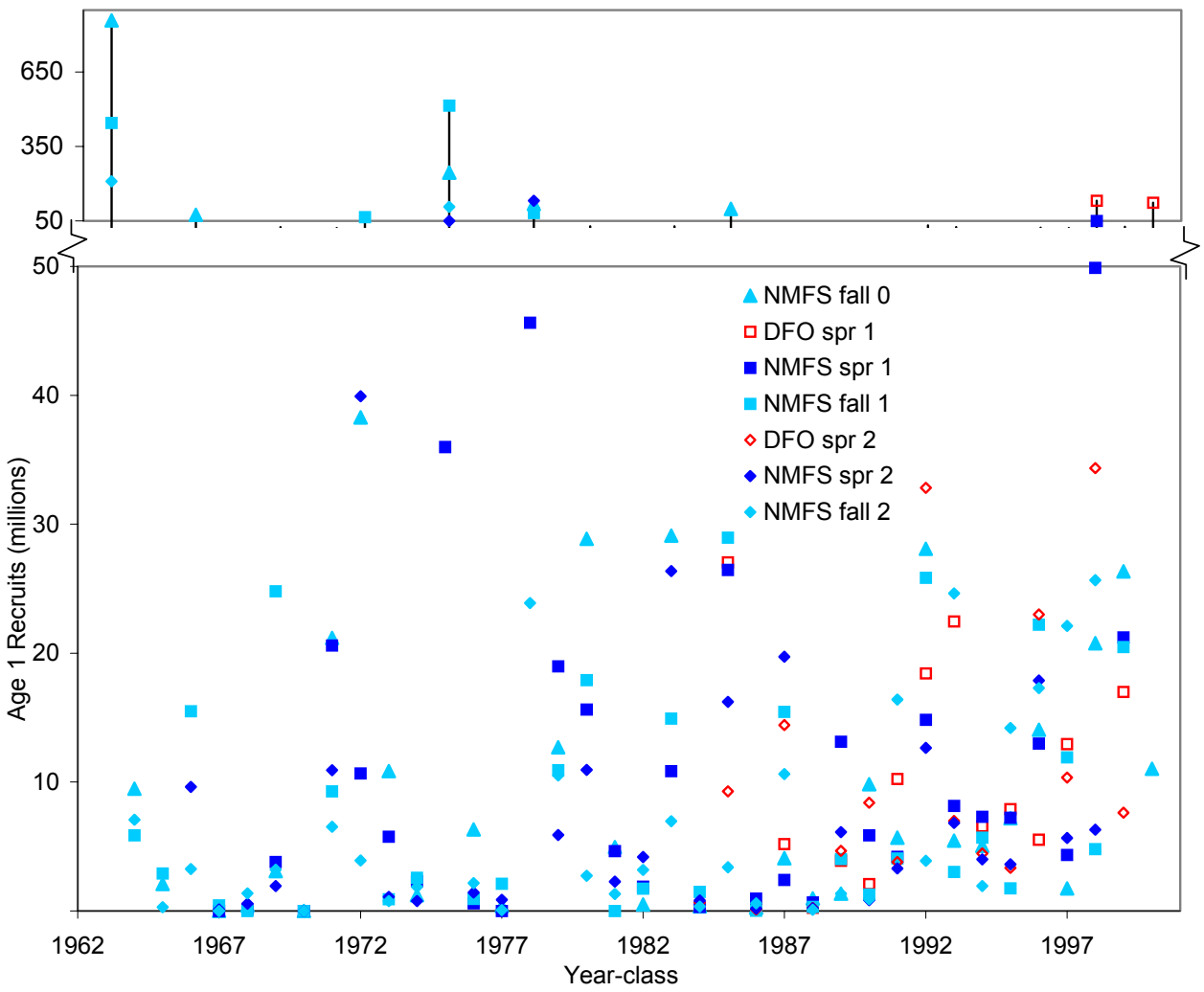

Figure 17. Year-class abundance for ages 0, 1 and 2 from the NMFS fall and ages 1 and 2 from the NMFS and DFO spring research surveys (adjusted by calibration constants) for haddock in unit areas 5Zjm.

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

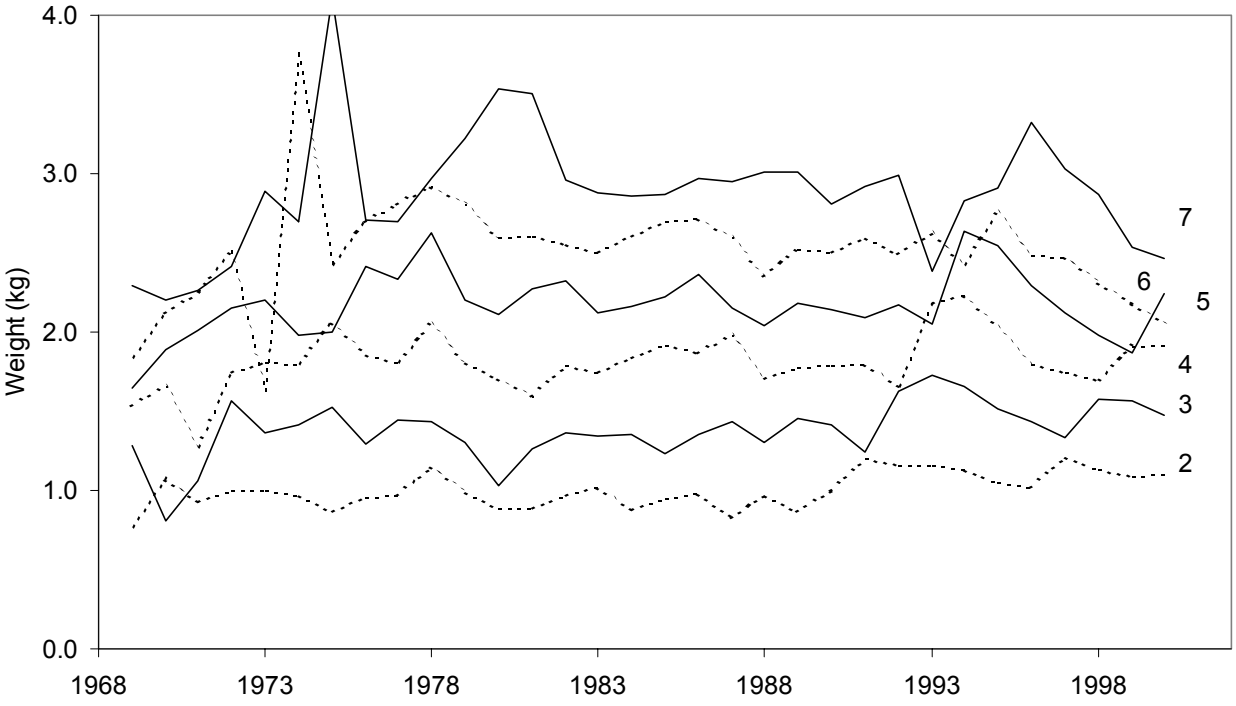

Figure 19. Weight at age for haddock in unit areas 5Zjm derived from the commercial fisheries.

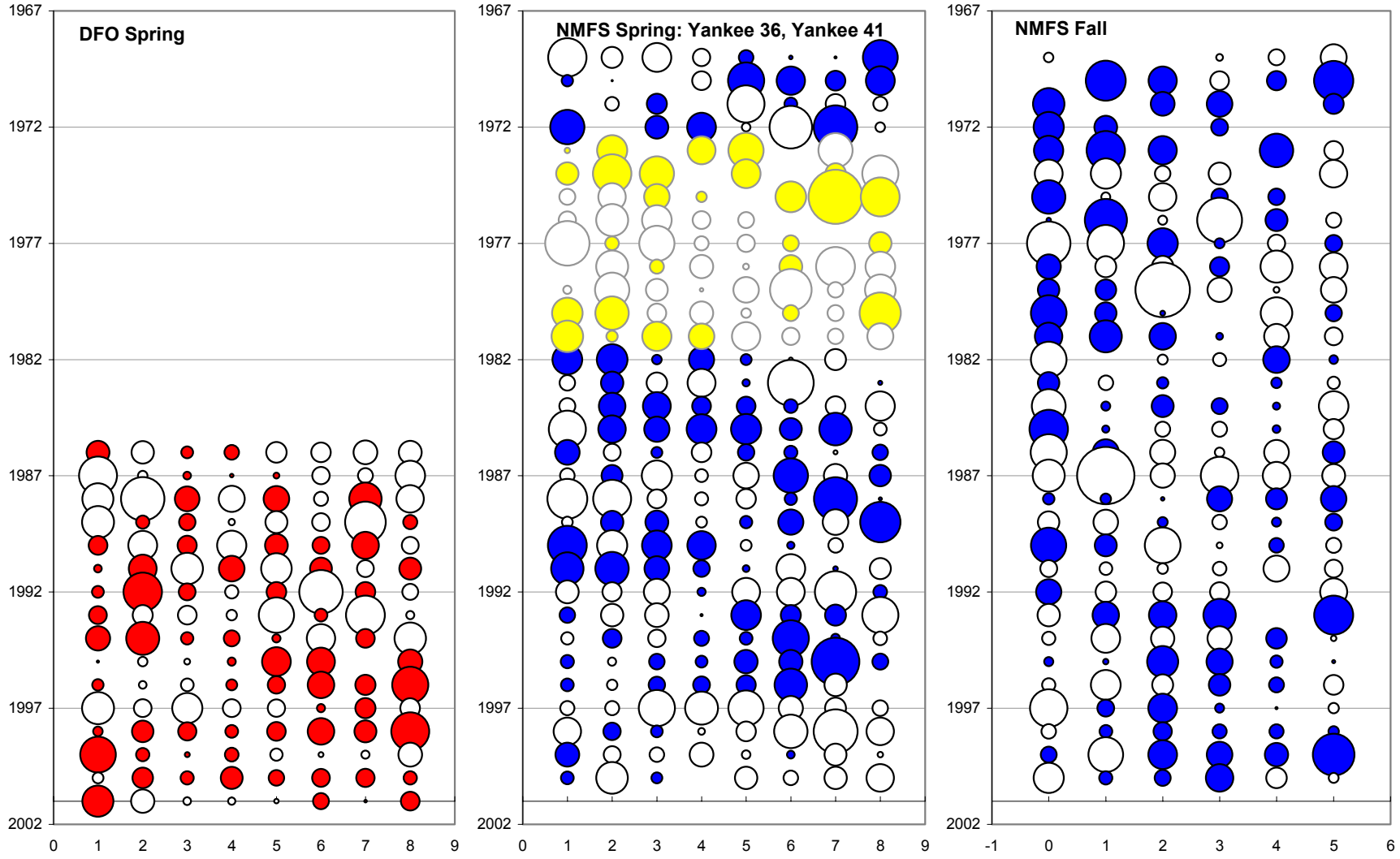

Figure 20. Residuals by year and age group for each research survey index. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude. From 1973-81, a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years.

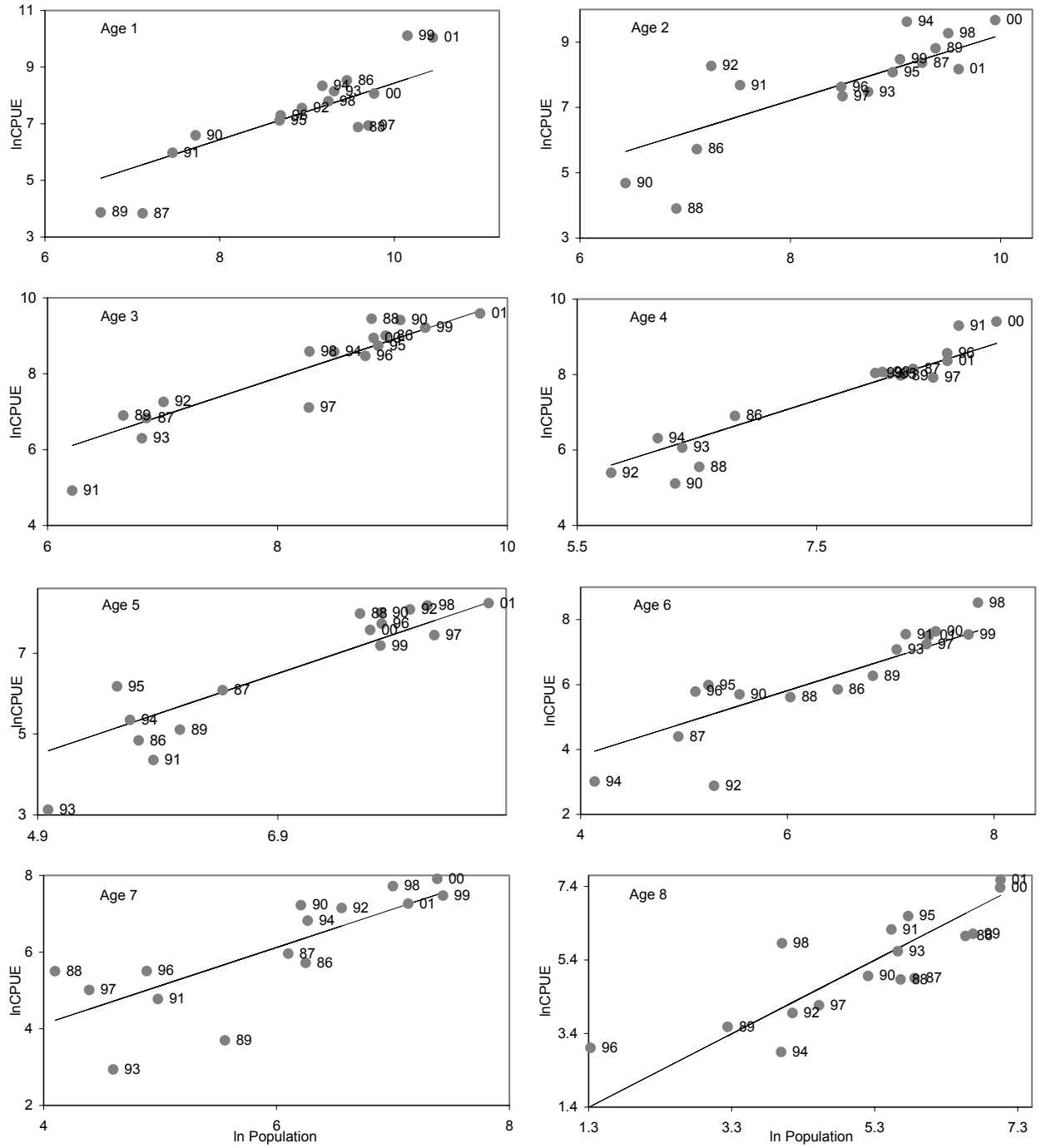

Figure 21. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **DFO spring** survey.

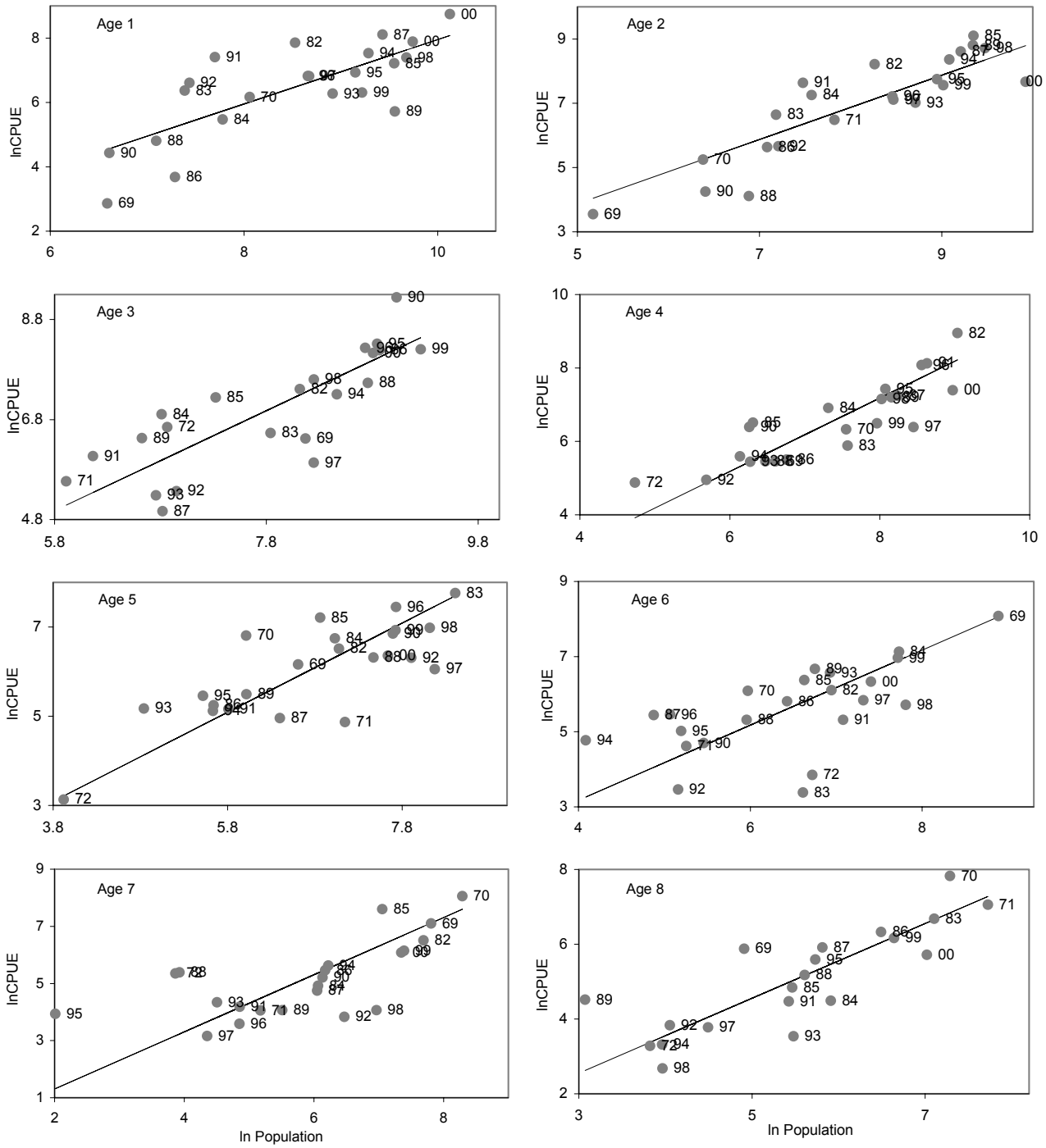

Figure 22. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **NMFS spring** survey with a Yankee 36 net.

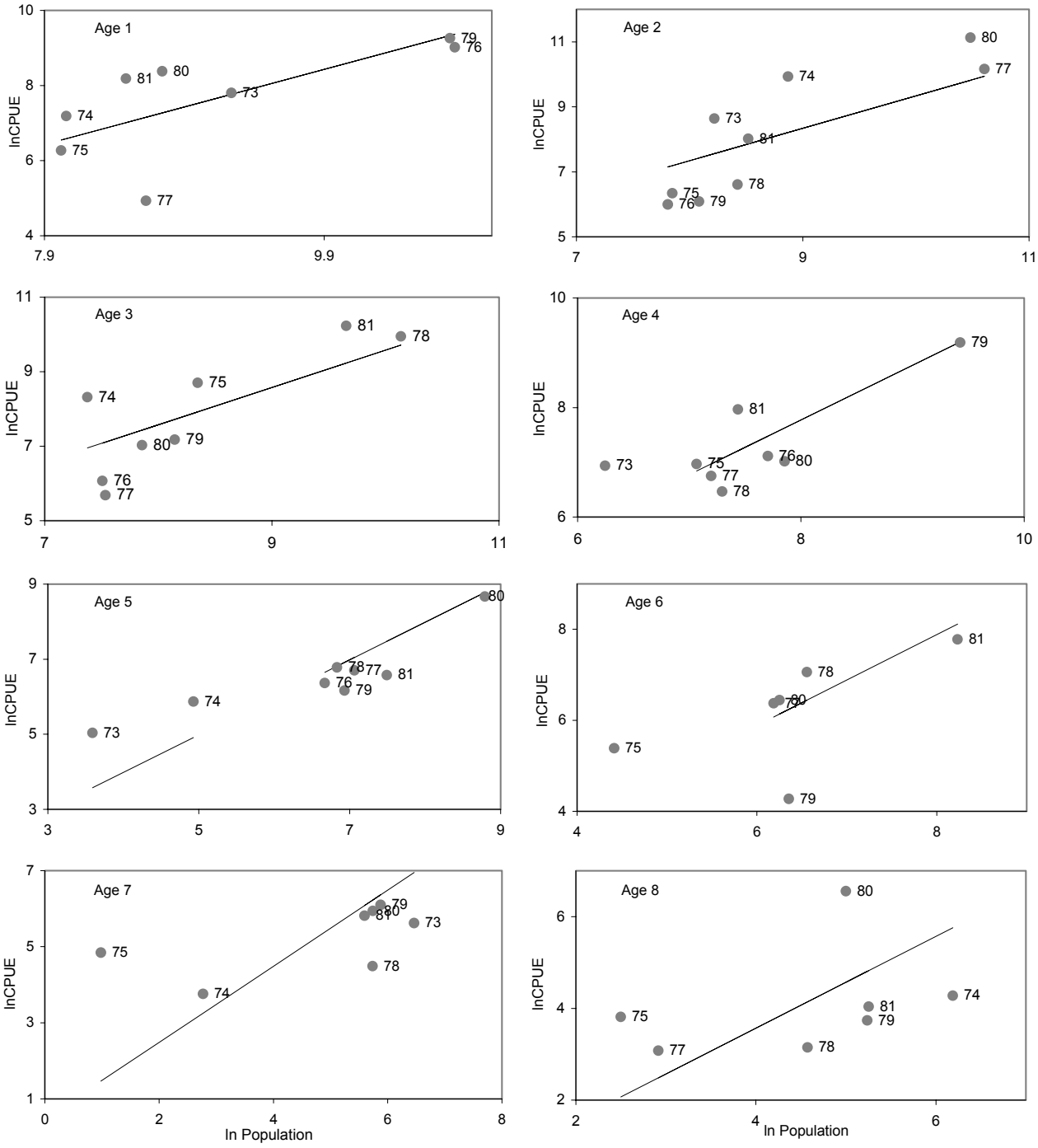

Figure 23. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **NMFS spring** survey with a Yankee 41 net.

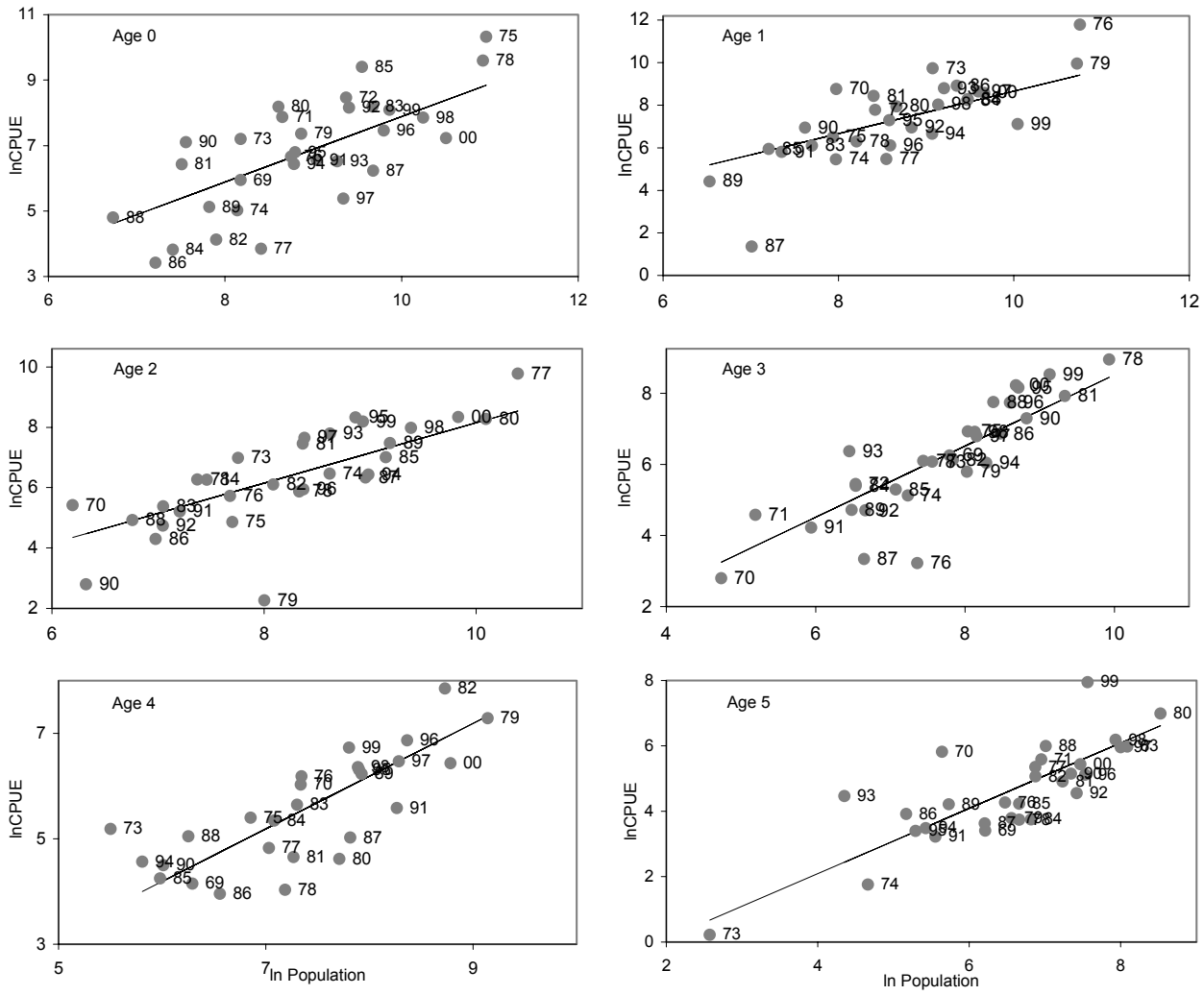

Figure 24. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **NMFS fall** survey.

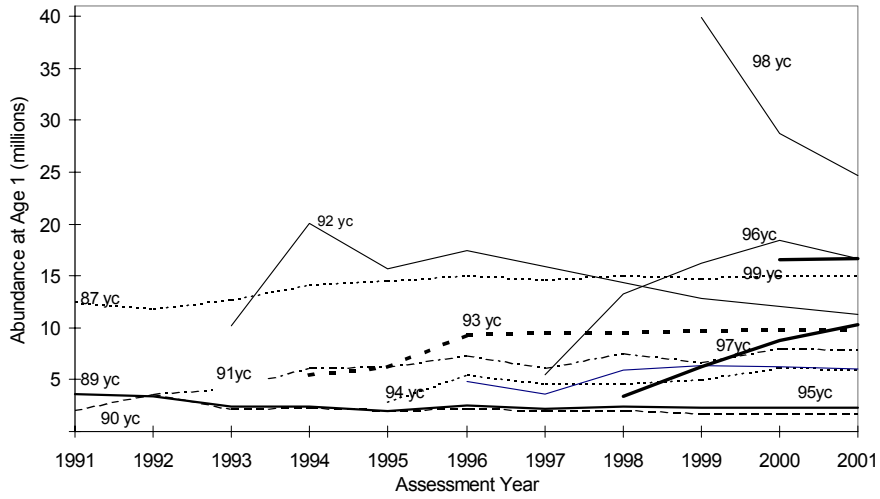

Figure 25. Successive estimates of 5Zjm haddock year-class abundance as additional years of data were included in the assessment did not display any persistent trends.

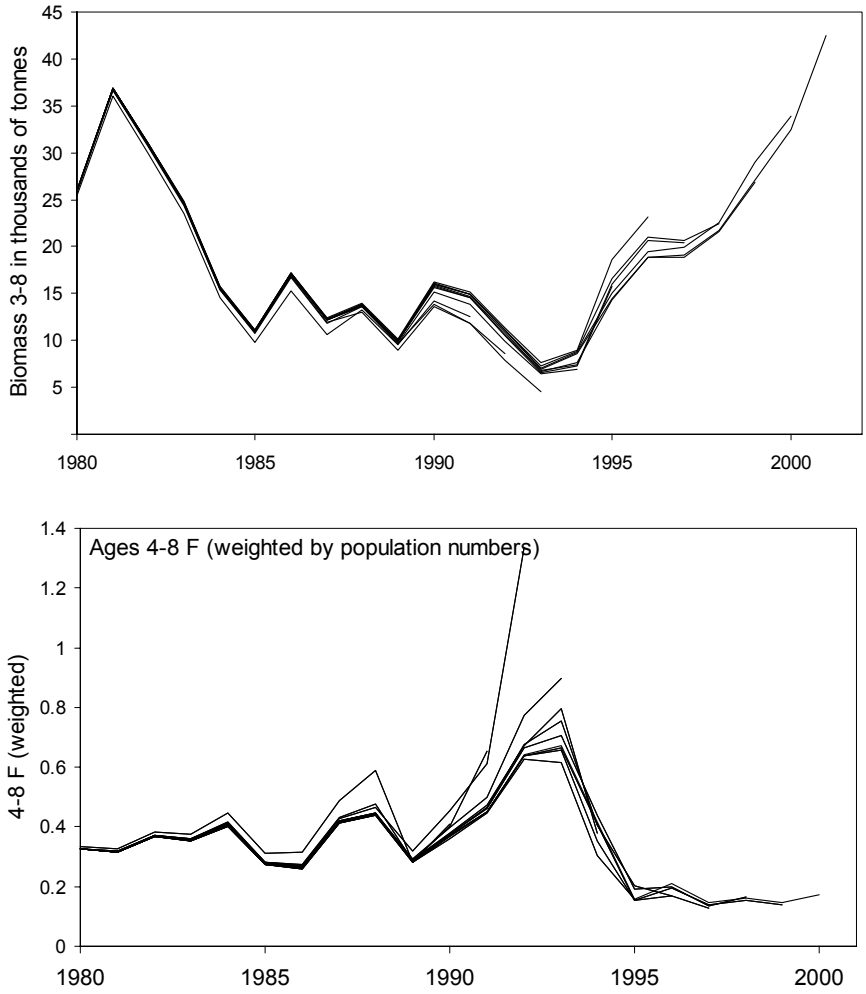

Figure 26. Retrospective estimates from VPA of 5Zjm haddock biomass and fishing mortality did not display any persistent trends for over or under estimation as successive years of data were excluded in the assessment.

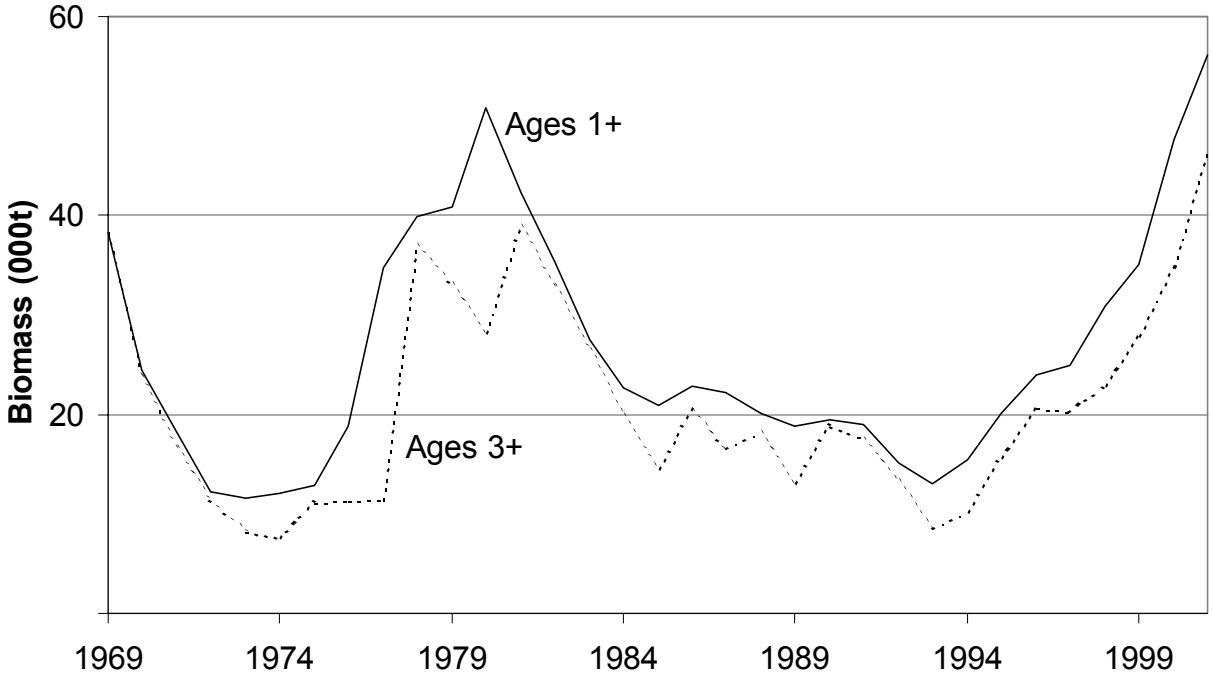

Figure 27. Beginning of year total (1+) and adult (3+) biomass for haddock in unit areas 5Zjm.

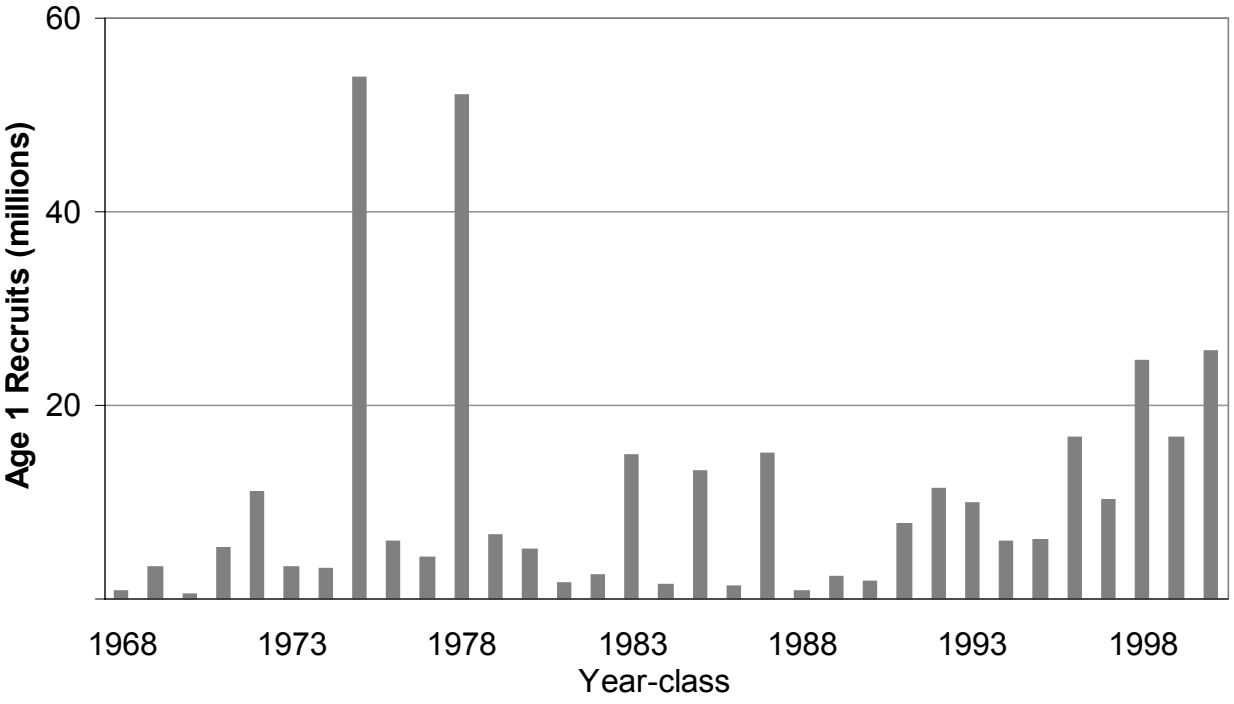

Figure 28. Number of age 1 recruits for haddock in unit areas 5Zjm.

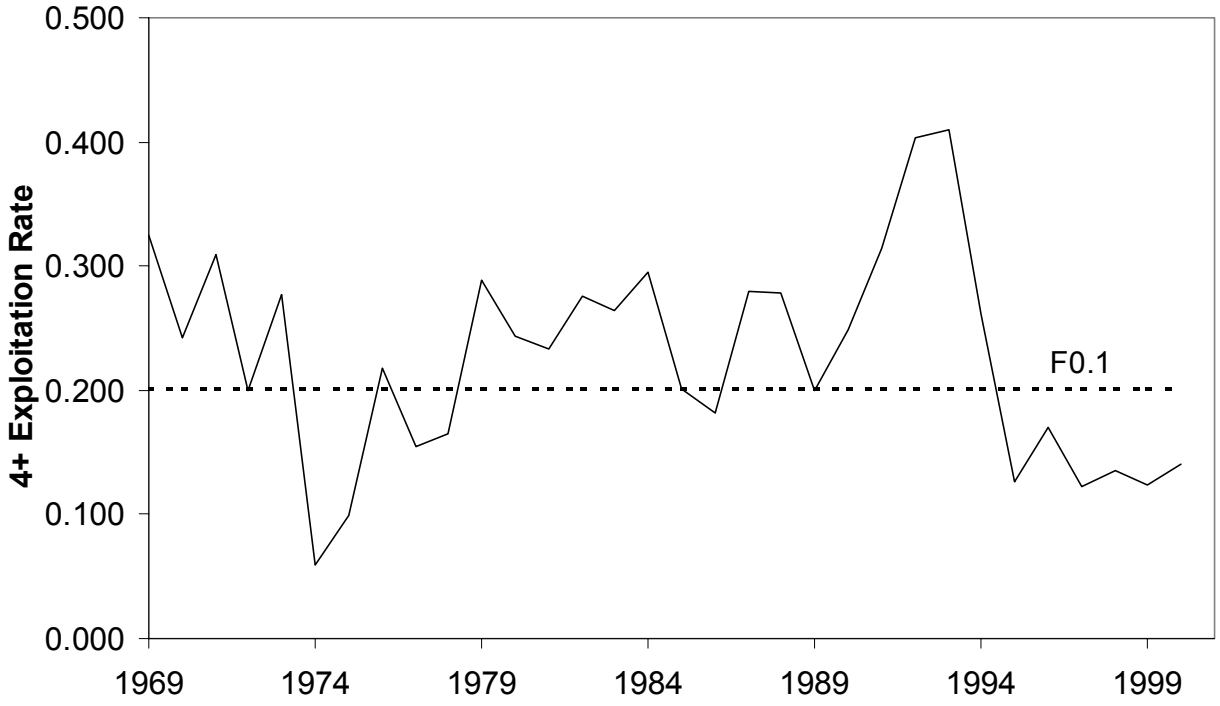

Figure 29. Exploitation rate for haddock ages 4+ in unit areas 5Zjm and the exploitation rate (20%) at $F_{9.1}$.

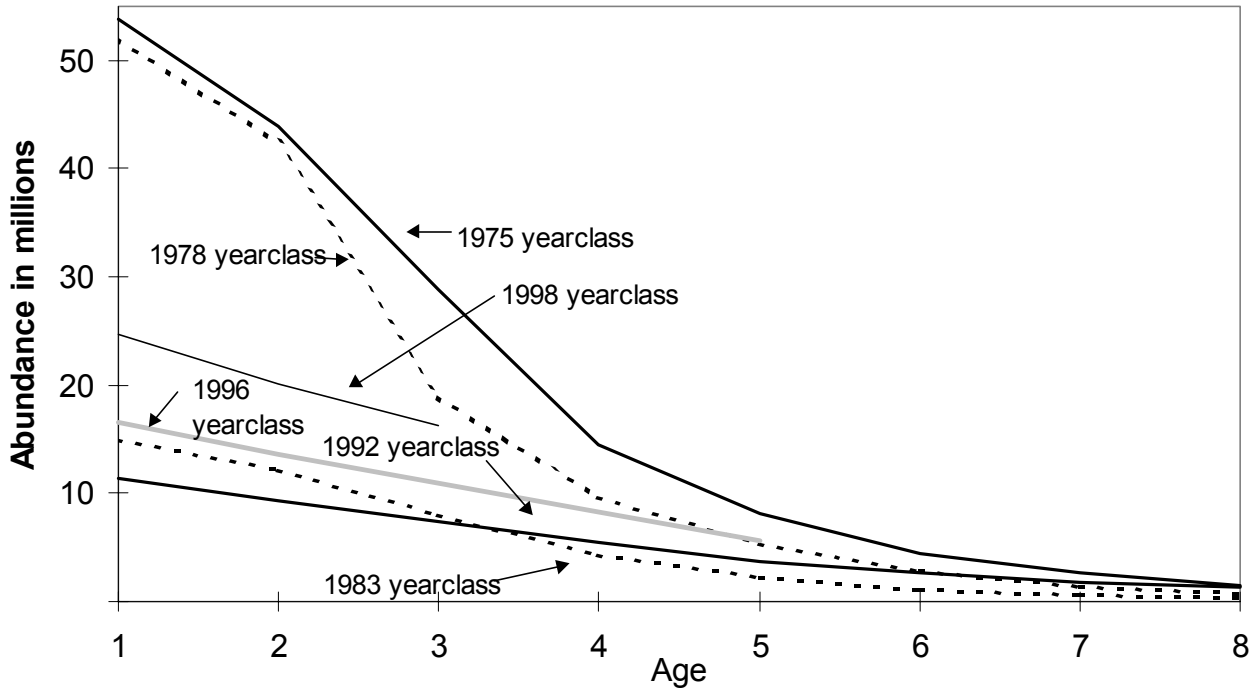

Figure 30. Decay of the 1992, 1996 and 1998 year-classes of the 5Zjm haddock population compared to the 1983, 1975 and 1978 as they progress through the fishery.

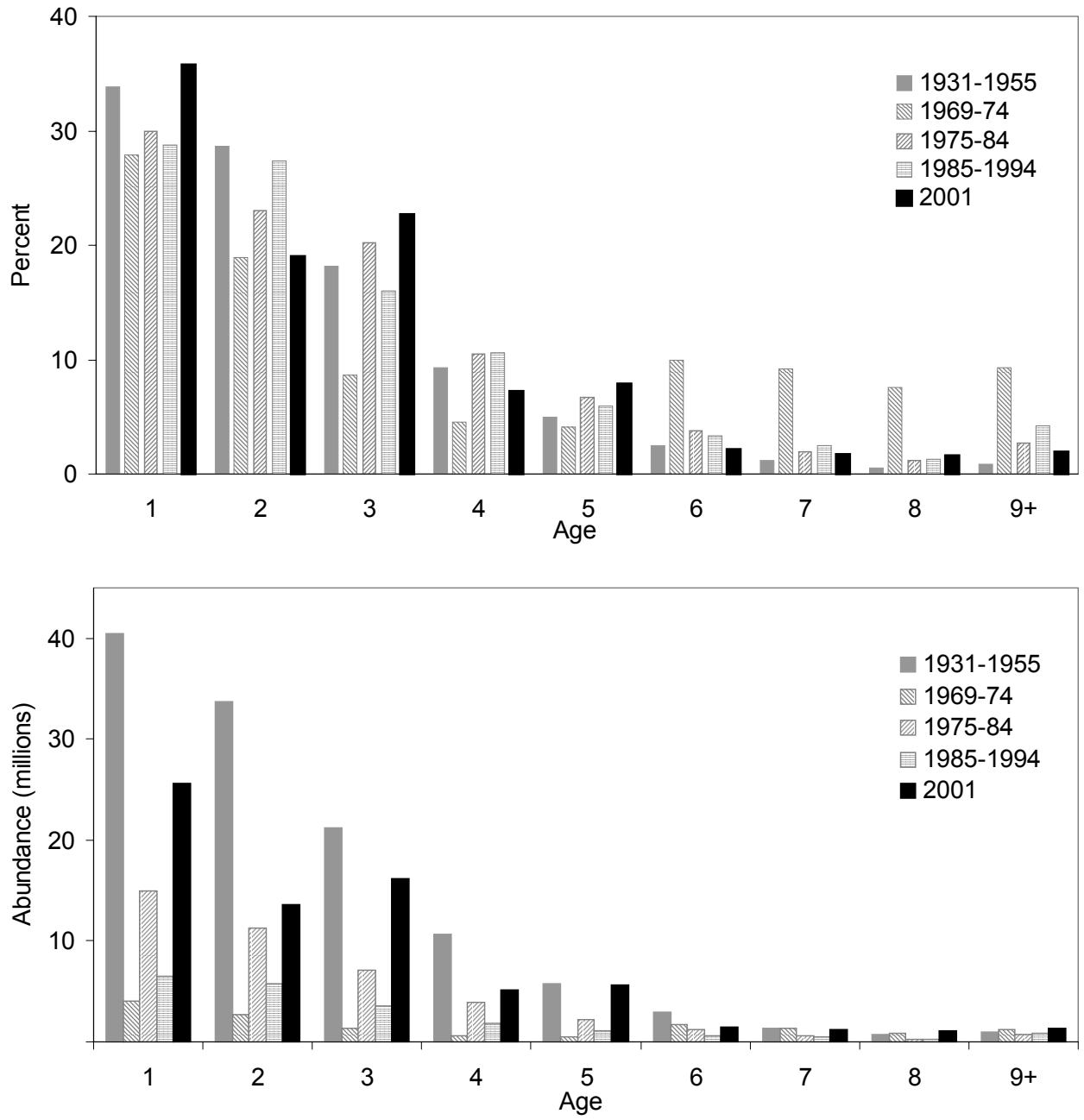

Figure 31. The age composition and absolute abundance at age of the 5Zjm haddock population in 2001 compared to earlier periods.

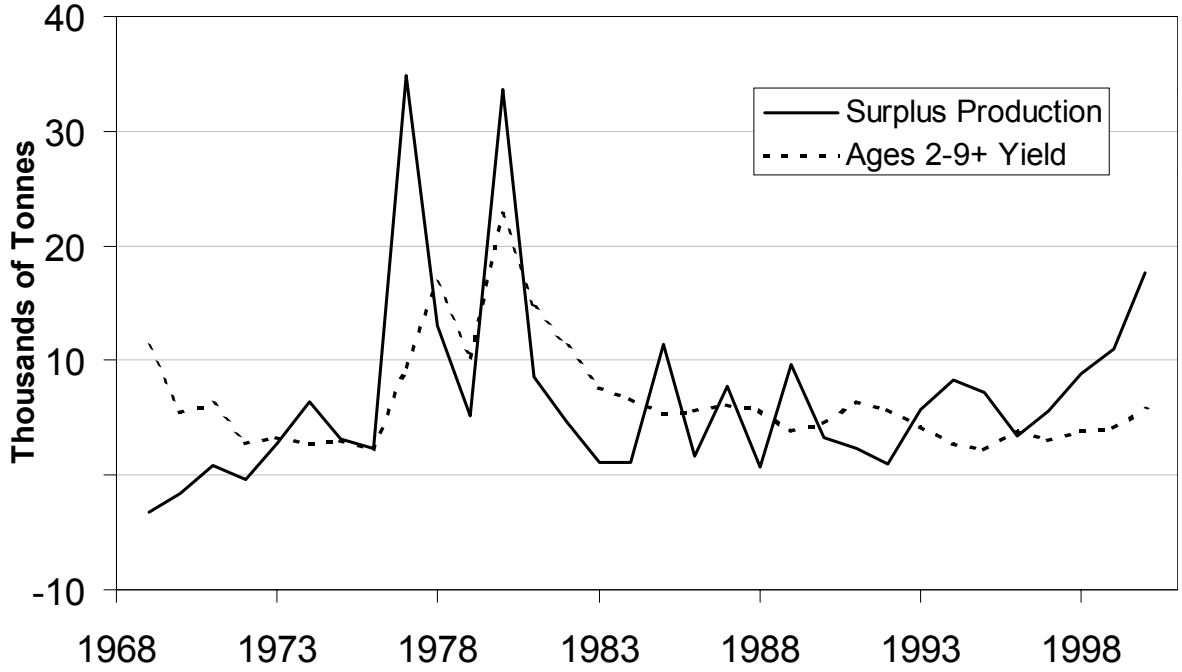

Figure 32. Surplus production of 5Zjm haddock available to the commercial fishery compared to amount actually harvested.

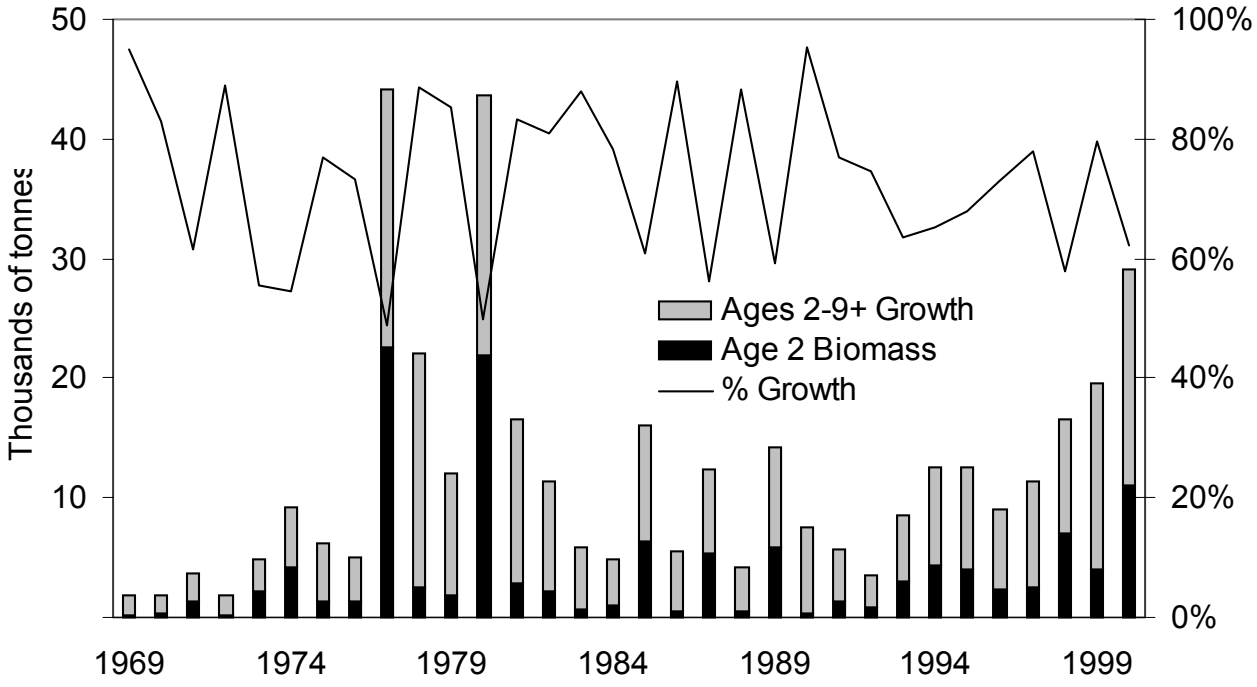

Figure 33. Amount of productivity attributible to growth of ages 2 to 8 5Zjm haddock and the amount contributed by recruitment of age 2 haddock.

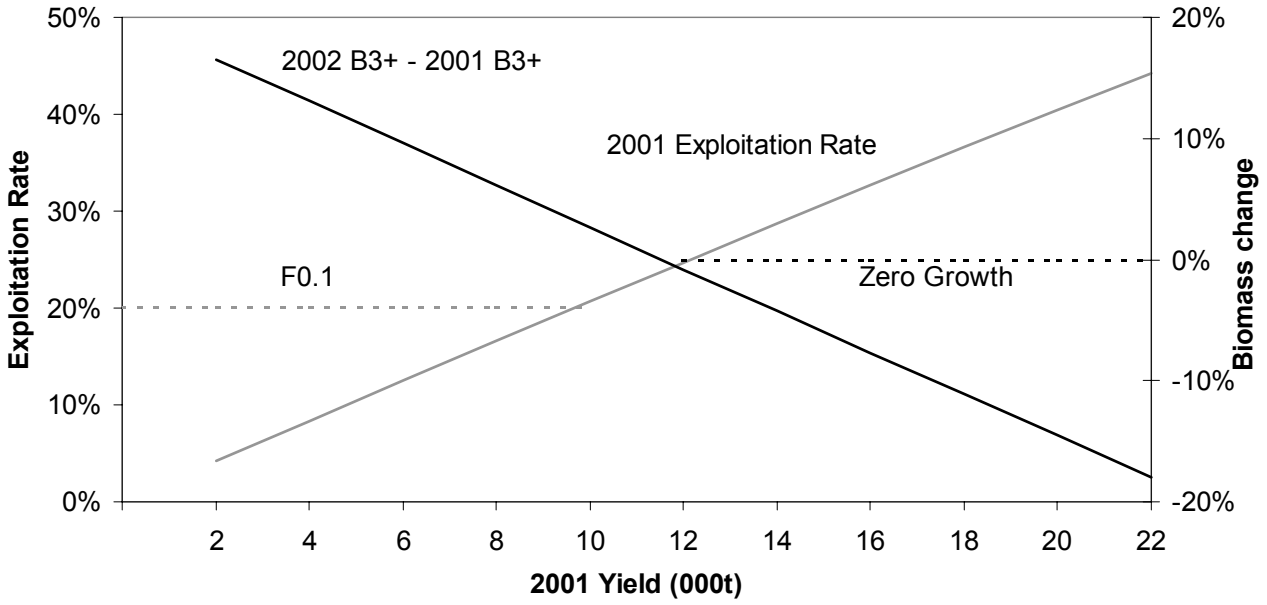

Figure 34. Expected exploitation rate in 2001 and expected change in biomass from 2001 to 2002 for 5Zjm haddock at various
quotas.

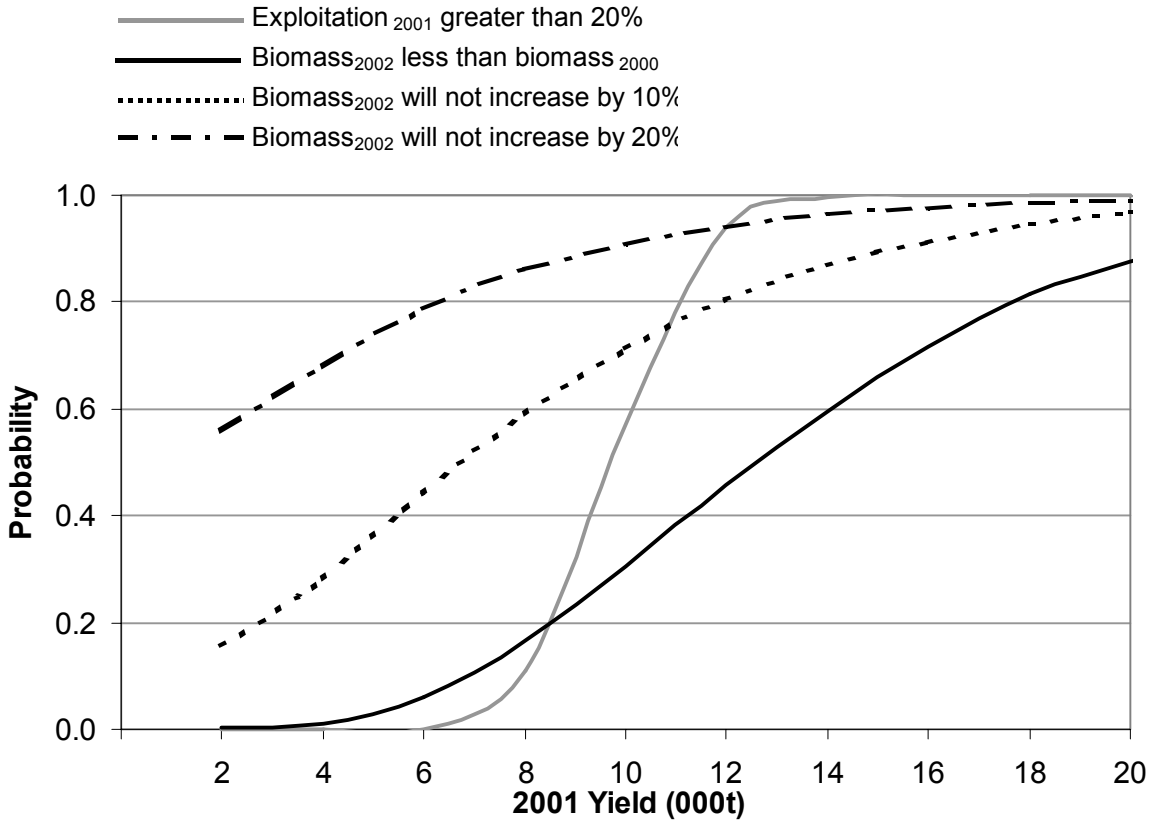

Figure 35. Probability of explopitation rate exceeding 20%, the $F_{0.1}$ reference level, and of the 2002 ages 3+ biomass being less than the 2001 biomass by 0%, 10% and 20% for 5Zjm haddock at various quotas.

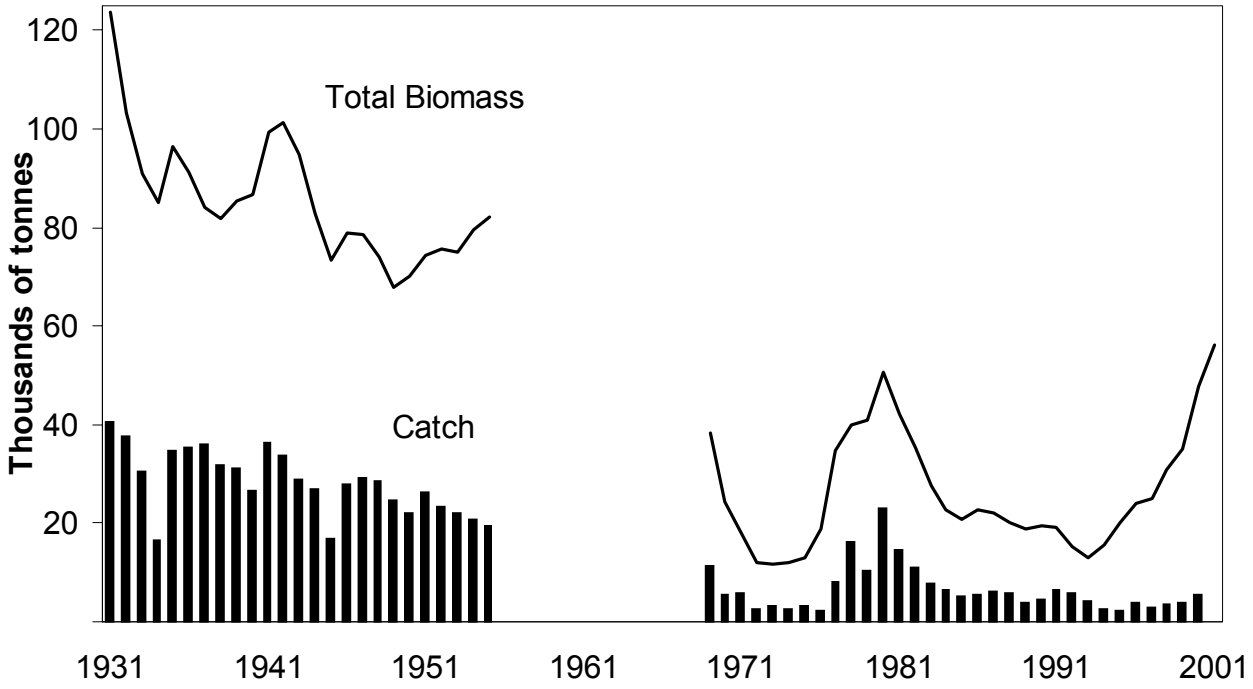

Figure 36. Historic catch and biomass of haddock in 5Zjm compared to recent catches and biomass.

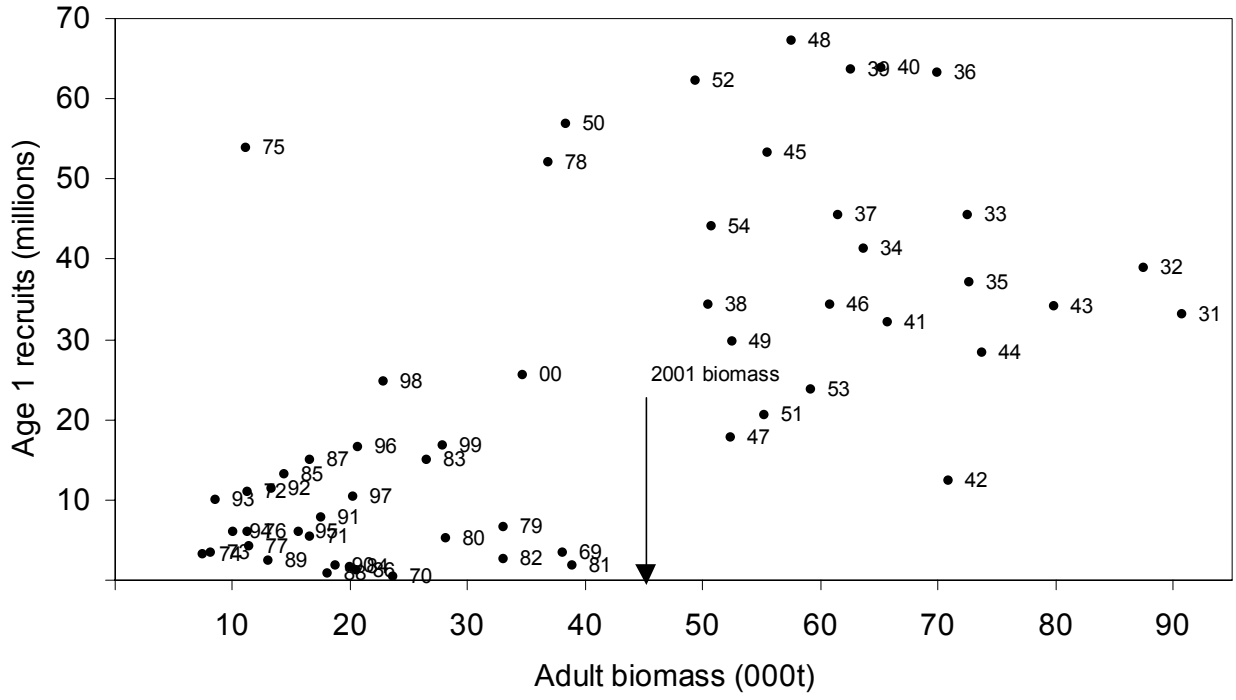

Figure 37. Relationship between mature (3+) 5Zjm haddock biomass and recruits at age 1 from 1931 to 1955 and 1969 to 2001.

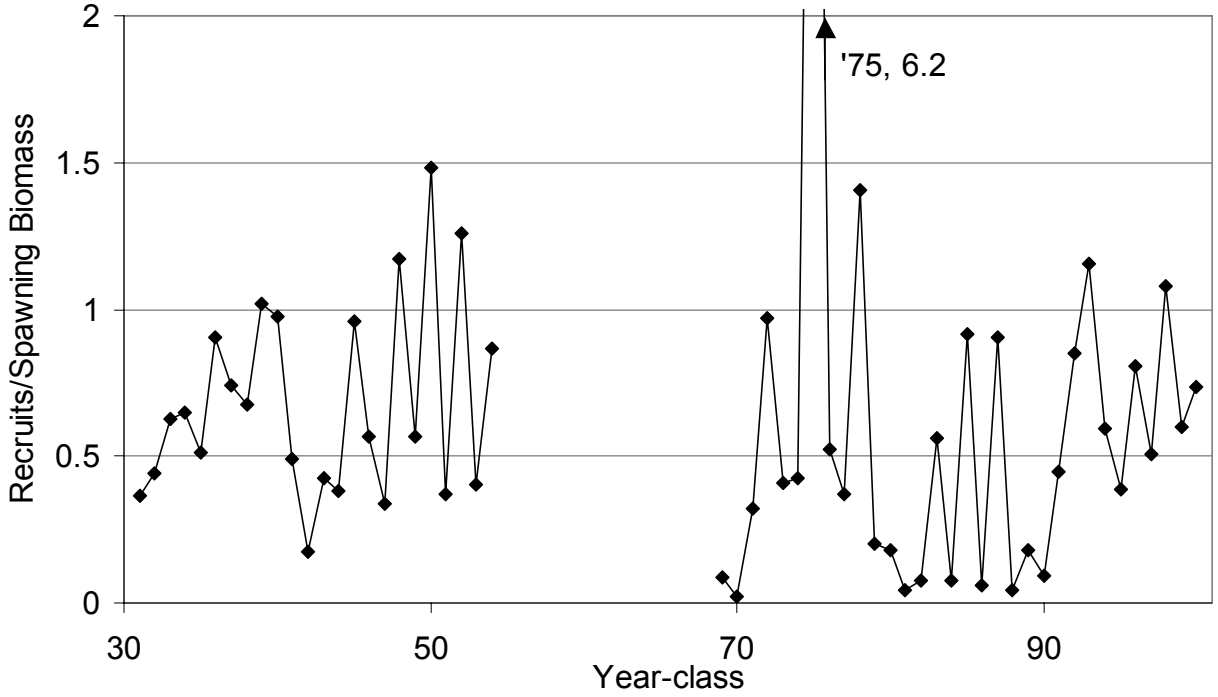

Figure 38. Ratio of recruits (numbers at age 1) to spawning biomass (kg) for 5Zjm haddock suggests that present survivorship appears comparable to that of the 1930s to 1950s.

Table A1. Inter-reader ageing agreement matrix for L. Van Eeckhaute for haddock ageing material from the 2000 DFO spring survey.

DFO 2000 Georges Bank Spring Survey (NED2000965)															
Test Age	Production Age														
	1	2	3	4	5	6	7	8	9	10	11	12	13	Omitted	Total
1	21														21
2	3	12	3												18
3		1	10												11
4				14											14
5					3	1									4
6						2									2
7							8	1							9
8								5	2					1	8
9									3						3
10										2					2
11															
12											1				1
13													1		1
Omitted		1													1
Total	24	14	13	14	3	3	8	6	5	2	1		1	1	95

Agreement = 81/92 = 88%
Ratio of ages above and below the line of equality is 7:5.