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Assessment of Eastern Georges Bank Haddock

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ABSTRACT

The total catch of eastern Georges Bank haddock in 2003 was 8,431 mt. This included estimated discards from the Canadian scallop fishery, which were very low relative to the total catch. The Canadian catch increased slightly from 6,525 in 2002 to 6,867 mt in 2003 while the USA catch increased substantially from 914 mt in 2002 to 1,564 mt in 2003. Eastern Georges Bank haddock catches fluctuated around 5,000 mt during 1985-1990. Under restrictive management measures, combined Canada/USA catches declined from over 6,400 mt in 1991 to a low of about 2,100 mt in 1995, averaged about 3,600 mt during 1996-1999 and have increased since then.

Adult population biomass has steadily increased from near an historical low of about 8,700 mt in 1993 to about 76,000 mt at the beginning of 2004. Eastern Georges Bank haddock biomass is now well within the range observed during 1931 to 1955 when the stock was more productive. Three strong year classes have been produced in recent years. The 2003 year class may be comparable to the outstanding 1963 year class. The 2000 year class is estimated to be larger than the strong 1975 and 1978 year classes and the 1998 year class is the third strongest since 1979. Fishing mortality has been below the reference threshold (Fref) of 0.26 since 1995. Reduced fishing mortality and lower bycatches of juveniles have increased haddock survival rates and led to greater abundance of older fish. The population age structure shows full representation of all age classes.

With an assumed total catch of 15,000 mt in 2004, a combined Canada/USA catch of 26,000 mt in 2005 would result in a neutral risk (50%) that fishing mortality in 2005 would exceed Fref. A catch of 23,000 mt would result in a low risk (25%) that fishing mortality in 2005 would exceed Fref. Catches in 2006 are expected to increase substantially as the 2003 year class becomes more fully recruited to the fishery.

RÉSUMÉ

Les prises totales d'aiglefin dans l'est du banc Georges en 2003 se chiffraient à 8 431 t, y compris les prises estimées rejetées en mer par les pétoncliers canadiens, très faibles par rapport aux prises totales. De 2002 à 2003, les prises canadiennes ont légèrement augmenté, passant de 6 525 t à 6 867 t, alors que les prises américaines ont nettement augmenté, passant de 914 t à 1 564 t. Les prises d'aiglefin dans ce secteur ont fluctué autour de 5 000 t de 1985 à 1990. Sous le coup de mesures de gestion restrictives, le total des prises canadiennes et américaines a chuté, passant de plus de 6 400 t en 1991 à un creux d'environ 2 100 t en 1995, pour ensuite augmenter, se situant en moyenne à environ 3 600 t de 1996 à 1999; cette tendance se poursuit.

De près d'un creux historique d'environ 8 700 t en 1993, la biomasse d'adultes dans le secteur est du banc Georges a régulièrement augmenté, pour se chiffrer à quelque 76 000 t au début de 2004; elle se situe maintenant largement dans la plage observée de 1931 à 1955, période pendant laquelle le stock était plus productif. Trois abondantes classes d'âge se sont manifestées dans les dernières années : celle de 2003 pourrait être tout aussi abondante que l'exceptionnelle classe d'âge 1963, celle de 2000 est estimée comme étant plus abondante que les fortes classes d'âge 1975 et 1978 tandis que celle de 1998 est la troisième plus abondante depuis 1979. Le taux de mortalité par pêche est inférieur au taux de référence cible ($F_{réf}$) de 0,26 depuis 1995. Le taux réduit de mortalité par pêche et des prises accessoires de juvéniles plus faibles ont résulté en un taux de survie accru et une plus forte abondance d'individus âgés. Toutes les classes d'âge sont représentées dans la structure des âges de la population.

À un niveau supposé de prises totales de 15 000 t en 2004, il est peu probable que des prises canado-américaines combinées de 26 000 m en 2005 résulteraient en un taux de mortalité par pêche cette année-là supérieur à $F_{réf}$, alors que des prises de 23 000 t résulteraient en un risque faible (25 %). On s'attend à ce que les prises en 2006 augmentent considérablement car la classe d'âge 2003 sera davantage recrutée à la pêche.

INTRODUCTION

Since 1990, Canada uses eastern Georges Bank, statistical unit areas j and m in NAFO sub-division 5Ze (Figure 1), as a haddock management unit (Gavaris 1989), referred to as "5Zjm". Canada and the USA jointly develop management measures for Georges Bank transboundary stocks including haddock. The 5Zjm management unit was adopted as the basis for a harvest allocation proposal for the two countries (DFO 2002). This assessment applies the approach used by Van Eeckhaute et al (2003) using Canadian and USA fisheries information updated to 2003. Results from the Fisheries and Oceans Canada (DFO) survey, updated to 2004, and the USA National Marine Fisheries Service (NMFS) surveys in the spring, updated to 2004, and fall, updated to 2003, were incorporated.

FISHERY

Commercial Catches

Haddock on Georges Bank have supported a commercial fishery since the early 1920s (Clark et al 1982, Gavaris and Van Eeckhaute 1998). Catches during the 1930s to 1950s ranged between 15,000 mt and 40,000 mt (Figure 2), averaging about 25,000 mt (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 NAFO Subdivision 5Ze, catches probably attained record high levels of about 60,000 mt during the early 1960s. Catches in the late 1970s and early 1980s, ranging up to about 23,000 mt, 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 mt during the mid to late 1980s. Under restrictive management measures in recent years, combined Canada/USA catches declined from over 6,400 mt in 1991 to a low of about 2,100 mt in 1995, fluctuated between about 3,000 mt and 4,000 mt until 1999 and have since increased to over 8,000 mt (Table 1, Figure 3). For 2003 the Canadian catch was 6,867 mt and the USA catch was 1564 mt.

Quotas are the principal means used to regulate the Canadian groundfish fisheries on Georges Bank. Canadian catches since 1995 were below the quota due to closure of some fleet sectors when the cod quotas were reached, except for the year 2000 when the catch of 5,402 mt was slightly above the Canadian quota of 5,400 mt. Quota regulation requires effective monitoring of fishery catch. Weights of all Canadian landings in 2003 were monitored at dockside and at-sea observers monitored 9% by weight of the haddock caught in 2003. Discarding and misreporting of haddock by the groundfishery have been considered negligible since 1992. Since 1994, all Canadian groundfish fisheries on Georges Bank have remained closed from January to early June.

In recent years, the Canadian fishery has been conducted primarily by vessels using otter trawls and longlines with some handlines and gillnets. During 2003, 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). Vessels over 65 ft operate on Enterprise Allocations, which are company quotas. Smaller vessels are allowed to fish the quota which has been allocated to the larger vessels under the Temporary Vessel Replacement Program (TVRP) and increasing amounts of this quota have been taken by the TVRP boats in recent years. In 2003, no otter trawlers greater than 65 ft participated in the haddock fishery. Most haddock were caught by otter trawlers and longliners in tonnage classes 2 and 3 (less than 150 tons) vessels less than 65 ft in overall length, two thirds by the otter trawlers and one third by the longliners (Table 3). The highest catches in 2003 occurred during July (Table 4, Figure 4).

Canadian landings until 1995 include those catches reported by the scallop fishery but, since 1996, this fishery has been prohibited from landing haddock and this species was then discarded. Haddock bycatch, when landings were allowed, was low with a maximum of 41 mt reported (Table 3). Discards of haddock from this fishery for 1996 to 2000 were estimated from scallop effort data and bycatch rates from observed trips conducted in 1994, 1995 and 1998 and ranged between 21 and 54 mt (Table 1). In 2001-2002, a monitoring program was conducted by the Canadian offshore scallop industry to examine bycatch of several species, including haddock. Twelve observer deployments on offshore scallop vessels were conducted between May 2001 and April 2002. Discards from this fishery in 2001 to 2003 are estimated to be 50, 36 and 78 mt, respectively (Appendix A).

USA haddock catches for 2003 were derived from mandatory dealer reports and fishing vessel logbooks using the same procedures as for 1994-2002. The USA fishery has been regulated using trawl mesh size increases, closed areas, days-at-sea limits, and trip limits (Table 2). Trip limits were introduced in 1994 and daily catch limits in 1996 to reduce fishing mortality. Low trip limits in the mid-1990s resulted in an increase in discards which were included in the USA catch at age data. Trip limits have been adjusted periodically to reduce discarding of haddock and improve haddock yields by increasing the limits. In 2003 the daily trip limit was suspended on May 1 and the 50,000 lbs trip cap was removed Oct 3. The combination of area closures, effort restrictions, and trip limits reduced USA fishing effort in 5Zjm, with the result that USA catches from 5Zjm were relatively low from 1993 to 2000. Even though Area II was closed, landings from 5Zjm, which come almost exclusively from tonnage classes 3 and 4 otter trawlers (50 to 500 tons), more than doubled from 604 mt in 2001 to 1,564 mt in 2003 (Table 5). Discards have remained low because of high trip limits combined with larger trawl mesh size. Catches by month have not been available since mandatory reporting began in 1994 (Table 6). Quarterly USA landings totals in 2003 were: 180 (11%), 1041 (67%), 92 (6%) and 251 mt (16%) (Table 7). USA landings were divided into 656 mt (42%) large, 893 mt (57%) scrod and 15 mt (1%) unclassified market categories.

Size and Age Composition

The size and age composition of the 2003 Canadian fishery was characterized using port, at-sea and industry samples from all principal gears and seasons. Samples were collected by DFO, observers and by an industry group, Scotia Fundy Mobile Gear Fishermen's Association. Comparison of length frequencies from these sources did not reveal any persistent differences (Figure 5), therefore, all data was combined (Table 8). The size composition of catch in the Canadian fisheries peaked at 51 cm (20 in) for otter trawlers and at 57 cm (22 in) for longliners (Figure 6). Gill-netters caught few haddock but they were larger. Haddock discards from the Canadian scallop fishery have not yet been processed with respect to size/age composition. Therefore, these discards are not included in the catch at age. The amount of discards estimated is minimal and, in previous years, landings from this fishery were small so omitting catches from this source should not unduly impact the results from analyses.

Length samples from USA 5Zjm landings in 2003 were inadequate to characterize the fishery by quarter since no scrod samples were collected in quarters 1 and 3 (Table 7). As a result, size composition data were augmented by length samples from adjacent areas (522 (5Zh) and 525 (5Zn)) with similar size compositions. Quarterly age samples were also inadequate and USA age composition data was augmented with 2003 DFO survey data for quarter 1 and with the 2003 Canadian commercial fishery age length keys for quarters 2, 3, and 4. The weight composition of the USA 5Zjm landings by market category was 42% large, peaking at 62 cm and 58% scrod, peaking at 55 cm. The scrod market category length samples did not contain any fish below 44 cm which is the minimum size limit for haddock in USA landings.

Ages of survey and commercial-caught haddock were separately assigned by DFO and NMFS age readers. Intra-reader agreement tests for the DFO reader conducted in 2003 indicated that age interpretations were internally consistent (Table B1). Intra-reader agreement for the NMFS haddock reader was generally good although there was some tendency for discrepancies to be in the same direction for haddock samples collected during quarters 1 and 2 (Table B2 and B3). Agreement between the DFO reader and the NMFS reader was acceptable (Table B4). Overall, age reader agreement was judged to be adequate for estimating catch at age.

The 2003 Canadian and USA catch at age estimates by quarter (Table 9) were added to the 1969-2002 catch at age data (Van Eeckhaute et al 2003). Although revised Canadian and USA landings were available for 2002, no adjustment to the 2002 catch at age was made as Canadian landings were still preliminary and the proration of USA landings by area have not been finalized. Combined Canada/USA annual catch at age and average fishery weights at age are summarized in Tables 10 and 11 and Figure 7 and 8. The 2000 year class (age 3) dominated the Canadian 2003 catch with the 1998 year class (age 5) contributing a high percentage. The USA catch was dominated by the 1998 year class with the 1996 and the 2000 year classes contributing. In comparison to the age composition of the catch during periods when year classes were quickly fished down, the older age groups (ages 9+) continued to contribute significantly to the 2003 catch (Figure 9). 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. The age composition during the 1969 to 1974 period was atypical since it was dominated by the outstanding 1962 and 1963 year classes which continued to contribute substantially at ages 6 and older.

ABUNDANCE INDICES

Commercial Catch Rates

Commerical fishery catch rates were calculated for the Canadian fishery based on representative trips (i.e., only those vessels which reported more than 1 mt from 5Zjm during 1994 and where cod, haddock and pollock comprised over 90% of the total catch). Catch rates for tonnage classes 2 and 3 otter trawlers and longliners have generally increased since 1993 to 2000 but have leveled out since then (Figure 10). Changes to regulations, gear modifications and varying fishing practices in recent years and other factors make comparison of annual catch rates difficult to interpret. As a result, commercial catch rates were not used as indices of relative abundance.

Research Surveys

Surveys of Georges Bank have been conducted by DFO each year (February) since 1986 and by NMFS each fall (October) since 1963 and each spring (April) since 1968. All surveys used a stratified random design (Figures 11 and 12). 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 12), 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 (Forrester et al 1997).

The spatial distribution of catches for the most recent surveys was plotted to show the distribution in comparison to the average over the previous 5 year period (Figures 13, 14 and 15). The 2003 year class at age 0 in the NMFS fall survey was abundantly and widely distributed as has been previously observed for large year classes. At age 1, the DFO February

survey found this year class abundantly distributed on the northern edge, peak and southern flank while the NMFS spring survey found large catches on the southern flank. Very low catches of the 2001 and 2002 year classes where observed in all three surveys. In winter/spring, adults (ages 3+) are usually more abundant on the Northern Edge but in 2004 adults were also found abundantly on the southern flank in the DFO February survey. A few months later, the NMFS spring survey observed them more widely spread out over the survey area than in the DFO survey, which is consistent with past years. In fall, adult haddock are more concentrated in the deeper waters along the slopes of the Northeast Peak and the Northern Edge, however, fall survey catches of adult haddock were unusually low in 2003, in comparison to the high catches in the spring surveys.

Age-specific, swept area abundance indices show that the three surveys are consistent and track year class strengths well (Tables 13, 14 and 15; Figure 16). Some year effects are evident, however. For example, the low spring catches observed for both the 1997 DFO and NMFS surveys. All three surveys show the 2003 year class as the strongest in the series. The NMFS fall survey failed to catch many of the 2000 yearclass in 2003.

The indices for ages 3-8 survey biomass peaked during the early 1960s (Figure 17). After declining to a record low in the early 1970s, they 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 generally increased during the 1990s. The DFO and NMFS spring 2004 biomass remained near the highest level observed. The NMFS 2003 fall survey adult biomass dropped substantially from the previous year, when it was near the highest level reported for this survey.

Survey recruitment indices for ages 0 and 1 suggest that the 2003 year class is as abundant as the outstanding 1963 year class (Figure 18). The abundance of the 2000 year class is comparable to the good 1975 and 1978 year classes, with the 1998 year class being the third strongest since the 1978. 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 exceptional 1963 year classes. Survey results also suggest that the 2001 and 2002 year classes are relatively weak.

GROWTH

Fishery weights at age (Table 11, Figure 8) for ages 2 and 3 are now generally higher than they were prior to the early 1990s. This increase reflects the change in gear selectivity which occurred around that time. Fishery weights in 2003 went down for all ages and all 2004 DFO survey weights except age 4 went down from 2003. There is a recent trend for older ages in both the fishery and DFO survey toward lower weights. Survey lengths at age also show decreases and are at or near their lower range (Table 16 and Figure 19). Average weight at age of haddock from the 1989, 1990 and 1991 year classes were higher than adjacent year classes in both the surveys and the commercial fisheries, giving the false impression of a declining trend in the years following. The method of calculation of the weights at age from the DFO survey, which were used for beginning of year population weights, was given in Gavaris and Van Eeckhaute (1998) and were derived from weights observed during the survey, weighted by population numbers at length and age. Fishery weights at age are derived from the sampled length at age and 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 commercial fishery gear selectivity (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 relationship and gutted-to-round weight conversion factors.

HARVEST STRATEGY

The Transboundary Management Guidance Committee has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference, F_{ref} = 0.26. When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding.

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 data. An investigation of model formulations and model assumptions was conducted by Gavaris and Van Eeckhaute (1998) They provide details for the established model formulation and objective function used in this assessment. Based on this formulation it was assumed that observation errors for the catch at age data were negligible. Observation errors for the abundance indices were assumed to be 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 was based on 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…2003.75, 2004.00 where t represents the beginning of the time interval during which the catch was taken. A catch of 0 was assumed for the 1st quarter of 2004 and the population was calculated to the beginning of 2004.25. The VPA was calibrated to bottom trawl survey abundance indices, $I_{s,a,t}$, for

s = DFO, ages a = 1, 2, 3…8, time t = 1986.16, 1987.16… 2004.16

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…2004.25

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…2003.69

The NMFS spring survey in 2004 was designated as occurring at time 2004.25 instead of 2004.29. 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 where there were frequent occurrences of zero catches were not included (e.g., NMFS fall survey ages 6 and older and ages greater than 8 in the NMFS spring and the DFO surveys). 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 determined using conditional non-parametric bootstrapping of model residuals (Efron and Tibshirani 1993,Gavaris and Van Eeckhaute 1998). Population abundance estimates had a relatively large potential bias at age 1, had a relative error of about 65% and a potential bias of over 10% while the relative error for other ages was between about 25% and 45% with a potential bias between 3% and 8% (Table 17). The relative bias on fishing mortality for ages 4 and older in 2003 was also small at about 3%. While the trends in the three surveys are generally consistent, they exhibit high variability and the average magnitude of residuals was large relative to other assessments. Although several large residuals were apparent, these data points do not appear to have a substantial impact on estimates of current abundance (Figures 20-24). Some patterns in the residuals (by cohort and by age) suggest year class and/or year effects in the survey data.

Retrospective Analysis

Retrospective analysis is used to detect a pattern of inconsistencies, where updates of previously estimated fishing mortality, biomass, and recruitment show a tendency to be predominantly higher or predominantly lower. This stock assessment model, however, does not exhibit a retrospective pattern. While recruitment estimates may sometimes change substantially when more data becomes available, e.g., the 1998 and 2000 year classes, successive estimates of year class abundance at age do not display any persistent tendency to be predominantly higher or lower (Figure 25). Similarly, retrospective analysis showed no persistent patterns in the estimates of adult biomass (ages 3-8) or fishing mortality (ages 4-8 weighted by population numbers) (Figure 26).

STATE OF RESOURCE

The state of the resource was based on results from the calibrated age structured VPA. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias estimated from the bootstrap, and used to construct the history of stock status (Tables 18-19). This approach for bias adjustment, in the absence of an unbiased point estimator with optimal statistical properties, was considered preferable to using potentially biased point estimates (O'Boyle 1998). The weights at age from the DFO survey (Table 16) were used to calculate beginning of year population biomass (Table 20). 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. The 1986-95 average weight at each age was used for 1969-85. Data to approximate the age composition of the catch from unit areas 5Zj and 5Zm were also available for the period between 1931 and 1955 in order to reconstruct an illustrative population analysis of eastern Georges Bank suitable for comparison of productivity.

Adult population biomass (ages 3+) during the late 1970s and early 1980s was about 40,000 mt, due to recruitment of the strong 1975 and 1978 year classes whose abundances were estimated at about 50 million each (Figure 27). 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 biomass has steadily increased from near an historical low of about 9,000 mt in 1993 to about 76,000 mt (80% Confidence Interval: 69,500 mt – 112,000 mt, Figure 28) at the beginning of 2004. The recent increase has been due to generally improved recruitment and was enhanced by lower exploitation and by reduced capture of small fish in the fisheries. Biomass has been increasing and is the highest it has been in about 30 years. It is now well within the range of the 1931-1955 biomass.

Recruitment improved in the 1990s and the 2003 year class, estimated at 905 million at age 1 may be comparable to the outstanding 1963 year class (Figure 27). The 2000 year class (81 million at age 1) is estimated to be larger than the strong 1975 and 1978 year classes. The 1998 year class (28 million at age 1) is the third strongest since that of 1978. The 1996 and 1999 year classes were estimated to be about 13 million, comparable to the 1983, 1985 and 1987 year classes, which were the strongest 3 year classes over about a 20 year time span. Two recent year classes, 2001 and 2002, are weak, at about 4 and 2 million fish, respectively.

The estimate of the 2003 year class had high uncertainty. A robust regression technique (least-trimmed squares regression analysis (Rousseeuw 1984)) was applied to provide an alternative estimate of the 2003 year class. VPA recruitment (age-1) was regressed on observed survey numbers at age zero or one using combinations of NMFS spring and fall as well as DFO survey data. Results confirmed that this year class is exceptional but its magnitude, estimated at about 500 to 600 million fish depending on the choice of surveys, may be smaller than the bias adjusted VPA estimate (905 million fish).

Fishing mortality for fully recruited ages 4+ fluctuated between 0.2 and 0.4 during the 1980s (Figure 29) and showed a marked increase between 1989 and 1993 to about 0.6, the highest observed, before declining to below the fishing mortality reference, $F_{ref} = 0.26$, where it has remained since 1995 ($F_{2003} = 0.16$: 80% Confidence Interval: 0.13 – 0.19, Figure 28).

Reduced fishing mortality in recent years has resulted in increased survival of recruiting year classes. The number of haddock of the 1992 year class surviving to age 8 was about 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). Avoidance of small fish by the fishery has resulted in increased survivorship at age 3 of the 1998 year class in comparison to the 1978 year class which was twice as strong.

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 the age of first recruitment to the fishery. This choice facilitated comparisons with historic stock productivity but may be less representative of the current fishery selectivity. Except for 1996 and 2003, 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 31). Growth of fish is the dominant component of the biomass gain but recruitment accounts for significant portions when stronger year classes enter the population (Figure 32). Growth of the 2000 year class was not enough to offset the small biomass gain from the weak recruiting 2001 year class and losses due to fishing and natural mortality. As a result, fishable biomass decreased slightly in 2004.

PRODUCTIVITY

Attributes like recruits per spawner, age structure and spatial distribution reflect possible fluctuations in the productive potential and can be used to qualify reference points and acceptable risk.

Stock-recruitment data indicates that the chance of a good year class is significantly enhanced for adult biomass above about 40,000 mt (Figure 33). Since 1969, only the 1975, 1978, 2000 and 2003 year classes have been above the average abundance of year classes observed during the period 1930-55. The recruits per adult biomass ratio was generally low during the 1980s (Figure 34). Except for the 2001 and 2002 year classes, which are lower, and the 2003, which is higher, the present recruits per adult biomass ratio appears comparable to

that of the 1931 to 1955 period, suggesting that higher recruitment might occur when the biomass is above 40,000 t.

Since 1995, in both absolute numbers and percent composition, a broad representation of age groups is now apparent, reflecting improving recruitment and lower exploitation, particularly at younger ages (Figure 35).

The spatial distribution patterns observed during the most recent bottom trawl surveys were similar to the average patterns over the previous five years. However, consistent with the pattern observed for previous large year classes, the exceptional 2003 year class at age 0 was distributed more widely throughout the survey area.

Observed DFO survey average weights at length, used to reflect condition, show a slight decrease in recent years for larger haddock (68-73 cm) although no trend is apparent for smaller haddock (50-53 cm) (Figure 36).

In summary, productivity has increased since the 1980s due to improved production of recruits per spawner and increases in the number of larger and older fish in the population.

OUTLOOK

The outlook is provided in terms of the possible consequences for alternative catch quotas in 2005 with respect to the harvest reference points. Uncertainty about standing stock generates uncertainty in forecast results. This uncertainty is expressed in the outlook as the risk of exceeding $F_{ref} = 0.26$.

Stock size estimates at the beginning of the second quarter in 2004 were used to start the forecasts. Abundances of the 2004 and 2005 year classes were assumed to be 20 million at age 0. For each forecast, partial recruitment to the fishery for ages 1, 2 and 3 and fishery weights at age were set to their averages during 1999-2003. Population weights at age were set to their observed 2004 values from the DFO survey (Table 21). It was also assumed that the total eastern Georges Bank total allowable catch (TAC) of 15,000 mt was caught in 2004. Natural mortality was assumed to be 0.2.

Given these forecast assumptions, a combined Canada/USA catch of 26,000 mt in 2005 would result in a neutral risk (50%) that fishing mortality in 2005 will exceed F_{ref}. A lower catch of 23,000 mt would produce a low risk (25%) that the fishing mortality in 2005 will exceed F_{ref} (Figure 37). Results indicate that the 2000 year class (age 5) would comprise the highest proportion of the total 2005 yield, accounting for about 47% of the catch at the 26,000 mt level. The 2003 year class would account for the second highest proportion at 27% of the catch biomass.

The accuracy of the risk calculations depend on model assumptions and data. Though these assumptions were judged to be reasonable, other factors not considered could generate additional uncertainty. In particular, 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. In this context, the risk profiles show the range of uncertainties and the consequences of alternative catch quotas.

Medium term forecasts were also conducted. In these forecasts, it was assumed that the stock was exploited at a constant fishing mortality rate of 0.26. Recruitment was assumed to equal either its most recent 10-year average (20 million, excluding the 2003 year class) or the

average recruitment which occurred during the period 1931 – 1955 (40 million) when the stock was at a more productive level. Results indicated that catches and biomass would increase substantially (Tables 22 and 23) under either recruitment scenario. The difference in projected total biomass, adult biomass and yield using the two recruitment assumptions was minimal.

SPECIAL CONSIDERATIONS

Consistent management by Canada and the USA is required to ensure that conservation objectives are not compromised.

The outstanding 2003 year class is likely to dominate the catch during 2006 to 2008. If this year class is as abundant as estimated (about 900 million fish), fishery yields at F_{ref} will increase by an order of magnitude starting in 2006. It is important to note that the estimate of the 2003 year class has high uncertainty. Alternative analyses support the conclusion that this year class is exceptional but suggest its magnitude may be somewhat smaller than the VPA estimate. This note of caution should be considered when evaluating the projection risk analysis. Measures should be taken to avoid wastage of this year class due to discarding.

Cod and haddock are often caught together in groundfish fisheries, although their catchabilities to the fisheries differ and they are not necessarily caught in proportion to their relative abundance. With current fishing practices and catch ratios, the achievement of rebuilding objectives for cod may constrain the harvesting of haddock. Modifications to fishing gear and practices, with enhanced monitoring, may mitigate these concerns.

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Table 1. Nominal catches (mt) of haddock from unit areas 5Zjm during 1969-2003. For "Other" it was assumed that 40% of the total 5Z catch was in 5Zjm.

	Landings			Discards		Canadian	USA Target	
Year	Canada	USA	Other	Canada	USA	Quotas	Quotas	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
1978	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	1693						5739
1989	3060	787						3847
1990	3340	1189						4529
1991	5456	949						6405
1992	4058	1629				5000		5687
1993	3727	421				5000		4148
1994	2411	33			258	3000		2702
1995	2065	22			25	2500		2112
1996	3663	36		33	41	4500		3773
1997	2749	48		36	63	3200		2895
1998	3371	311		54	14	3900		3751
1999	3681	355		33		3900		4069
2000	5402	187		21		5400		5611
2001	6774	604		50		6989		7428
2002	6489	914		36		6740		7438
2003	6789	1564		78		6933		8431

[1] 1895 mt 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 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. Total allowable catch (TAC) = 5000 mt.
1993	Area 2 closure in effect from Jan 1-June30.	OT fishery permitted to operate in Jan. and Feb. Increase in use square mesh. TAC = 5000 mt.
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. TAC = 3000 mt.
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. TAC = 2500 mt.
1996	July: Additional Days-at-Sea restrictions, trip limit raised to 1000 lbs.	Fixed gear history requirement dropped. TAC = 4500 mt.
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. TAC = 3200 mt.
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. TAC = 3900 mt.
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.	TAC= 3900 mt.
2000	October: Daily trip limit suspended to April 2001but retained max. trip limit of 50,000 lbs/trip.	TAC= 5400 mt.
2001-2002	Day and trip limit adjustments. Daily trip limit suspended July 5, 2002.	TAC= 6989 mt. and 6740 mt. for 2001 and 2002 respectiviely.
2002-2003	30,000 – 50,000 lb/trip limit. Trip limit suspended in Oct. 2003.	TAC= 8431 for 2003 mt.
2004	May 1, day and trip limits removed.	No changes.

Table 3. Canadian landings (mt) of haddock in unit areas 5Zjm during 1969-2003 by gear category and tonnage class for principle gears.

Year	Otter Trawl						Longline			Scallop		
	Side	Stern								Fishery	Other	Total
		2	3	4	5	Total[1]	2	3	Total[1]			
1969	777	0	1	225	2902	3127	2	21	23	15	15	3941
1970	575	2	0	133	1179	1314	6	72	78	2	2	1970
1971	501	0	0	16	939	955	18	129	151	3	3	1610
1972	148	0	0	2	260	263	23	169	195	1	3	609
1973	633	0	0	60	766	826	23	80	105	0	0	1565
1974	27	0	6	8	332	346	29	59	88	1	1	462
1975	222	0	1	60	963	1024	25	81	107	0	0	1353
1976	217	0	2	59	905	967	48	108	156	9	15	1355
1977	370	92	243	18	2025	2378	43	51	94	41	28	2871
1978	2456	237	812	351	5639	7039	121	47	169	27	305	9968
1979	1622	136	858	627	1564	3185	190	80	271	2	2	5080
1980	1444	354	359	950	6254	7917	129	51	587	4	69	10017
1981	478	448	629	737	2344	4159	331	99	1019	2	2	5658
1982	115	189	318	187	3341	4045	497	187	712	2	0	4872
1983	106	615	431	107	1130	2283	593	195	815	3	4	3208
1984	5	180	269	21	149	620	614	192	835	2	3	1463
1985	72	840	1401	155	348	2745	562	33	626	16	41	3484
1986	51	829	1378	95	432	2734	475	98	594	23	35	3415
1987	48	782	1448	49	1241	3521	854	113	1046	39	89	4703
1988[2]	72	1091	1456	186	398	3183	428	200	695	16	97	4046
1989	0	489	573	376	536	1976	713	175	977	12	106	3060
1990	0	928	890	116	471	2411	623	173	853	7	76	3340
1991	0	1610	1647	81	689	4028	900	271	1309	9	119	5456
1992	0	797	1084	56	645	2583	984	245	1384	4	90	4058
1993	0	535	1179	67	699	2489	794	156	1143	2	96	3727
1994	0	495	911	79	112	1597	498	47	714	9	100	2411
1995	0	523	896	14	214	1647	256	75	390	7	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
2001	0	1564	2555	0	757	5112	754	302	1633		29	6774
2002	0	1217	2720	0	657	4954	794	151	1522		12	6489
2003	0	1186	3247	0	0	4986	816	249	1792		11	6789

[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 landings (mt) of haddock by Canada in unit areas 5Zjm during 1969-2003.

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
2001	0	0	0	0	0	971	1335	930	1267	1075	647	548	6774
2002	0	0	0	0	0	572	1704	983	1364	820	593	452	6489
2003	0	0	0	0	0	845	1840	1298	892	956	644	314	6789

[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 landings (mt) of haddock in unit areas 5Zjm during 1969-2003 by gear category and tonnage class. Details for 1994-2003 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
2001			602	2	604
2002			913	1	914
2003			1564		1564

Table 6. Monthly landings (mt) of haddock by USA in unit areas 5Zjm during 1969-2003. Details for 1994-2003 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
2001													604
2002													914
2003													1564

Table 7. USA landings of haddock in 2003 by quarter and market category from unit areas 5Zjm and NMFS sampling intensity for lengths and ages.

Market category	Large	Scrod	Unclassified	Total
		Landings (mt)		
Quarter 1	82.91	96.23	0.49	179.63
Quarter 2	496.49	538.43	5.69	1040.61
Quarter 3	49.89	36.68	5.63	92.20
Quarter 4	26.29	221.91	2.96	251.16
Total	655.58	893.25	14.77	1563.60
		Lengths per 100 mt (Number measured)		
Quarter 1	118.20 (82.91)	0 (0)	N/A	54.56 (179.63)
Quarter 2	127.50 (496.49)	53.49 (538.43)	N/A	88.51 (1040.61)
Quarter 3	218.48 (49.89)	0 (0)	N/A	118.22 (92.20)
Quarter 4	426.02 (26.29)	42.81 (221.91)	N/A	82.42 (251.16)
Total	145.21 (655.58)	42.88 (893.25)	N/A	85.38 (1563.60)
		Ages per 100 mt (Number aged)		
Quarter 1	38.60 (32)		N/A	17.81 (32)
Quarter 2	34.44 (171)	13.74 (74)	N/A	23.54 (245)
Quarter 3	84.19 (42)		N/A	45.55 (42)
Quarter 4	95.09 (25)	11.72 (26)	N/A	20.31 (51)
Total	41.18 (270)	11.20 (100)	N/A	23.66 (370)

Table 8. Sampling for landings of the 2003 5Zjm Canadian haddock fishery.

Qtr.	Gear	Month	Landings (kg)	Length Frequency Samples				Ages	
				At Sea		Port			
				Trips	Measured	Samples	Measured	At Sea	Port
2	OT IN	June	827,342	19	13,589	14	3,197		
	LL IN	June	17,904	1	789	1	210	118	193
	GN IN	June	181	Q3GN					
3	OT IN	July	1,468,025	10	4,494	7	1,614		
		Aug	763,614	5	3,017	6	1,240		
		Sept	520,001	2	1,456	1	230		
	LL IN	July	370,891			5	1,173		
		Aug	531,052	9	10,763	8	1,960	34	433
		Sept	367,547	5	4,215	4	912		
	GN IN	July	785						
		Aug	3,787			1	210		
		Sept	3,989			2	445		
4	OT IN	Oct	627,726	2	990	4	956		
		Nov	522,978	5	1,972	5	1,155		
		Dec	256,506			3	710		
	LL IN	Oct	326,968	6	7,087	6	1,442		
		Nov	120,720	1	2,822			16	406
		Dec	57,282	2	2,273	1	267		
	GN IN	Oct	1,454			1	210		
		Nov	474						
		Dec	11						
Totals			6,789,238	67	53,467	69	15,931	168	1,032

OT=Otter Trawl Bottom, GN=Gill Net, LL=Longline, IN=Tonnage Class 0-3

Table 9. Components of the 2003 catch at age numbers of haddock from unit areas 5Zjm by quarter. Discards from the Canadian scallop fishery are not included.

Quarter	Age Group									
	1	2	3	4	5	6	7	8	9+	1+
Canada										
2003	0	0	0	0	0	0	0	0	0	0
2003.25	92	286	115031	40368	212339	69595	37759	6718	24158	506348
2003.5	285	1818	1036167	112035	592636	192913	235293	34089	79971	2285206
2003.75	14	2009	482818	70677	341602	77069	91067	22150	30129	1117535
Year total	391	4112	1634016	223080	1146577	339578	364119	62958	134258	3909089
USA										
2003	0	0	10800	6600	39000	9800	10900	4900	8700	90700
2003.25	0	0	40600	29300	185700	53300	70800	32400	74200	486300
2003.5	0	0	8900	1600	12600	3400	8100	2000	5000	41600
2003.75	0	0	34600	9500	54800	11800	16100	4200	4400	135200
Year total	0	0	94900	46900	292100	78300	105900	43500	92200	753900
Total										
2003	0	0	10800	6600	39000	9800	10900	4900	8700	90700
2003.25	92	286	155631	69668	398039	122895	108559	39118	98358	992648
2003.5	285	1818	1045067	113635	605236	196313	243393	36089	84971	2326806
2003.75	14	2009	517418	80177	396402	88869	107167	26350	34529	1252735
Year total	391	4112	1728916	270080	1438677	417878	470019	106458	226558	4662889

Table 10. Total annual commercial catch at age numbers (000's) of haddock from unit areas 5Zjm during 1969-2003.

Year	Age Group										
	0	1	2	3	4	5	6	7	8	9+	1+
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	34	1438
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
2001	0	2	60	1676	544	803	276	207	220	170	3958
2002	0	1	285	205	1855	371	660	111	106	278	3872
2003	0	0	4	1729	270	1439	418	470	106	227	4663

Table 11. Average weight at age (kg) of haddock from the commercial fishery in unit areas 5Zjm during 1969-2003. 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
2001	0.394	1.102	1.471	1.755	2.107	2.367	2.186	2.522
2002	0.405	1.009	1.418	1.763	1.941	2.343	2.660	2.382
2003	0.475	0.757	1.382	1.590	1.852	1.894	2.344	2.842
Low	0.394	0.757	0.812	1.272	1.649	1.631	2.186	2.032
High	0.797	1.215	1.724	2.235	2.639	3.760	4.114	4.009
Median	0.600	0.999	1.418	1.795	2.147	2.509	2.872	3.112
Average	0.586	1.002	1.384	1.805	2.156	2.488	2.837	3.097
1999-2003	0.523	1.013	1.462	1.788	2.001	2.177	2.445	2.667

Table 12. Conversion factors used to adjust for changes in door type and survey vessel in the NMFS surveys during 1968-2004.

		Spring		Fall	
Year	Door	Vessel	Conversion	Vessel	Conversion
1968	BMV	Albatross IV	1.49	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
2001	Polyvalent	Albatross IV	1	Albatross IV	1
2002	Polyvalent	Albatross IV	1	Albatross IV	1
2003	Polyvalent	Delaware II	0.82	Delaware II	0.82
2004	Polyvalent	Albatross IV	1		

Table 13. Total swept area estimates of abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from DFO surveys during 1986-2004.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1986	5057	306	8176	997	189	348	305	425	401	16205
1987	46	4286	929	3450	653	81	387	135	1132	11099
1988	971	49	12714	257	4345	274	244	130	686	19670
1989	48	6664	991	2910	245	526	40	34	265	11724
1990	726	108	12300	168	4466	299	1370	144	389	19968
1991	383	2163	134	10819	114	1909	117	505	225	16368
1992	1914	3879	1423	221	4810	18	1277	52	656	14249
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	1455	2290	4784	5305	3113	303	274	38	684	18247
1997	1033	1550	1222	2742	2559	1397	150	65	372	11090
1998	2379	10626	5348	3190	5312	5028	2248	348	601	35080
1999	24593	4787	10067	3104	1963	1880	1764	448	174	48780
2000	3177	15865	7679	12108	2900	2074	2726	1591	813	48932
2001	23026	3519	14633	4255	5608	1808	1426	1963	2299	58536
2002	732	28174	5977	12659	2980	2644	647	528	2420	56760
2003	1682	1503	82161	5533	15105	3675	2355	1106	1986	115107
2004	91843	539	2682	54882	5001	9695	1654	954	634	167883

Table 14. Total swept area estimated abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from NMFS spring surveys during 1968-2004. 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	68	679	4853	2045	240	123	234	11496
1969	17	35	614	235	523	3232	1220	358	489	6724
1970	478	190	0	560	998	441	3165	2491	769	9092
1971	0	655	261	0	144	102	58	1159	271	2650
1972	2594	0	771	132	25	47	211	27	1214	5020
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	8228	402	424	1127	532	0	0	0	22	10735
1977	126	26003	262	912	732	568	0	22	102	28727
1978	0	743	20859	641	880	1163	89	23	116	24516
1979	10496	441	1313	9764	475	72	445	42	9	23056
1980	4355	66450	1108	1086	5761	613	371	693	360	80797
1981	3281	2823	27085	2906	751	2455	347	56	21	39725
1982	584	3703	1658	7802	767	455	697	0	0	15666
1983	238	770	686	359	2591	30	0	798	58	5529
1984	1366	1414	1046	910	847	1189	133	73	490	7469
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	205	158	602	32	46	46	0	1905
1993	1870	1116	197	232	195	717	77	35	43	4480
1994	1025	4272	1487	269	184	118	278	28	84	7745
1995	921	2312	4184	1727	265	152	51	272	214	10099
1996	912	1365	3789	3190	1905	237	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
2001	10503	1186	3304	1232	374	294	113	20	20	17047
2002	231	40432	10938	4044	1492	473	287	229	236	58362
2003	125	1105	16915	2245	3773	476	200	82	286	25206
2004	195013	4724	2644	45872	3544	5261	960	1245	842	260104

Table 15. Total swept area estimated abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from NMFS fall surveys during 1963-2003. 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	105993	40995	10314	3378	5040	4136	1477	451	276	172061
1964	1178	123976	46705	4358	807	1865	477	211	167	179742
1965	259	1503	51338	8538	479	302	142	148	208	62918
1966	9325	751	1742	20323	3631	671	138	133	84	36798
1967	0	3998	73	327	1844	675	141	88	88	7233
1968	55	113	800	28	37	2223	547	177	313	4293
1969	356	0	0	509	62	30	739	453	108	2257
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	275	7702
1973	1223	16797	1598	0	168	0	0	8	16	19809
1974	151	234	961	169	0	6	0	0	70	1589
1975	30365	664	192	1042	239	0	0	0	28	32530
1976	738	121717	431	25	484	71	0	17	37	123521
1977	47	238	26323	445	125	211	84	4	4	27480
1978	14642	547	530	7706	56	42	94	0	0	23617
1979	1598	21605	14	335	1489	45	12	0	0	25098
1980	3556	2788	5829	0	101	1081	108	25	4	13492
1981	596	4617	2585	2748	89	136	318	0	15	11103
1982	62	0	673	465	2508	153	97	528	42	4527
1983	3609	444	236	501	289	402	17	12	86	5598
1984	45	3775	856	233	194	45	262	0	41	5451
1985	12148	381	1646	199	70	68	46	30	21	14611
1986	30	7471	109	961	52	50	72	24	23	8793
1987	508	0	843	28	152	38	22	0	0	1592
1988	122	3983	184	2348	155	400	142	140	38	7513
1989	167	83	2645	112	509	68	73	0	0	3656
1990	1217	1041	36	1456	65	196	24	5	0	4040
1991	705	331	267	52	289	25	10	0	0	1679
1992	3484	1052	172	110	0	95	0	18	18	4948
1993	652	6656	3601	585	0	87	96	30	0	11707
1994	625	782	927	419	96	32	0	24	0	2905
1995	892	1436	5993	3683	550	30	0	0	53	12637
1996	1742	453	570	2302	963	167	0	0	0	6196
1997	217	5738	3368	592	690	385	0	0	13	11004
1998	2566	2966	4214	1085	705	526	722	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
2001	659	16626	1382	6939	3000	1586	306	127	58	30684
2002	172	1864	44602	6040	5120	1660	863	457	354	61131
2003	196182	60	285	3415	655	739	20	99	158	201613

Table 16. Average weight at age (kg) from DFO surveys during 1986-2004, which are used to represent beginning of year weights.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1986	0.135	0.451	0.974	1.445	3.044	2.848	3.598	3.376	3.918
1987	0.150	0.500	0.716	1.672	2.012	2.550	3.148	3.151	3.629
1988	0.097	0.465	0.931	1.795	1.816	1.918	2.724	3.264	3.871
1989	0.062	0.474	0.650	1.392	1.995	2.527	2.158	2.859	3.141
1990	0.149	0.525	0.924	1.181	1.862	2.073	2.507	2.815	3.472
1991	0.120	0.685	0.800	1.512	1.695	2.434	2.105	3.122	3.432
1992	0.122	0.602	1.118	1.061	2.078	2.165	2.709	2.284	3.440
1993	0.122	0.481	1.227	1.803	1.274	2.332	2.343	2.739	3.280
1994	0.107	0.469	1.047	1.621	1.927	2.154	3.154	2.688	3.084
1995	0.086	0.493	0.963	1.556	2.222	2.445		2.991	3.184
1996	0.139	0.495	0.919	1.320	1.932	2.555	2.902	2.611	3.588
1997	0.132	0.506	0.782	1.205	1.664	2.176	2.454	2.577	3.158
1998	0.107	0.535	1.035	1.161	1.570	1.954	2.609	3.559	3.462
1999	0.130	0.474	0.911	1.290	1.259	1.869	2.131	2.722	2.992
2000	0.116	0.543	0.949	1.478	1.871	1.789	2.298	2.508	2.901
2001	0.093	0.524	1.005	1.371	1.798	2.165	2.250	2.593	2.928
2002	0.096	0.332	0.778	1.138	1.494	1.965	2.177	2.206	2.708
2003	0.080	0.369	0.846	1.063	1.477	1.645	2.208	2.229	2.487
2004	0.064	0.310	0.781	1.151	1.306	1.558	1.622	1.956	2.216
Low	0.062	0.310	0.650	1.061	1.259	1.558	1.622	1.956	2.216
High	0.150	0.685	1.227	1.803	3.044	2.848	3.598	3.559	3.918
Median	0.116	0.493	0.924	1.371	1.816	2.165	2.399	2.722	3.184
Average	0.111	0.486	0.913	1.380	1.805	2.164	2.505	2.750	3.205

Table 17. Statistical properties of estimates of population abundance (numbers in 000's) at time 2004.25 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	987636	630042	0.638	126895	0.128
2	1577	678	0.430	132	0.084
3	2579	827	0.321	98	0.038
4	41777	12328	0.295	1465	0.035
5	5198	1324	0.255	123	0.024
6	6154	1805	0.293	195	0.032
7	1519	465	0.306	47	0.031
8	777	347	0.446	42	0.055
		Survey Calibration Constants			
DFO Survey					
1	0.211	0.045	0.213	0.005	0.025
2	0.464	0.097	0.209	0.012	0.026
3	0.935	0.206	0.220	0.015	0.016
4	0.875	0.192	0.219	0.020	0.023
5	1.024	0.220	0.215	0.024	0.023
6	0.888	0.190	0.214	0.023	0.025
7	1.109	0.252	0.227	0.023	0.021
8	1.119	0.253	0.226	0.031	0.028
NMFS Spring Survey – Yankee 36 – 1969-72/1982-2004					
1	0.127	0.024	0.186	0.002	0.019
2	0.352	0.065	0.186	0.008	0.021
3	0.458	0.080	0.174	0.003	0.007
4	0.441	0.084	0.190	0.009	0.020
5	0.501	0.088	0.175	0.009	0.017
6	0.406	0.072	0.177	0.004	0.010
7	0.435	0.081	0.187	0.006	0.014
8	0.504	0.093	0.184	0.007	0.014
NMFS Spring Survey – Yankee 41 – 1973-81					
1	0.225	0.072	0.319	0.010	0.046
2	0.511	0.164	0.320	0.020	0.040
3	0.639	0.213	0.334	0.036	0.057
4	0.793	0.258	0.326	0.030	0.038
5	0.963	0.332	0.345	0.052	0.054
6	0.887	0.367	0.414	0.065	0.073
7	1.595	0.579	0.363	0.060	0.038
8	0.633	0.230	0.363	0.024	0.039
NMFS Fall Survey					
0	0.120	0.019	0.161	0.003	0.022
1	0.292	0.049	0.168	0.005	0.017
2	0.235	0.038	0.163	0.004	0.016
3	0.231	0.038	0.164	0.003	0.012
4	0.176	0.030	0.173	0.001	0.008
5	0.161	0.027	0.168	0.003	0.018

Table 18. Beginning of year population abundance (numbers in 000's) for haddock in unit areas 5Zjm during 1969-2004 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2004.25.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	768	189	4375	853	905	8990	3021	185	809	20096	19327	19138
1970	3349	629	138	2295	465	448	4796	1745	486	14352	11003	10374
1971	456	2715	439	107	1569	249	253	2904	1335	10027	9571	6857
1972	5375	373	1128	138	61	1064	64	67	2441	10711	5336	4963
1973	11030	4152	305	587	49	31	792	19	1661	18626	7597	3444
1974	3343	8122	1827	244	153	7	17	614	1224	15551	12208	4087
1975	3222	2718	4750	1280	200	99	4	14	1430	13715	10493	7775
1976	53930	2633	1972	2593	868	159	51	2	1156	63365	9435	6802
1977	5900	43962	2022	1467	1403	599	131	25	933	56442	50542	6580
1978	4206	4831	28840	1599	1043	885	349	107	759	42617	38411	33581
1979	51917	3438	3681	14523	1160	703	457	213	692	76783	24867	21429
1980	6637	42506	2799	2832	8089	625	400	185	690	64763	58126	15620
1981	5118	5425	18954	1989	2051	4507	342	216	661	39264	34146	28722
1982	1710	4190	3833	9542	1280	1239	2606	176	683	25259	23549	19358
1983	2532	1400	2768	2195	5289	865	679	1487	592	17807	15275	13874
1984	14884	2073	1015	1675	1306	2884	522	462	1318	26141	11257	9183
1985	1553	12186	1628	607	1065	836	1371	264	1034	20545	18992	6806
1986	13251	1268	8039	986	338	703	574	796	915	26869	13618	12349
1987	1276	10816	1003	4295	656	150	467	368	1214	20244	18968	8153
1988	15040	1045	7053	707	2156	450	73	309	1135	27967	12927	11882
1989	787	12280	809	3837	470	991	272	28	1055	20529	19742	7462
1990	2385	644	9007	591	2478	269	525	196	829	16924	14538	13894
1991	1804	1949	521	6226	372	1361	160	284	764	13440	11635	9686
1992	7985	1469	1192	347	3243	224	764	67	673	15964	7979	6510
1993	10815	6523	991	694	171	1360	106	343	502	21505	10690	4167
1994	12615	8840	5099	498	320	65	551	57	494	28540	15925	7084
1995	4733	10303	7006	3484	271	212	8	336	388	26741	22008	11705
1996	6321	3864	8370	5250	2472	173	151	4	532	27136	20815	16951
1997	13093	5164	3133	6404	3501	1635	85	107	369	33491	20398	15234
1998	9289	10692	4149	2490	4738	2417	1159	58	351	35343	26054	15362
1999	27830	7596	8589	3129	1798	3375	1565	844	292	55018	27189	19593
2000	12894	22757	6180	6339	2271	1248	2449	1050	820	56008	43114	20357
2001	80785	10551	18347	4652	4035	1632	836	1811	1304	123953	43168	32617
2002	3908	66062	8577	13447	3305	2553	1079	493	2185	101609	97702	31640
2003	1860	3195	53778	6825	9277	2361	1475	781	1838	81391	79531	76336
2004	904871	1519	2608	42378	5335	6264	1547	772	1840	967135	62264	60745

Table 19. Fishing mortality rate for haddock in unit areas 5Zjm during 1969-2004 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2004.25. 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	0.470	0.422	31
1970	0.010	0.159	0.057	0.180	0.425	0.371	0.302	0.258	0.543	0.287	23
1971	0.000	0.678	0.956	0.367	0.188	1.164	1.131	0.332	0.397	0.375	29
1972	0.058	0.003	0.453	0.832	0.467	0.096	0.993	0.288	0.210	0.219	18
1973	0.106	0.621	0.022	1.143	1.738	0.413	0.054	0.641	0.112	0.322	25
1974	0.007	0.336	0.156	0.000	0.242	0.491	0.003	0.051	0.050	0.059	5
1975	0.002	0.121	0.405	0.188	0.025	0.460	0.336	0.172	0.021	0.108	9
1976	0.004	0.064	0.096	0.414	0.171	0.000	0.522	0.000	0.016	0.262	21
1977	0.000	0.222	0.035	0.141	0.261	0.339	0.000	1.007	0.017	0.179	15
1978	0.002	0.072	0.486	0.121	0.194	0.460	0.293	0.107	0.013	0.195	16
1979	0.000	0.005	0.062	0.385	0.419	0.363	0.703	0.249	0.022	0.379	29
1980	0.002	0.608	0.142	0.122	0.385	0.402	0.416	0.346	0.019	0.308	24
1981	0.000	0.147	0.486	0.241	0.304	0.348	0.465	0.178	0.012	0.295	23
1982	0.000	0.215	0.358	0.390	0.192	0.401	0.361	0.481	0.107	0.358	27
1983	0.000	0.121	0.302	0.319	0.406	0.304	0.185	0.342	0.065	0.341	26
1984	0.000	0.042	0.314	0.253	0.246	0.544	0.481	0.486	0.298	0.389	29
1985	0.002	0.216	0.301	0.387	0.216	0.175	0.344	0.246	0.127	0.247	20
1986	0.003	0.035	0.427	0.208	0.610	0.208	0.246	0.263	0.049	0.221	18
1987	0.000	0.228	0.149	0.489	0.177	0.527	0.213	0.228	0.104	0.365	28
1988	0.003	0.055	0.409	0.208	0.577	0.304	0.759	0.173	0.099	0.362	28
1989	0.000	0.110	0.114	0.237	0.358	0.435	0.129	1.603	0.047	0.246	20
1990	0.002	0.013	0.169	0.264	0.400	0.320	0.415	0.268	0.057	0.317	25
1991	0.005	0.292	0.207	0.452	0.306	0.377	0.671	0.819	0.091	0.420	31
1992	0.002	0.194	0.341	0.507	0.669	0.551	0.601	0.536	0.158	0.578	40
1993	0.002	0.046	0.487	0.574	0.770	0.703	0.423	0.650	0.170	0.579	40
1994	0.002	0.033	0.181	0.409	0.213	1.881	0.295	0.863	0.094	0.328	26
1995	0.003	0.008	0.089	0.143	0.247	0.140	0.503	0.186	0.046	0.145	12
1996	0.002	0.010	0.068	0.205	0.213	0.511	0.145	2.064	0.167	0.211	17
1997	0.003	0.019	0.030	0.101	0.170	0.144	0.187	0.087	0.109	0.128	11
1998	0.001	0.019	0.082	0.126	0.139	0.235	0.117	0.258	0.116	0.154	13
1999	0.001	0.006	0.104	0.120	0.165	0.121	0.199	0.137	0.097	0.140	12
2000	0.001	0.015	0.084	0.252	0.131	0.200	0.102	0.216	0.093	0.190	16
2001	0.001	0.007	0.111	0.142	0.258	0.213	0.328	0.149	0.161	0.196	16
2002	0.001	0.006	0.028	0.171	0.137	0.349	0.123	0.275	0.155	0.184	15
2003	0.002	0.003	0.038	0.046	0.193	0.222	0.447	0.165	0.147	0.163	14

Table 20. Beginning of year biomass (tonnes in 000's) for haddock in unit areas 5Zjm during 1969-2004 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2004.25.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	88	97	4091	1283	1803	21080	8205	541	2788	39975	39887	39790
1970	385	324	129	3451	926	1049	13028	5111	1676	26080	25695	25371
1971	52	1397	411	161	3127	583	687	8506	4600	19524	19471	18075
1972	618	192	1055	208	121	2495	173	196	8409	13467	12849	12657
1973	1268	2136	285	884	98	73	2150	56	5722	12672	11404	9268
1974	384	4179	1708	367	306	17	46	1799	4217	13022	12637	8459
1975	370	1398	4441	1924	398	231	10	40	4928	13741	13370	11972
1976	6199	1355	1844	3900	1729	374	138	6	3983	19528	13329	11974
1977	678	22619	1890	2206	2796	1404	355	73	3214	35236	34558	11938
1978	483	2486	26963	2404	2078	2074	949	313	2613	40364	39880	37395
1979	5968	1769	3441	21841	2310	1648	1242	625	2383	41228	35260	33491
1980	763	21870	2617	4259	16117	1464	1087	543	2377	51098	50335	28465
1981	588	2791	17721	2991	4087	10569	929	633	2279	42588	42000	39208
1982	197	2156	3584	14349	2550	2906	7078	515	2354	35688	35491	33335
1983	291	720	2588	3301	10538	2027	1845	4355	2038	27704	27413	26693
1984	1711	1067	949	2520	2602	6763	1418	1354	4542	22925	21214	20147
1985	179	6270	1522	913	2122	1960	3724	774	3564	21027	20849	14579
1986	1784	573	7832	1424	1028	2001	2067	2686	3584	22978	21194	20621
1987	192	5403	718	7183	1319	383	1470	1159	4404	22232	22040	16637
1988	1462	485	6563	1269	3915	863	198	1008	4395	20159	18696	18211
1989	49	5822	526	5343	938	2504	587	80	3313	19162	19113	13291
1990	355	338	8324	698	4615	558	1316	551	2877	19632	19276	18938
1991	216	1335	417	9411	630	3312	337	886	2620	19163	18947	17612
1992	976	885	1332	368	6740	485	2069	153	2314	15323	14347	13462
1993	1319	3138	1216	1252	218	3172	248	939	1648	13149	11830	8692
1994	1346	4148	5338	808	617	140	1739	152	1522	15810	14464	10316
1995	408	5084	6748	5422	602	518	19	1006	1234	21040	20632	15548
1996	876	1912	7692	6930	4774	443	438	10	1907	24983	24107	22195
1997	1731	2615	2449	7719	5826	3558	209	275	1165	25546	23816	21200
1998	997	5724	4295	2892	7438	4723	3024	206	1215	30514	29517	23793
1999	3608	3598	7823	4035	2263	6308	3335	2298	875	34143	30534	26937
2000	1492	12365	5863	9372	4248	2233	5628	2634	2379	46214	44722	32356
2001	7542	5524	18444	6378	7253	3533	1882	4697	3819	59072	51530	46006
2002	374	21904	6673	15299	4938	5017	2349	1088	5916	63557	63184	41279
2003	150	1180	45500	7254	13703	3883	3257	1741	4572	81241	81091	79911
2004	57818	471	2038	48786	6968	9761	2511	1511	4077	133941	76123	75652

Table 21. Risk projection input for haddock in unit areas 5Zjm for the 2005 fishery and projection input for the 2005 to 2008 fishery. A catch of 15,000 mt in 2004 and M = 0.2 were assumed for the forecasts. Two projections were made, one using 20 million recruits for the 2004 to 2009 year classes, the other using 40 million.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
Population Numbers (000s)									
2004.25	860740	1445	2481	40311	5075	5958	1472	735	1750
Partial Recruitment to the Fishery[1]									
2004.25	0.01	0.04	0.42	1	1	1	1	1	1
2005	0.01	0.04	0.42	1	1	1	1	1	1
2006[4]	0.01	0.04	0.42	1	1	1	1	1	1
2007[4]	0.01	0.04	0.42	1	1	1	1	1	1
2008[4]	0.01	0.04	0.42	1	1	1	1	1	1
Weight at beginning of year for population (kg)[2]									
2004.25	0.06	0.31	0.78	1.15	1.31	1.56	1.62	1.96	2.22
2005	0.06	0.31	0.78	1.15	1.31	1.56	1.62	1.96	2.22
2006	0.06	0.31	0.78	1.15	1.31	1.56	1.62	1.96	2.22
2007[4]	0.06	0.31	0.78	1.15	1.31	1.56	1.62	1.96	2.22
2008[4]	0.06	0.31	0.78	1.15	1.31	1.56	1.62	1.96	2.22
2009[4]	0.06	0.31	0.78	1.15	1.31	1.56	1.62	1.96	2.22
Weight at age for catch (kg)[3]									
2004.25	0.52	1.01	1.46	1.79	2.00	2.18	2.44	2.67	3.54
2005	0.52	1.01	1.46	1.79	2.00	2.18	2.44	2.67	3.54
2006[4]	0.52	1.01	1.46	1.79	2.00	2.18	2.44	2.67	3.54
2007[4]	0.52	1.01	1.46	1.79	2.00	2.18	2.44	2.67	3.54
2008[4]	0.52	1.01	1.46	1.79	2.00	2.18	2.44	2.67	3.54
Maturity[5]									
2004.25	0	0	1	1	1	1	1	1	1
2005	0	0	1	1	1	1	1	1	1
2006	0	0	1	1	1	1	1	1	1

[1]Average of 1999 – 2003 for ages 1 to 3.
[2]Equal to 2004 from DFO survey.
[3]Average of 1999 – 2003 from fishery.
[4]2006-2008 projection only.
[5]Risk projection only.

Table 22. Projection results for haddock in unit areas 5Zjm for the 2005 to 2008 fishery using 20 million recruits for the 2004 to 2009 year classes.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
Population Numbers (000s)												
2004.25	860740	1445	2481	40311	5075	5958	1472	735	1750			
2005	17214	739711	1236	2002	29765	3747	4400	1087	1835			
2006	16375	14057	599358	907	1264	18790	2365	2777	1844			
2007	16375	13372	11390	439949	573	798	11862	1493	2918			
2008	16375	13372	10834	8361	277733	362	504	7488	2785			
2009	16375	13372	10834	7953	5278	175328	228	318	6485			
Population Biomass (mt)												
2004.25	54999	448	1939	46407	6628	9285	2388	1437	3878	127409	72410	71962
2005	1100	229357	966	2305	38877	5839	7138	2126	4066	291773	290673	61316
2006	1046	4359	468385	1045	1651	29279	3838	5432	4087	519121	518075	513716
2007	1046	4146	8901	506479	748	1243	19245	2920	6465	551195	550148	546002
2008	1046	4146	8467	9625	362759	563	817	14645	6170	408238	407192	403046
2009	1046	4146	8467	9156	6894	273202	370	622	14369	318272	317225	313079
Projected Catch Numbers (000s)												
2004.25	1224	8	144	5330	671	788	195	97	231			
2005	41	6938	116	417	6203	781	917	227	382			
2006	39	132	56298	189	263	3916	493	579	384			
2007	39	125	1070	91688	119	166	2472	311	608			
2008	39	125	1018	1742	57881	75	105	1561	580			
Catch Biomass (mt)												
2004.25	640	8	210	9528	1343	1715	476	259	820	15000		
2005	21	7028	170	746	12414	1700	2241	604	1354	26278		
2006	20	134	82316	338	527	8525	1205	1544	1361	95969		
2007	20	127	1564	163897	239	362	6043	830	2153	175236		
2008	20	127	1488	3115	115835	164	257	4162	2055	127222		

Table 23. Projection results for haddock in unit areas 5Zjm for the 2005 to 2008 fishery using 40 million recruits for the 2004 to 2009 year classes.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
Population Numbers (000s)												
2004.25	860740	1445	2481	40311	5075	5958	1472	735	1750			
2005	34428	739711	1236	2002	29765	3747	4400	1087	1835			
2006	32749	28114	599358	907	1264	18790	2365	2777	1844			
2007	32749	26743	22780	439949	573	798	11862	1493	2918			
2008	32749	26743	21669	16721	277733	362	504	7488	2785			
2009	32749	26743	21669	15906	10556	175328	228	318	6485			
Population Biomass (mt)												
2004.25	54999	448	1939	46407	6628	9285	2388	1437	3878	127409	72410	71962
2005	2200	229357	966	2305	38877	5839	7138	2126	4066	292873	290673	61316
2006	2093	8717	468385	1045	1651	29279	3838	5432	4087	524526	522433	513716
2007	2093	8292	17802	506479	748	1243	19245	2920	6465	565288	563195	554903
2008	2093	8292	16934	19250	362759	563	817	14645	6170	431522	429430	421138
2009	2093	8292	16934	18311	13787	273202	370	622	14369	347980	345887	337595
Projected Catch Numbers (000s)												
2004.25	1224	8	144	5330	671	788	195	97	231			
2005	81	6938	116	417	6203	781	917	227	382			
2006	77	264	56298	189	263	3916	493	579	384			
2007	77	251	2140	91688	119	166	2472	311	608			
2008	77	251	2035	3485	57881	75	105	1561	580			
Catch Biomass (mt)												
2004.25	640	8	210	9528	1343	1715	476	259	820	15000		
2005	42	7028	170	746	12414	1700	2241	604	1354	26300		
2006	40	267	82316	338	527	8525	1205	1544	1361	96123		
2007	40	254	3129	163897	239	362	6043	830	2153	176948		
2008	40	254	2976	6229	115835	164	257	4162	2055	131972		

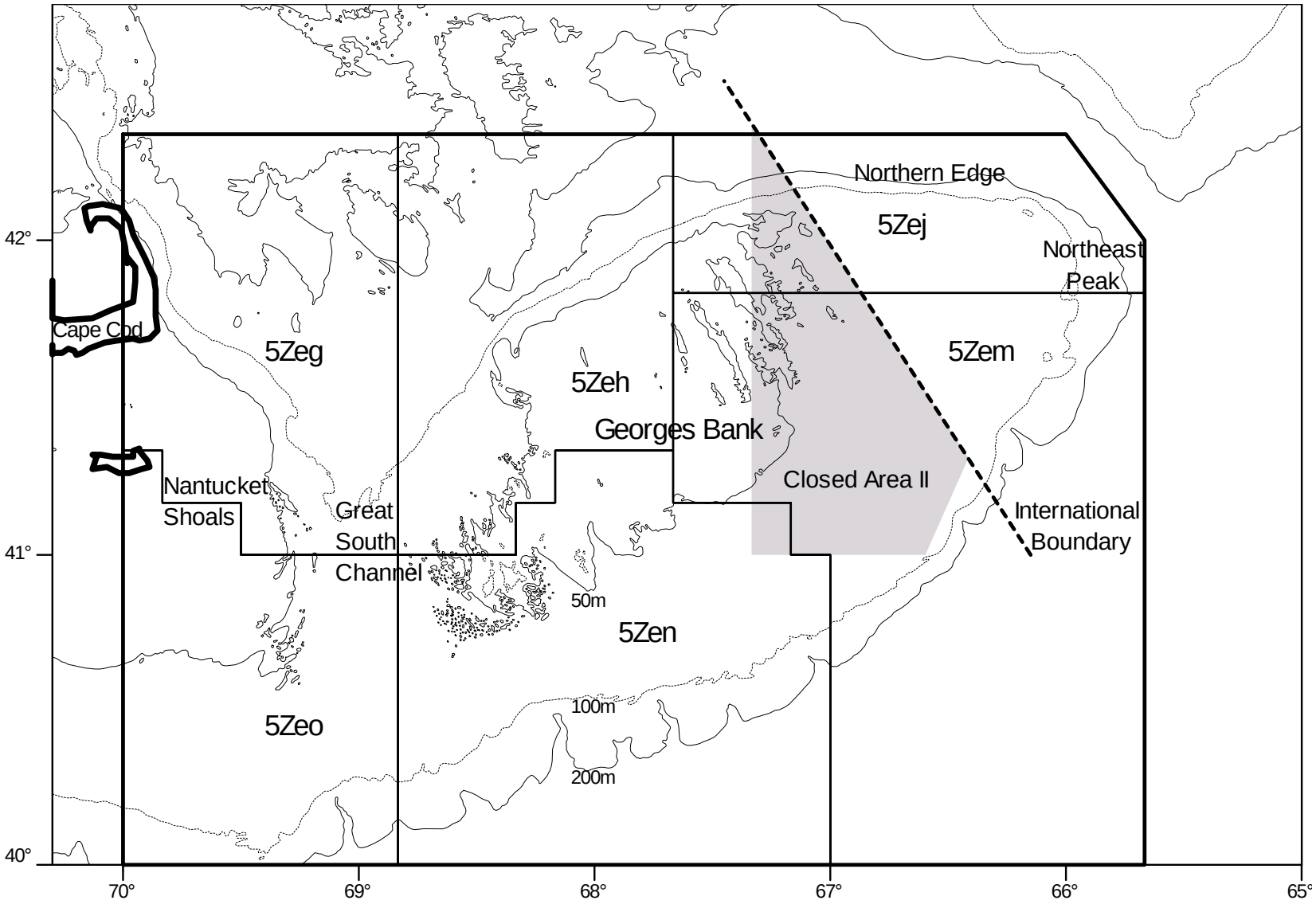

Figure 1. Fisheries statistical unit areas in NAFO Subdivision 5Ze.

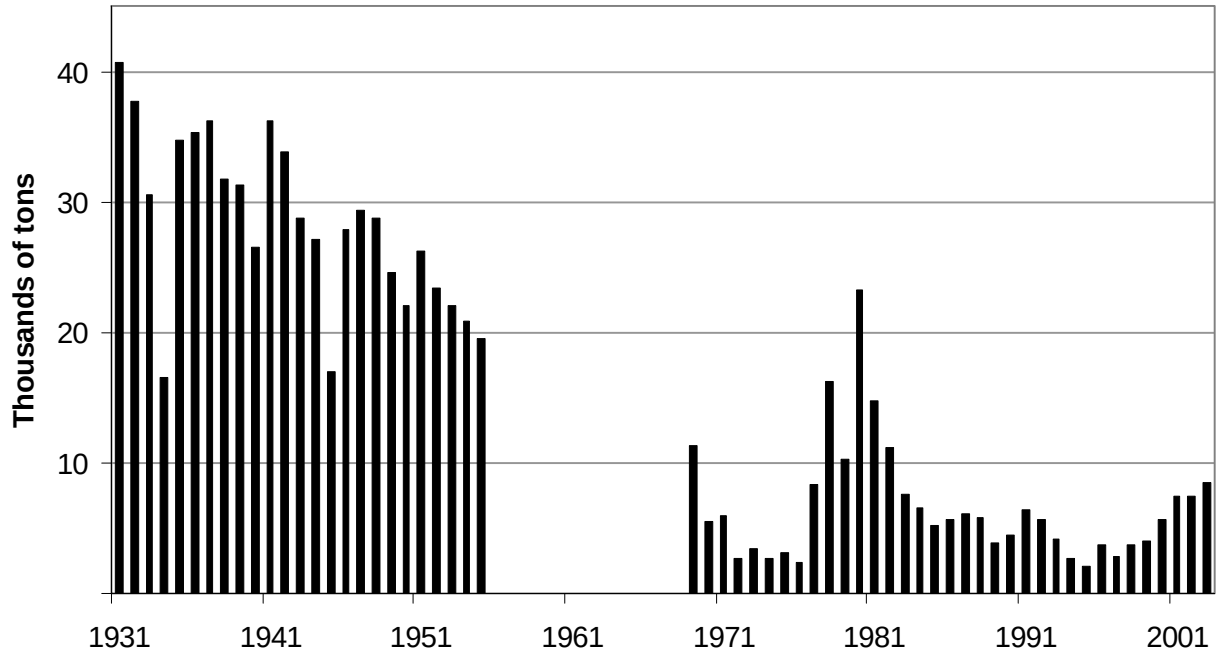

Figure 2. Historical catch of haddock in 5Zjm during 1931-1955 compared to recent catches during 1969-2003.

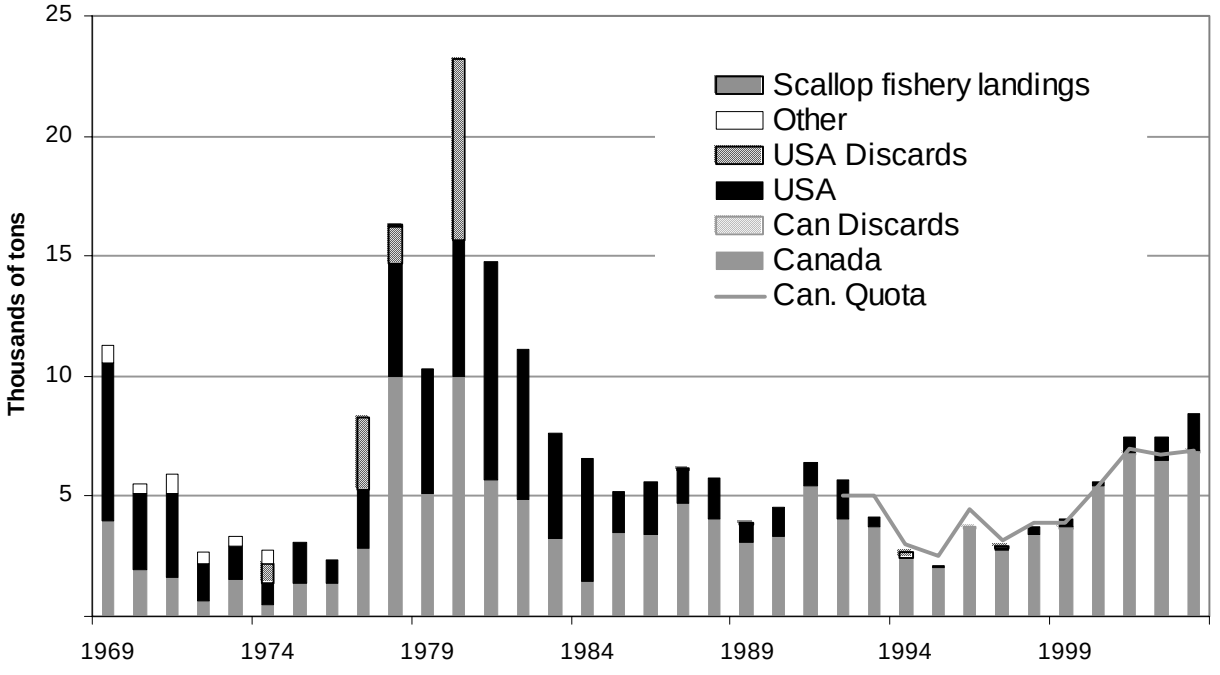

Figure 3. Nominal catch of haddock in unit areas 5Zjm during 1969-2003.

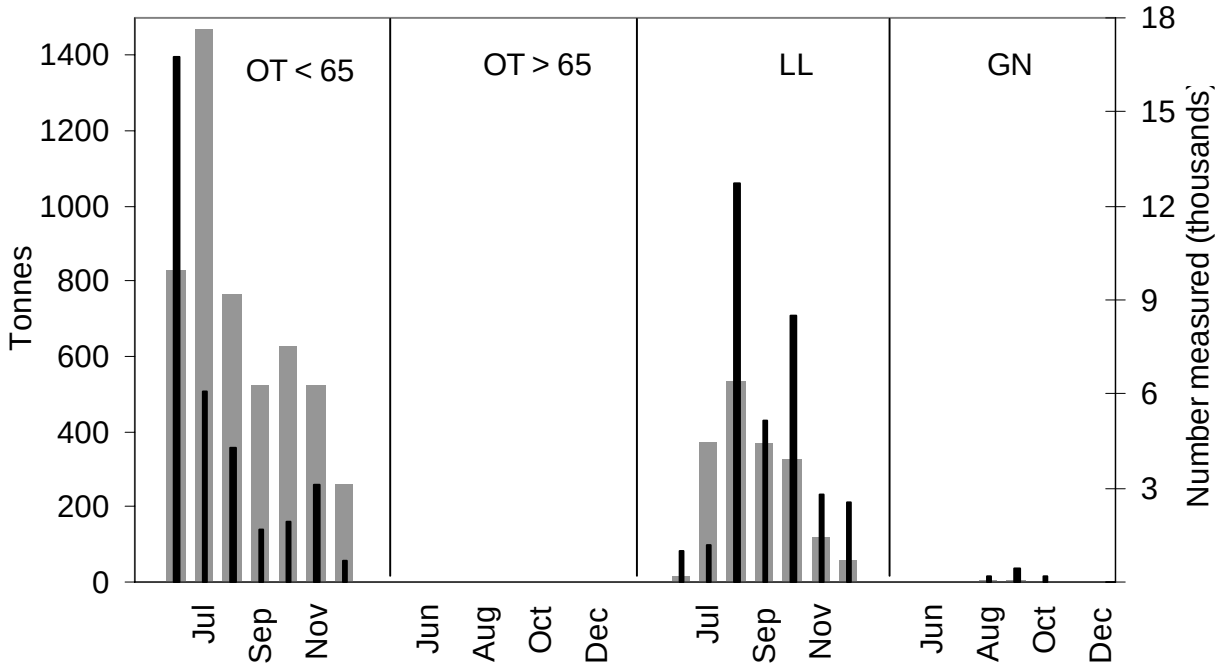

Figure 4. Haddock catches in 5Zjm by month and gear for the Canadian commercial fishery in 2003 (wide gray bars) with sampling levels (narrow black bars).

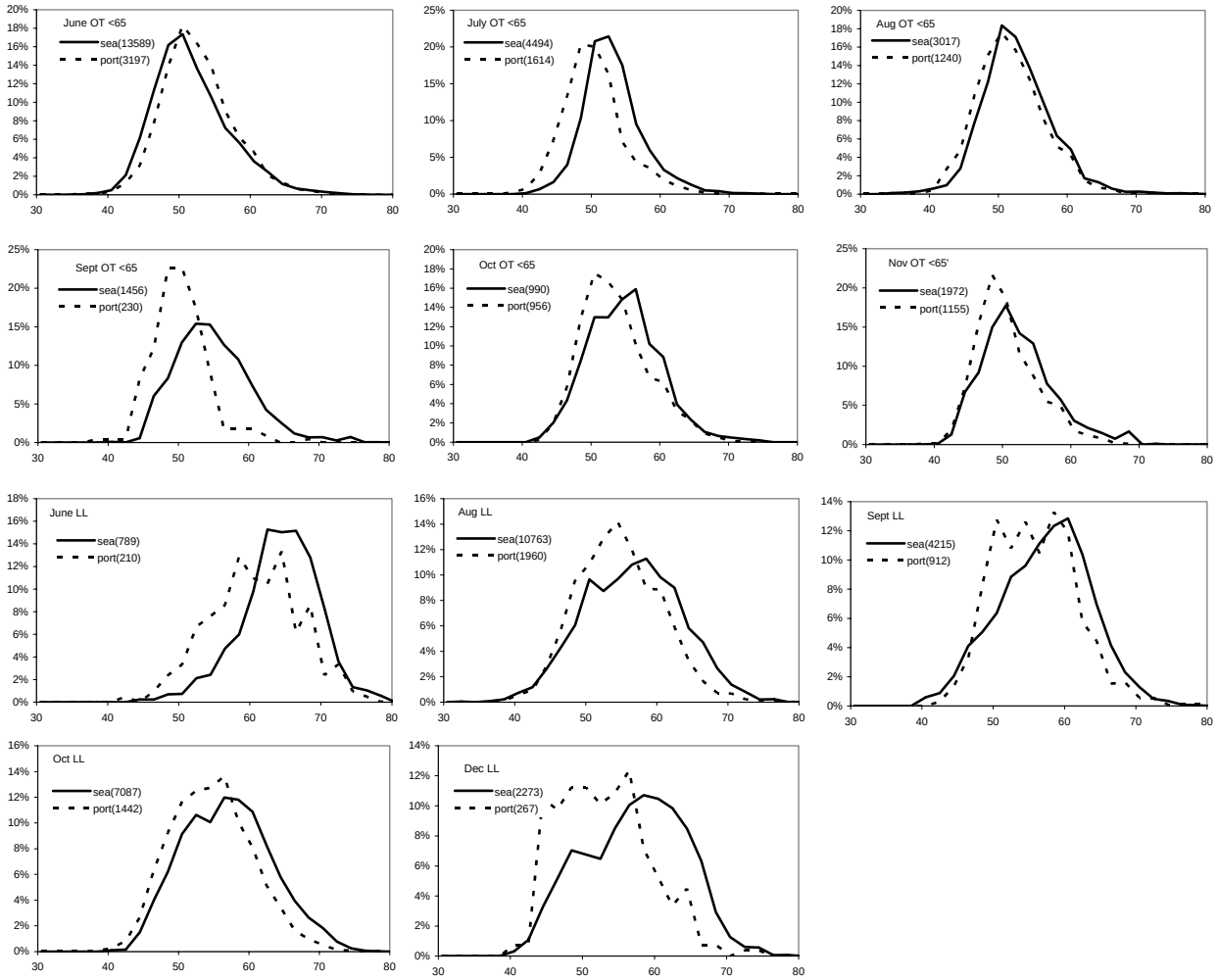

Figure 5. Comparison of length frequencies obtained at port and at sea from the Georges Bank commerical fishery in 2003. The number of fish measured is shown in brackets.

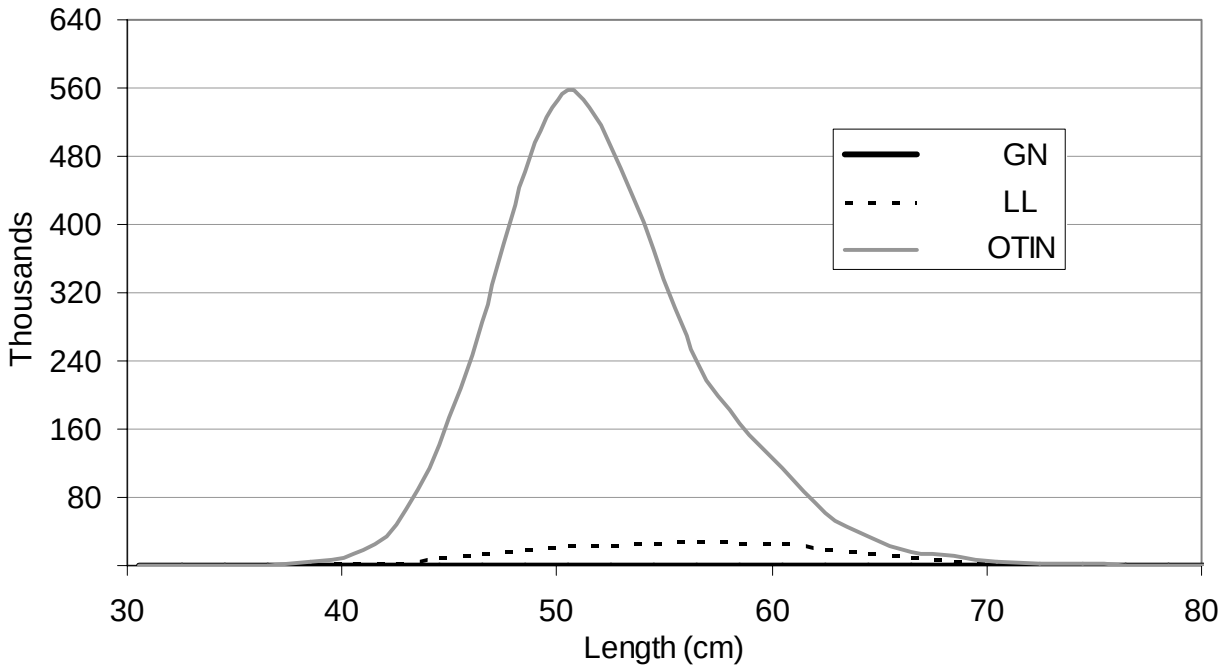

Figure 6. Catch at length by the principal Canadian 5Zjm commercial haddock fisheries in 2003.

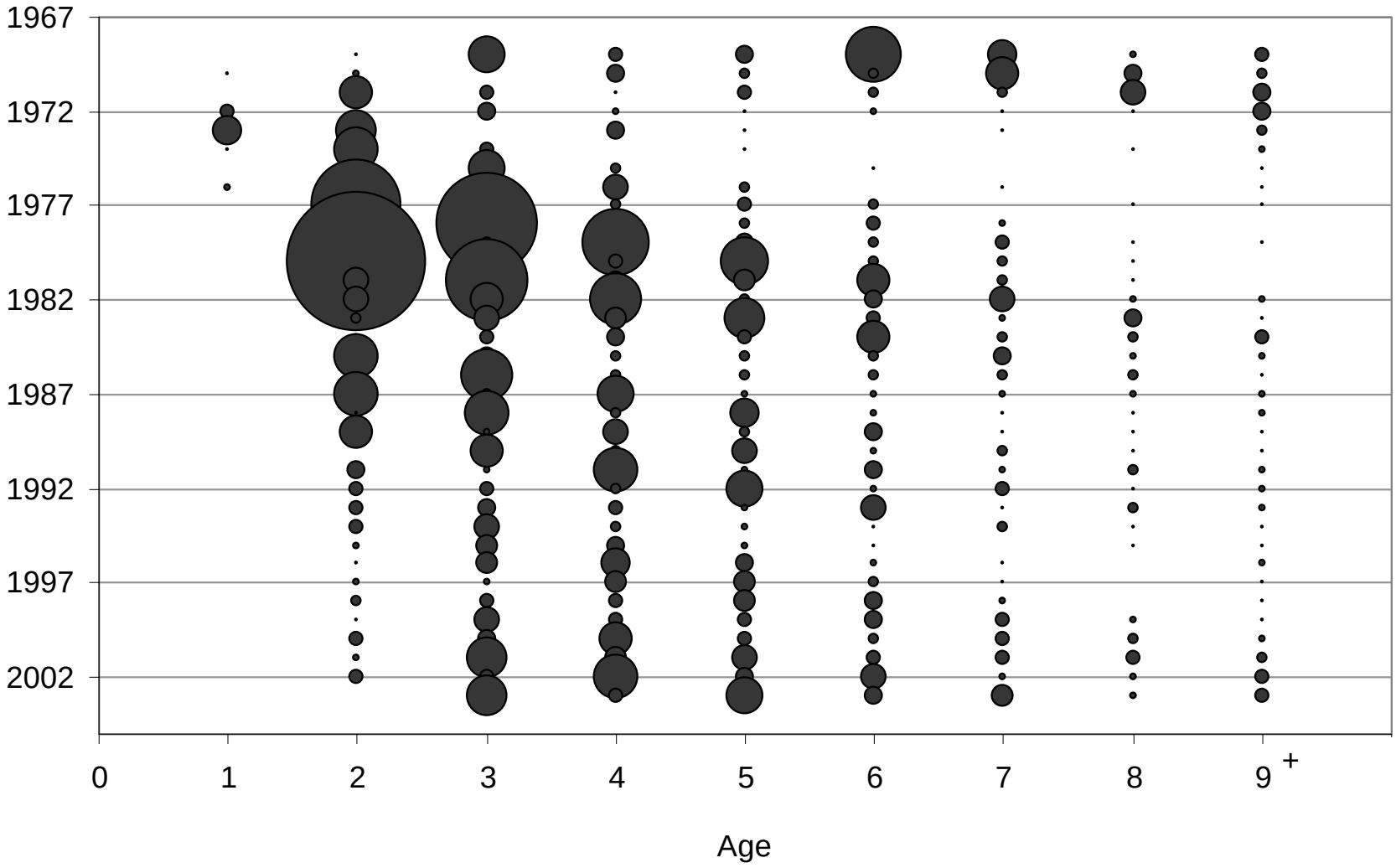

Figure 7. Total commercial catch at age (numbers) of haddock from unit areas 5Zjm during 1969-2003. The bubble area is proportional to magnitude (see Table 9).

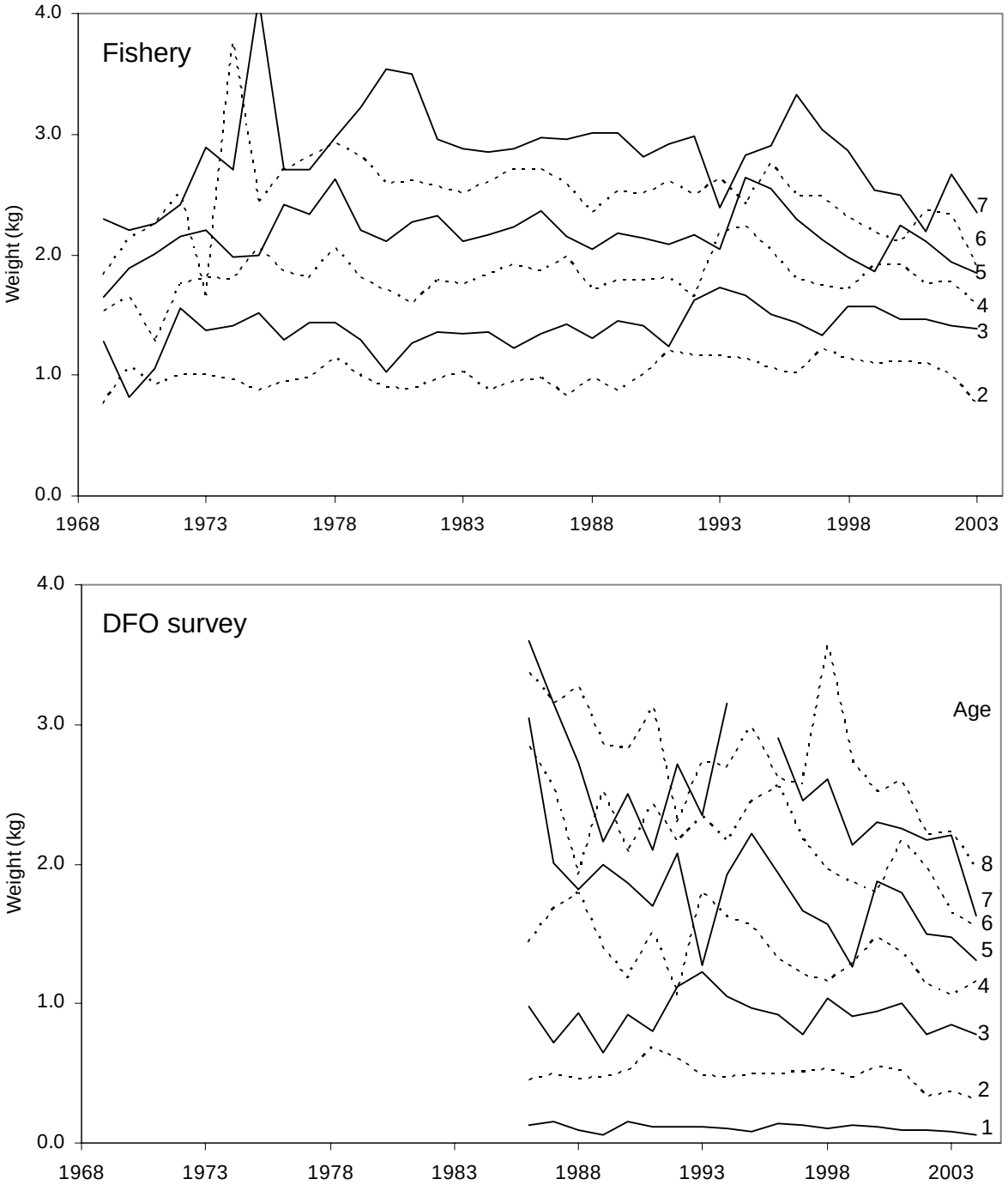

Figure 8. Average weights at age for haddock in unit areas 5Zjm from the commercial fishery during 1969-2003 and from the DFO survey during 1986-2004.

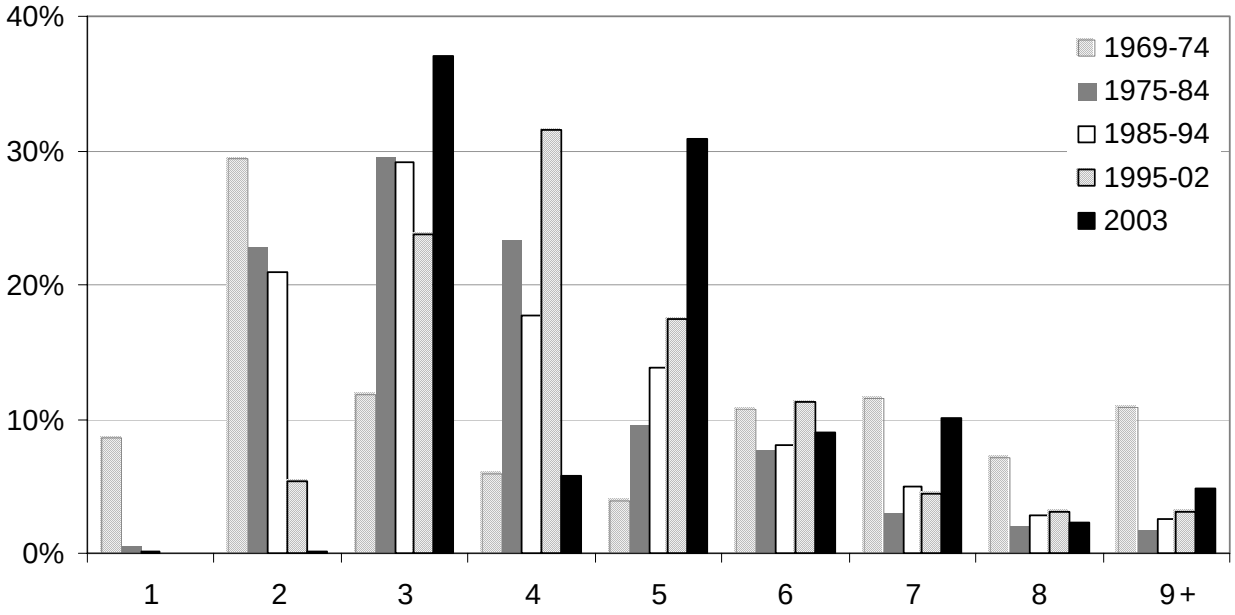

Figure 9. Age composition of the haddock catch for the 5Zjm commercial fishery in 2003 compared to the average age composition for the total catch of all fisheries during 1969-1974, 1975-1984, 1985-1994, and 1995-2002.

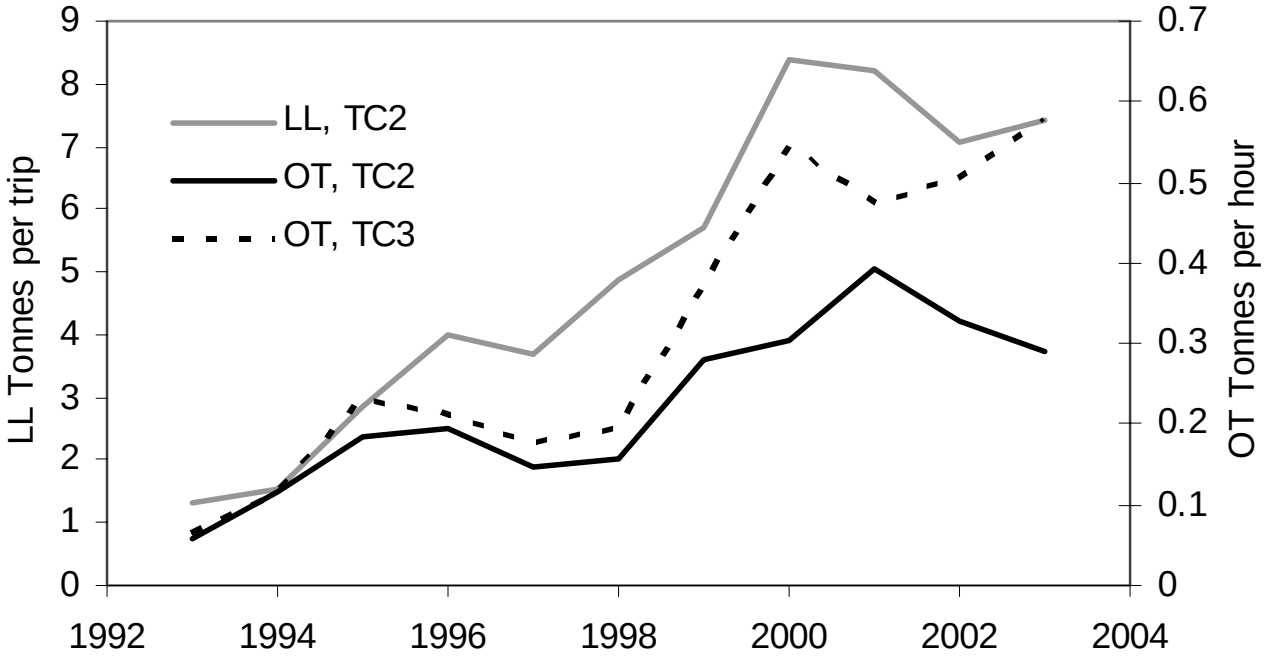

Figure 10. Catch rates for haddock from the Canadian commercial fishery in 5Zjm during 1993-2003 (LL = longline, OT = otter trawl, TC = tonnage class).

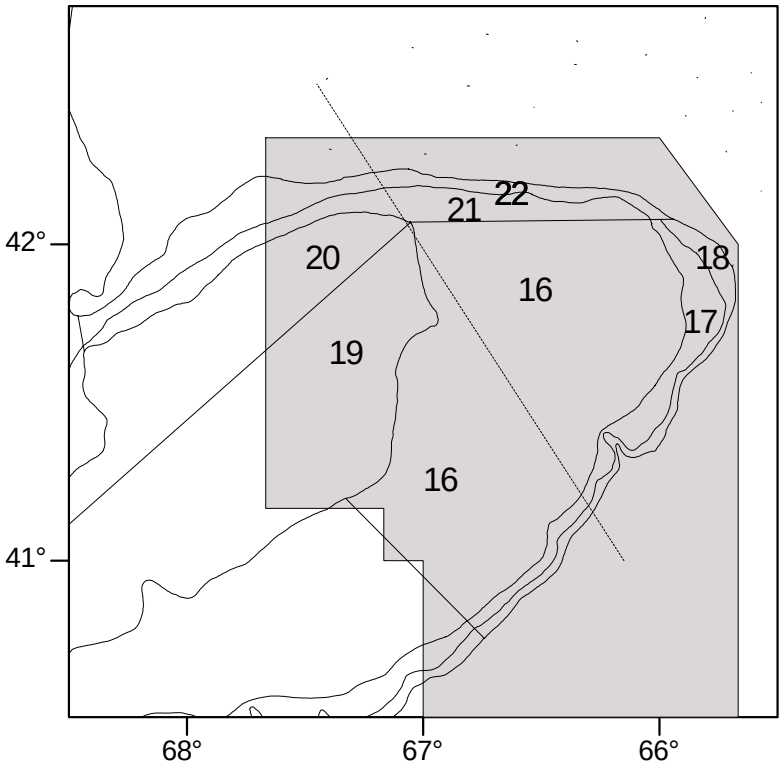

Figure 11. Stratification scheme used for NMFS surveys. The 5Zjm management area is indicated by shading.

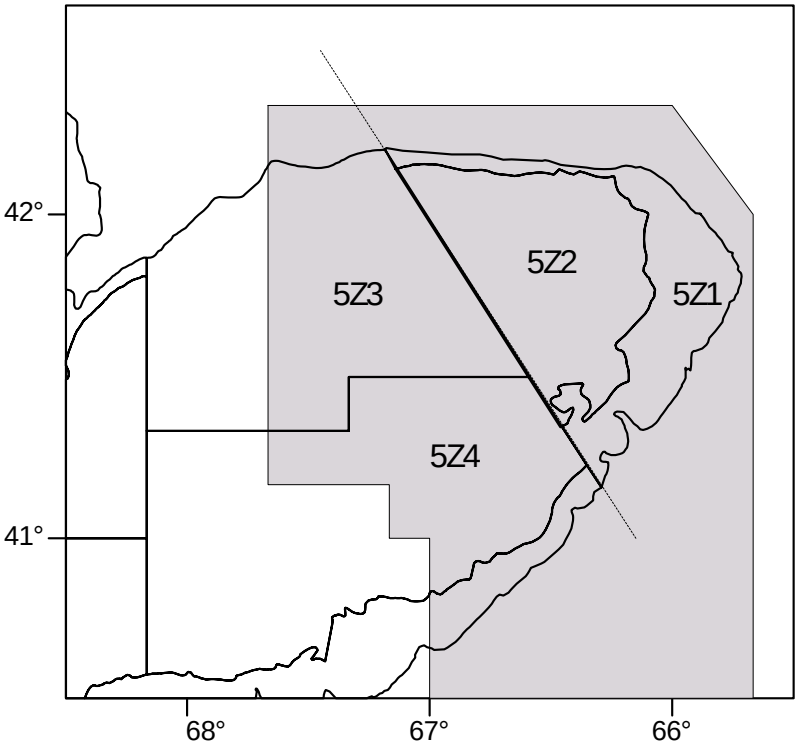

Figure 12. Stratification scheme used for the DFO survey. The 5Zjm management area is indicated by shading.

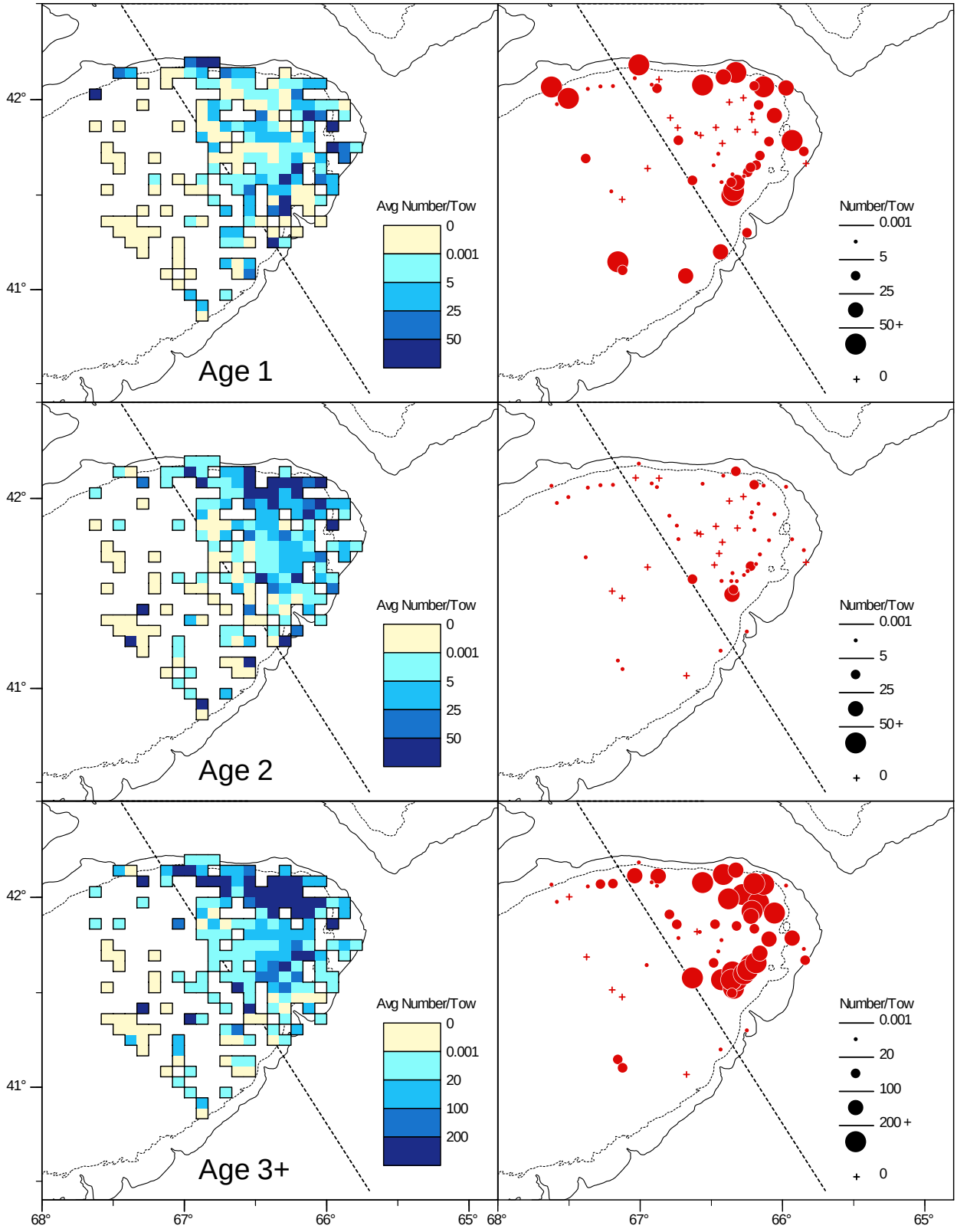

Figure 13. Distribution of 5Zjm haddock abundance (number/tow) as observed from the **DFO** survey. The squares (left panels) are shaded relative to the average catch for 1999 to 2003. The expanding symbols (right panels) represent the **2004** survey catches.

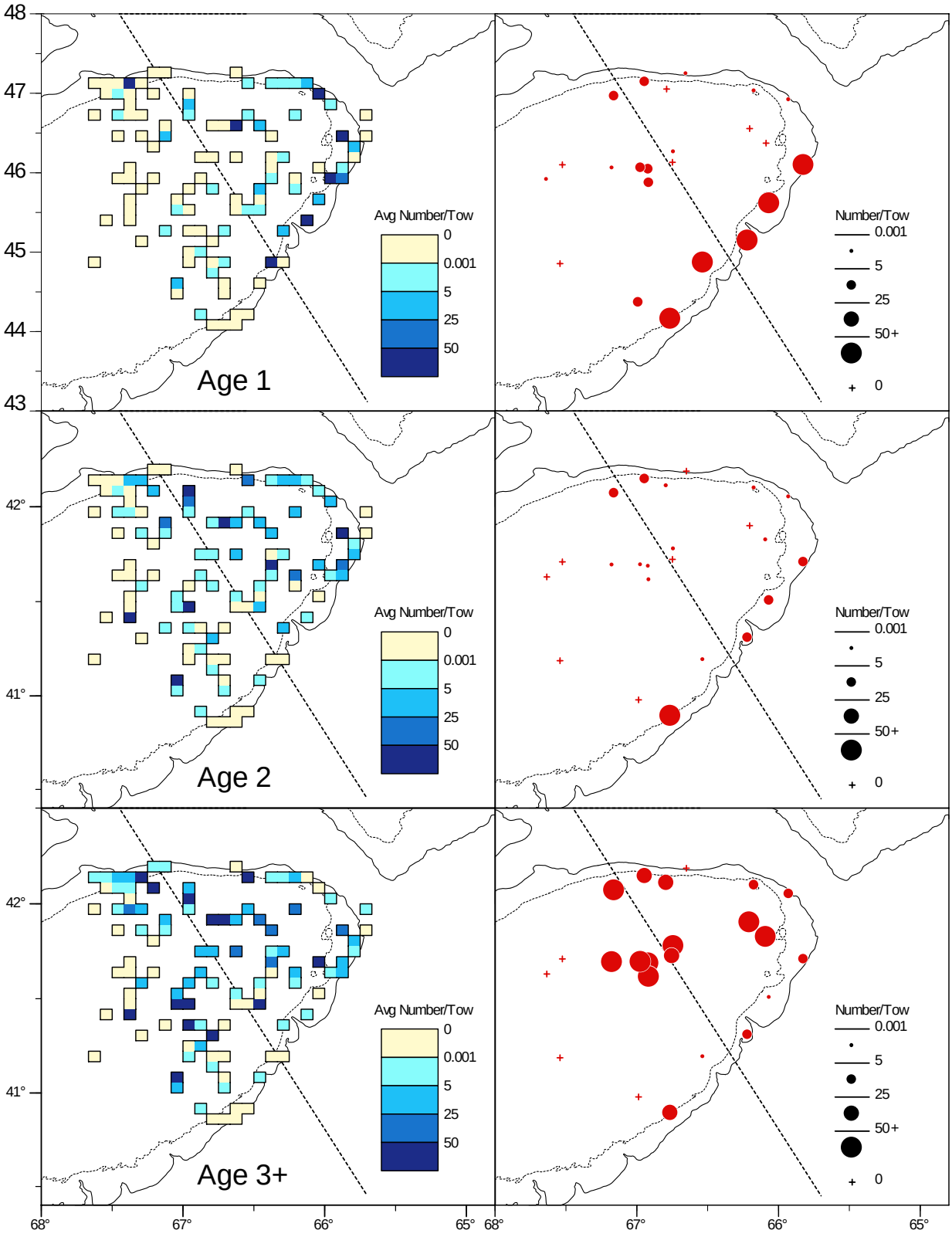

Figure 14. Distribution of 5Zjm haddock abundance (number/tow) as observed from the **NMFS spring** survey. The squares (left panels) are shaded relative to the average catch for 1999 to 2003. The expanding symbols (right panels) represent the **2004** survey catches.

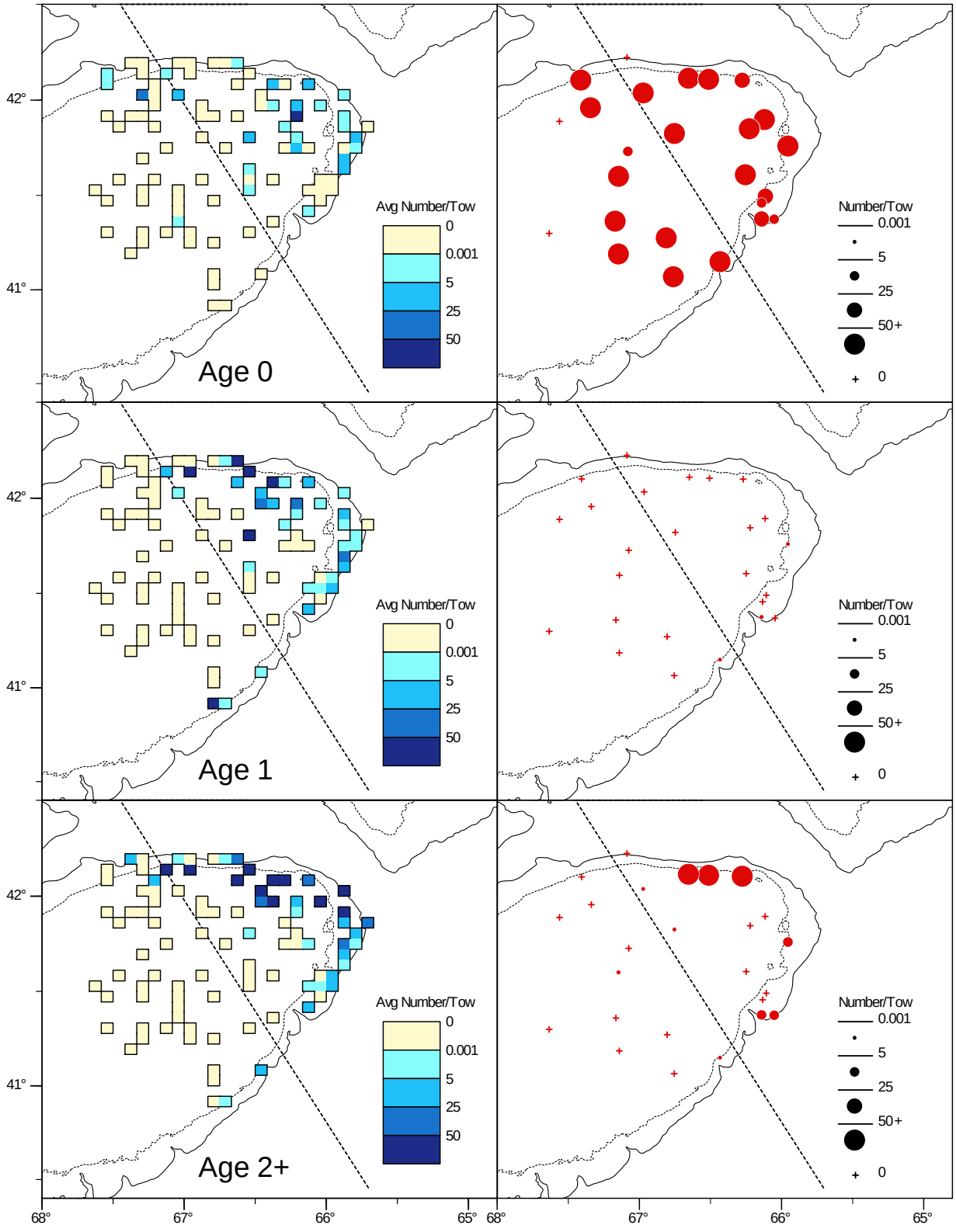

Figure 15. Distribution of 5Zjm haddock abundance (number/tow) as observed from the **NMFS fall** survey. The squares (left panels) are shaded relative to the average catch for 1998 to 2002. The expanding symbols (right panels) represent the **2003** survey catches.

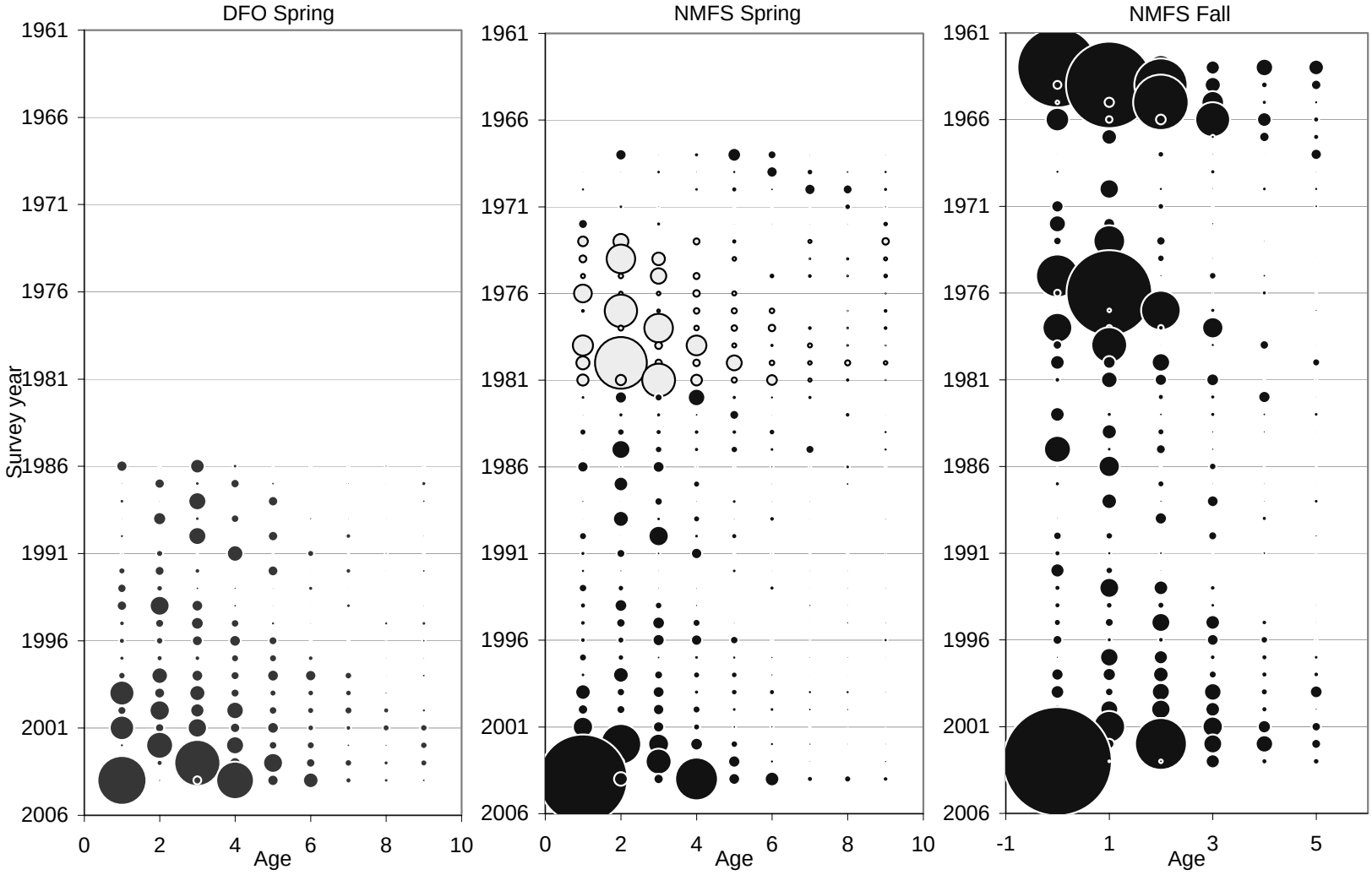

Figure 16. Estimated abundance at age (numbers in 000's) of haddock for the DFO, NMFS spring and NMFS fall surveys during 1963-2004. Bubble area is proportional to magnitude (see Tables 12-14). Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 1973-81 (pale circles), 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 catchability of the survey.

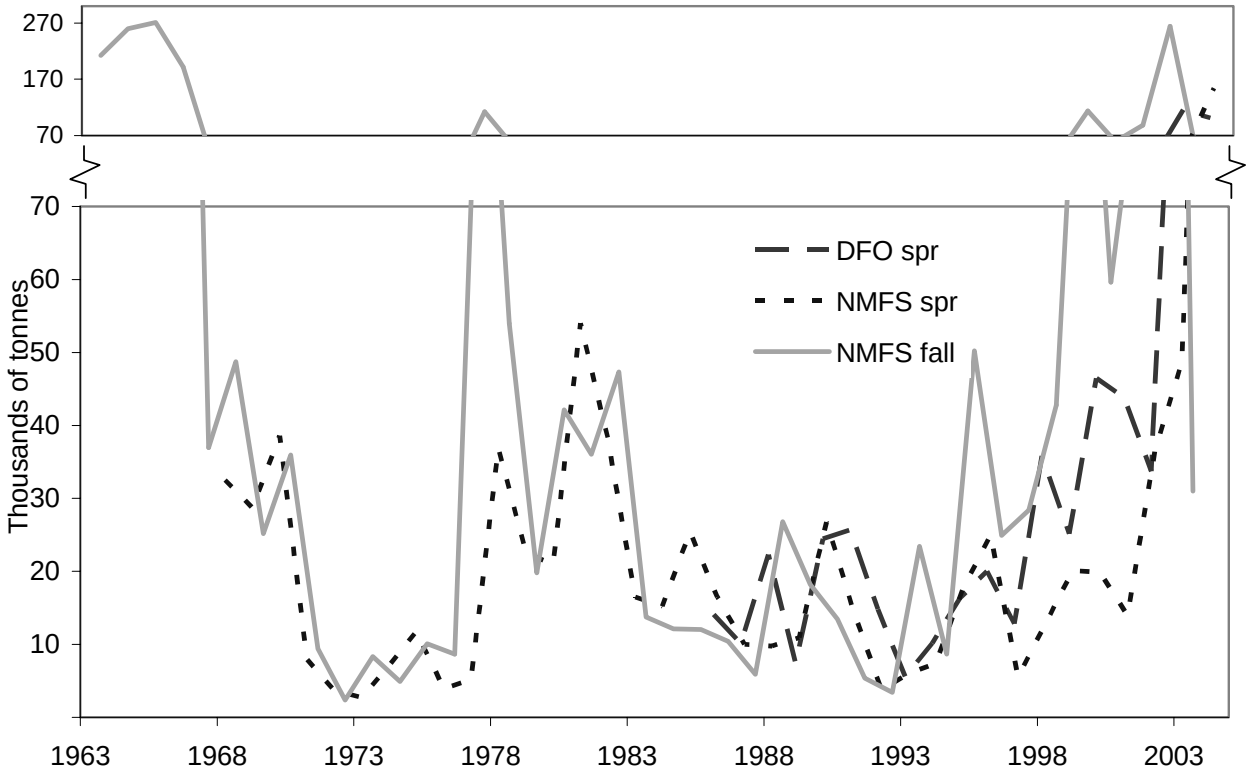

Figure 17. Biomass from NMFS fall (ages 2-8), NMFS spring (ages 3-8) and DFO (ages 3-8) research surveys (scaled by calibration constants, Table 16) for haddock in unit areas 5Zjm during 1963-2004.

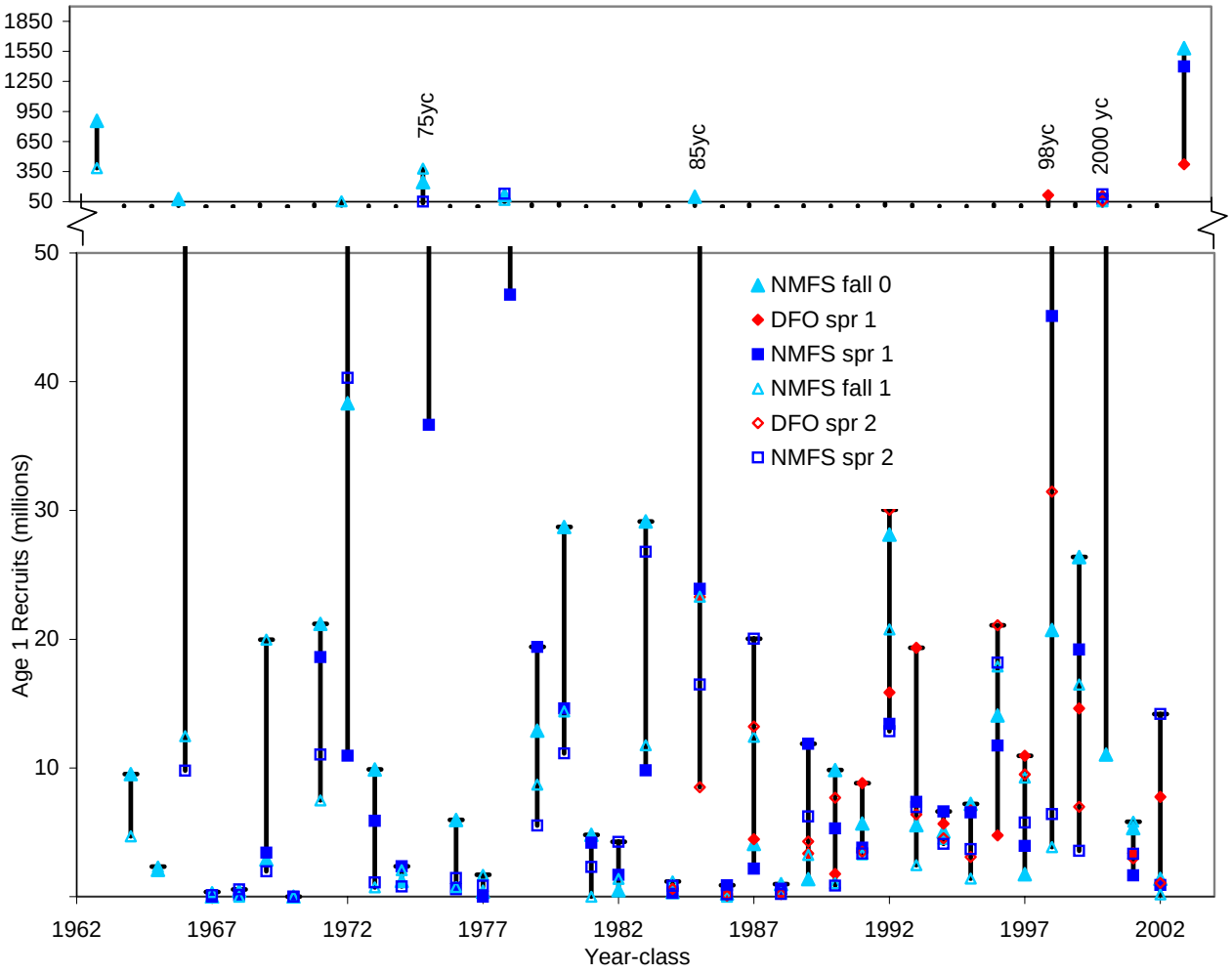

Figure 18. Year-class abundance for ages 0 and 1 from the NMFS fall and ages 1 and 2 from the NMFS spring and DFO research surveys (scaled by calibration constants, Table 16) for haddock in unit areas 5Zjm during 1963-2003.

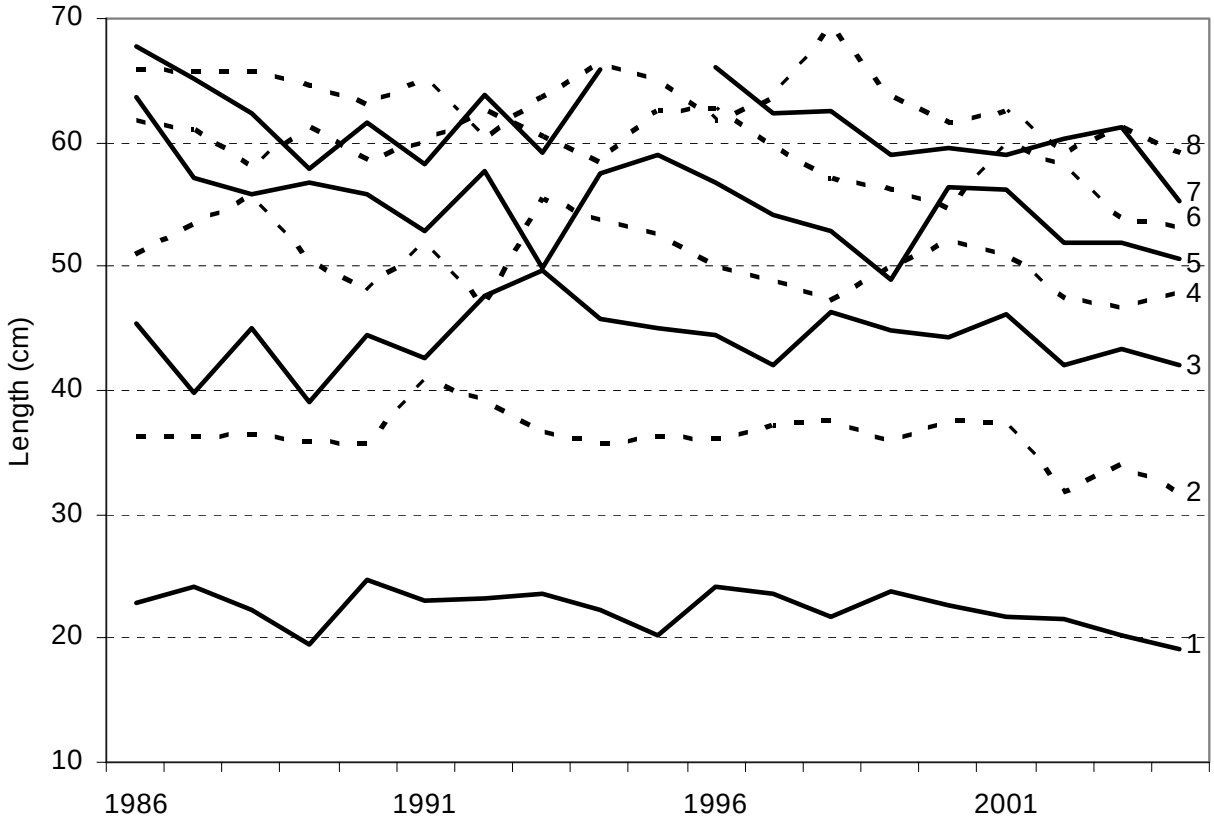

Figure 19. Length at age for haddock in unit areas 5Zjm derived from DFO surveys during 1986-2004.

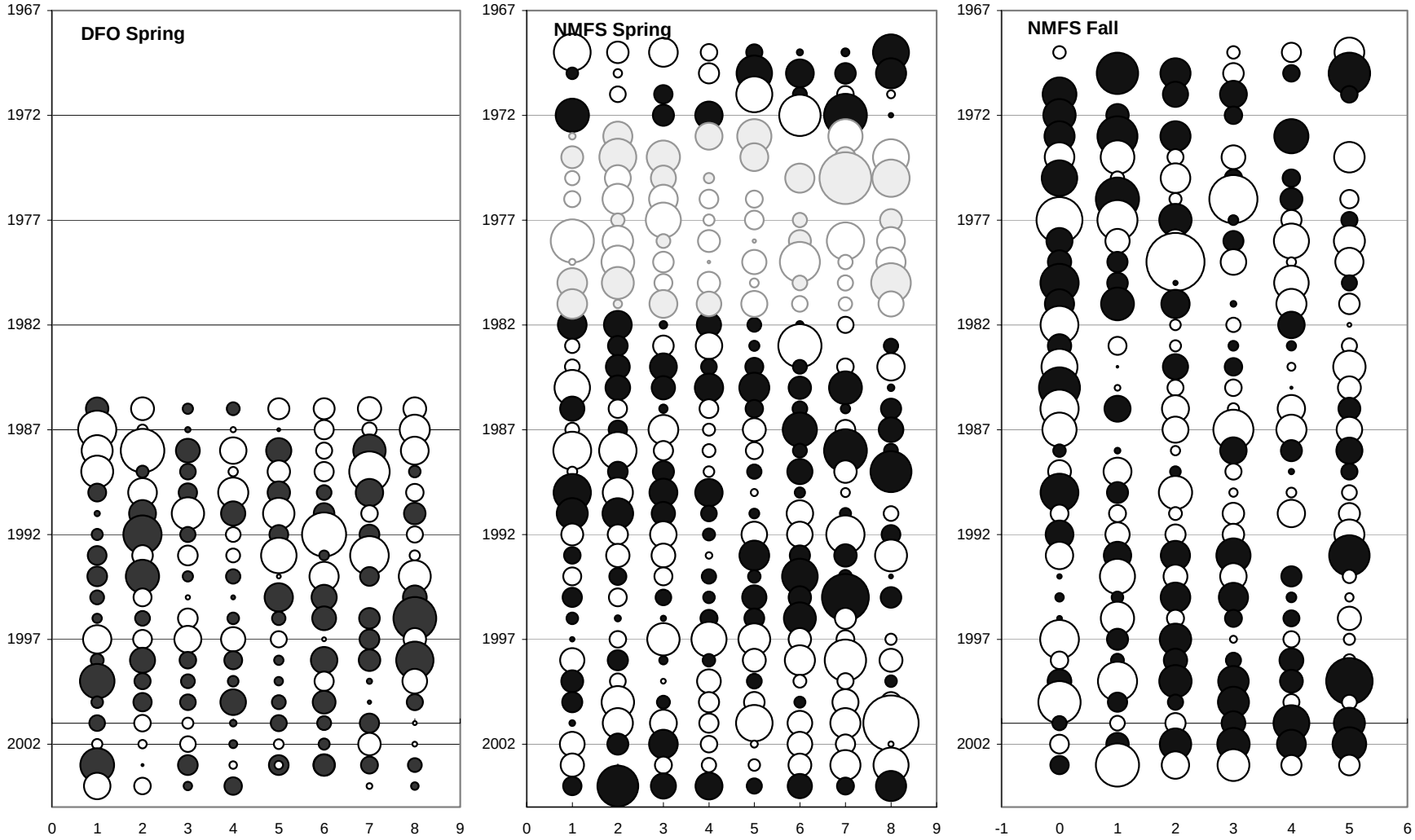

Figure 20. Residuals by year and age group for research survey indices during 1969-2004. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years.

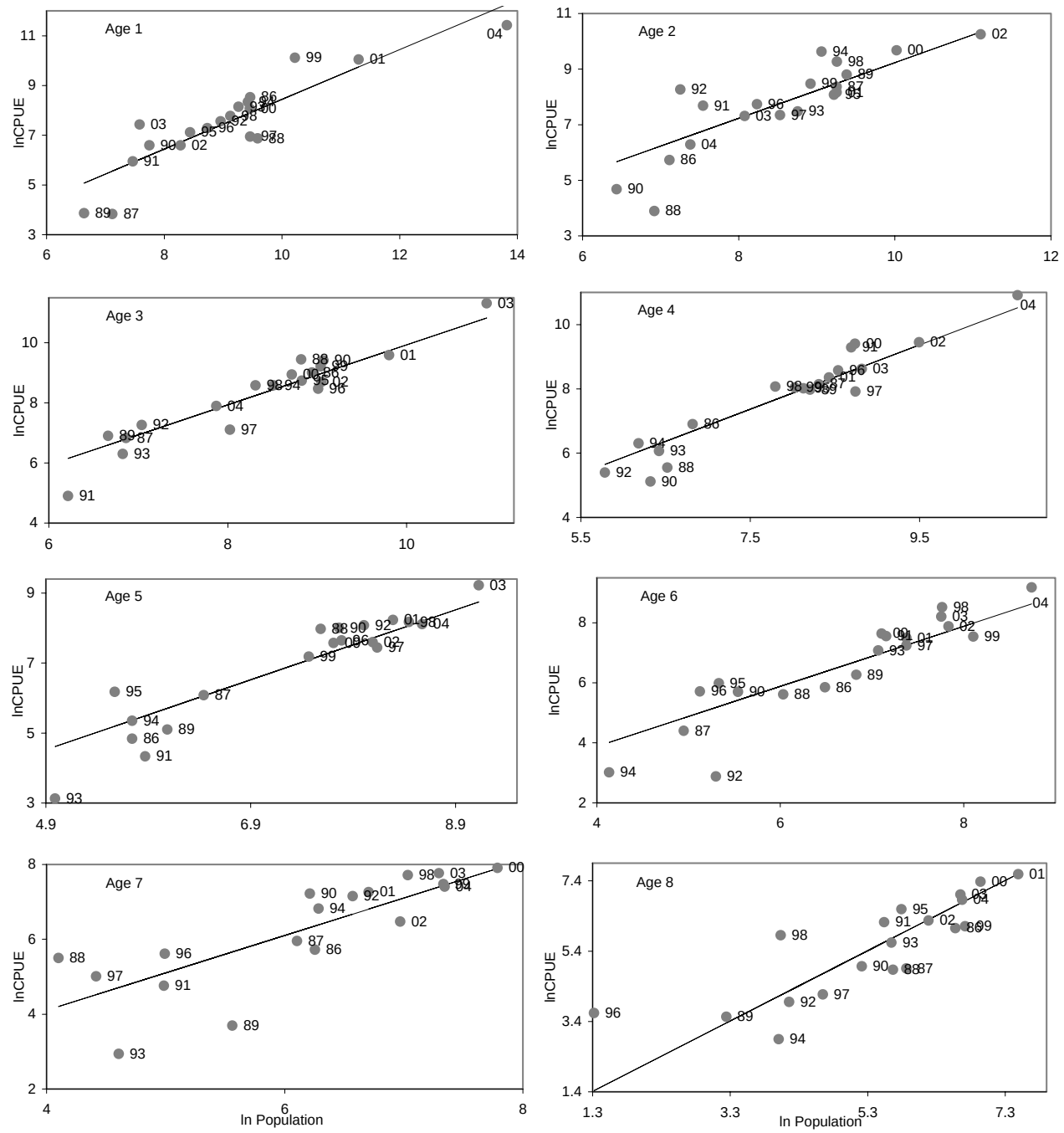

Figure 21. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **DFO** survey during 1986-2004.

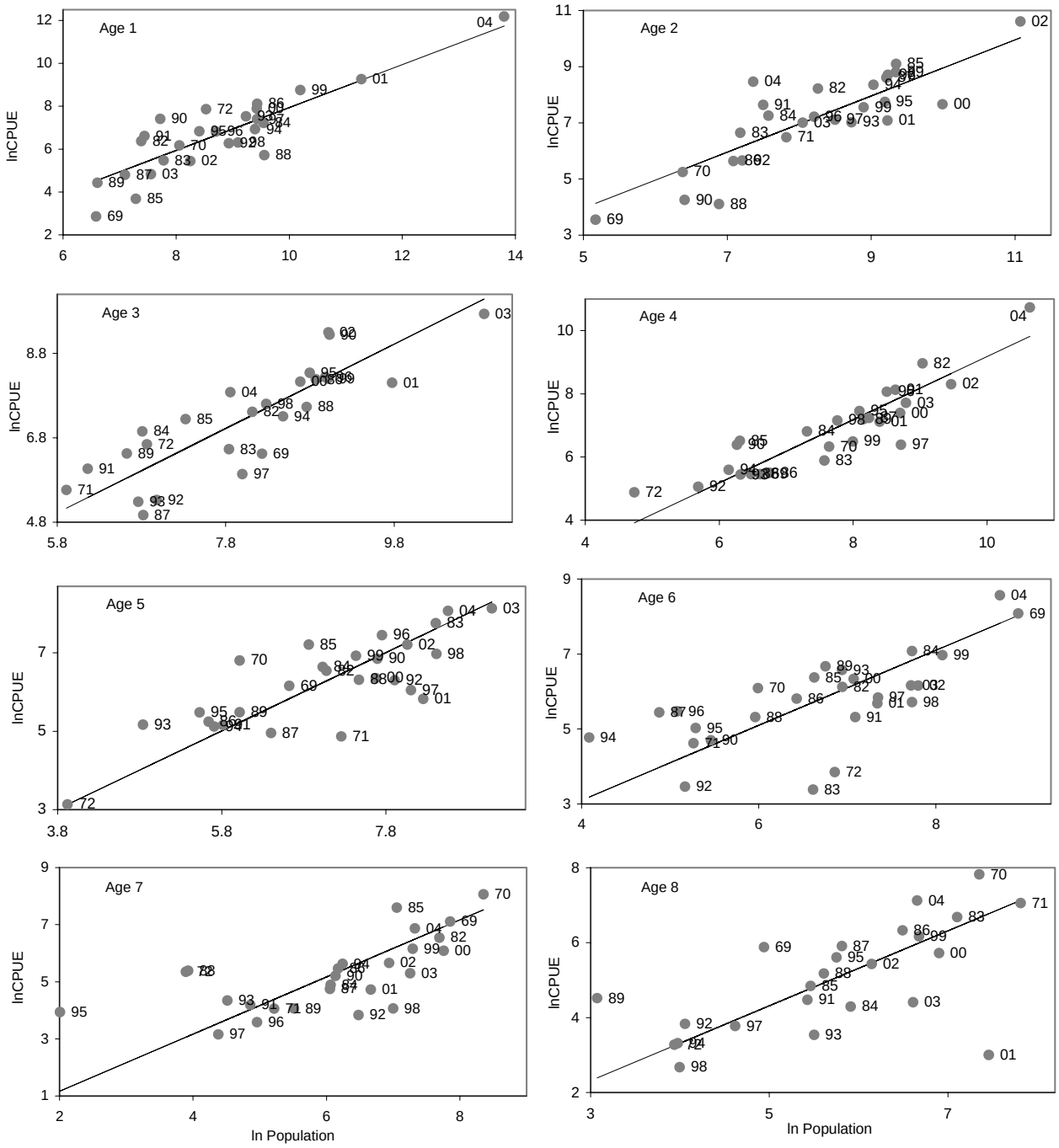

Figure 22. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **NMFS spring** survey with a Yankee 36 net during 1969-1972 and 1982-2004.

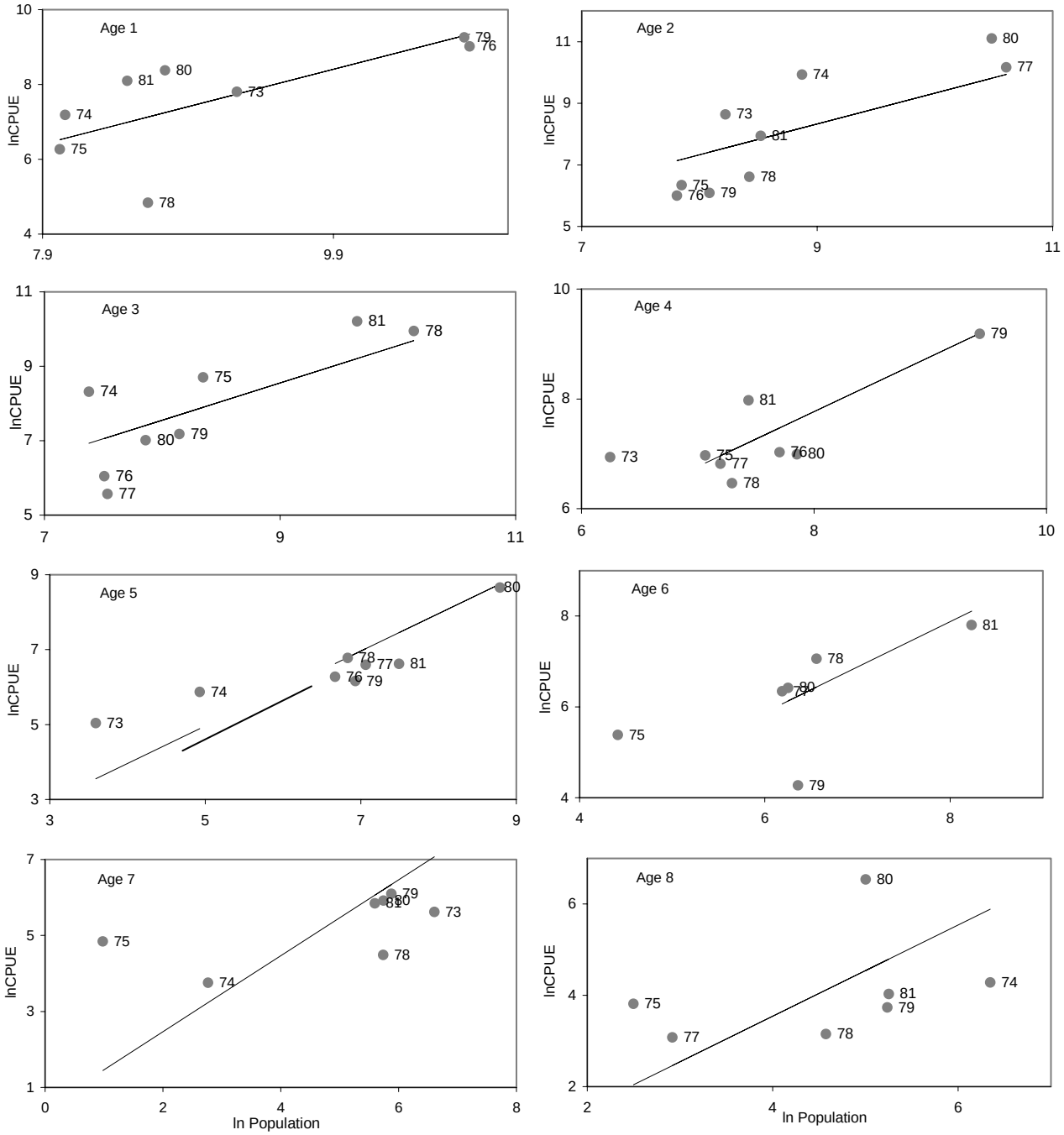

Figure 23. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **NMFS spring** survey with a Yankee 41 net during 1973-1981.

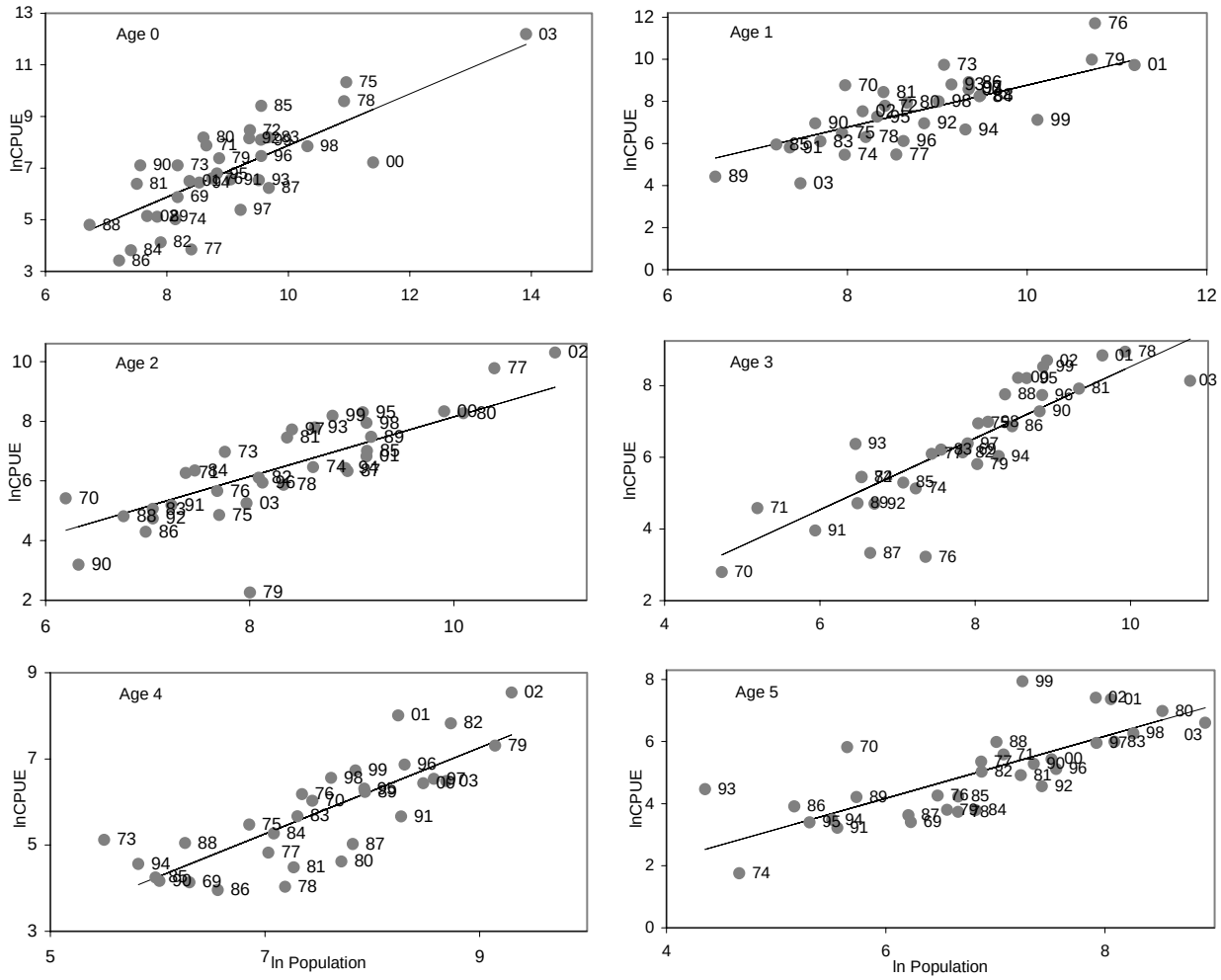

Figure 24. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **NMFS fall** survey 1969-2003.

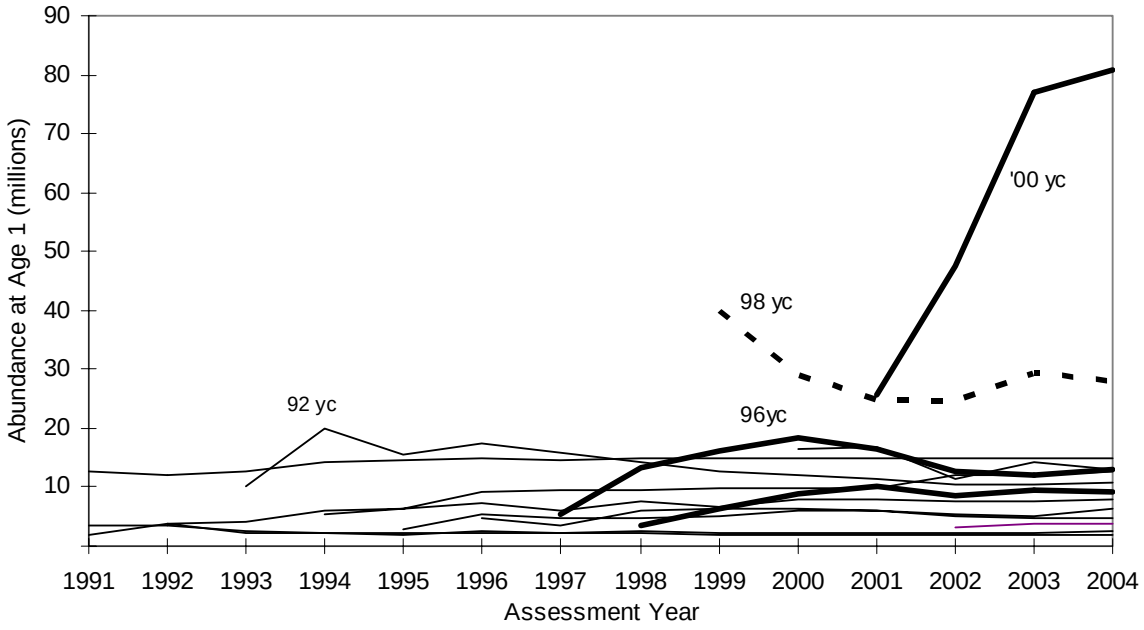

Figure 25. Successive estimates of 5Zjm haddock year-class abundance as additional years of data were included in the assessment did not display any persistent trends.

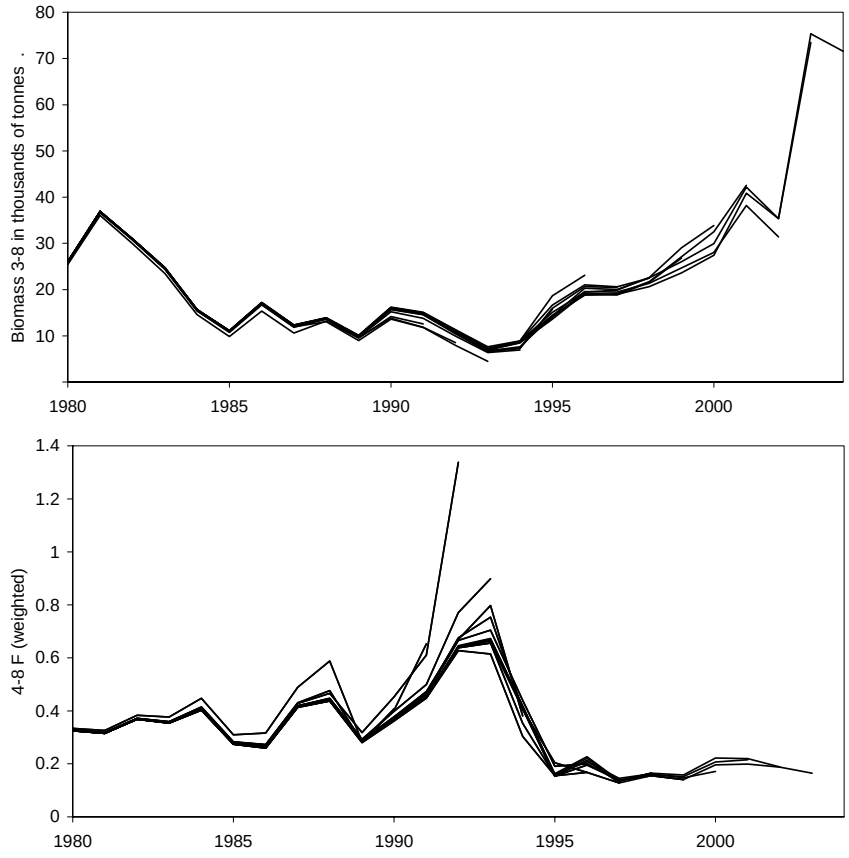

Figure 26. Retrospective estimates from VPA of 5Zjm haddock biomass and fishing mortality did not display any persistent trends for over or under estimation as successive years of data were excluded in the assessment.

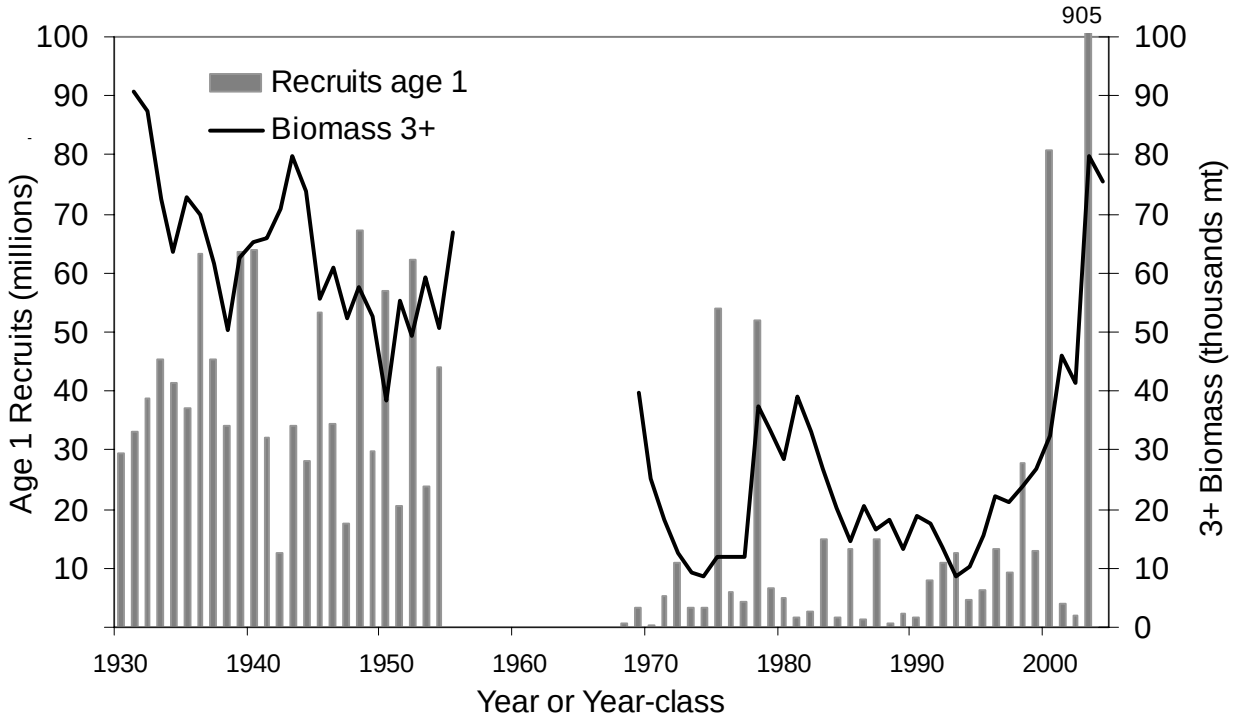

Figure 27. Beginning of year adult (3+) biomass and number of age 1 recruits for haddock in unit areas 5Zjm during 1931-1955 and 1969-2004.

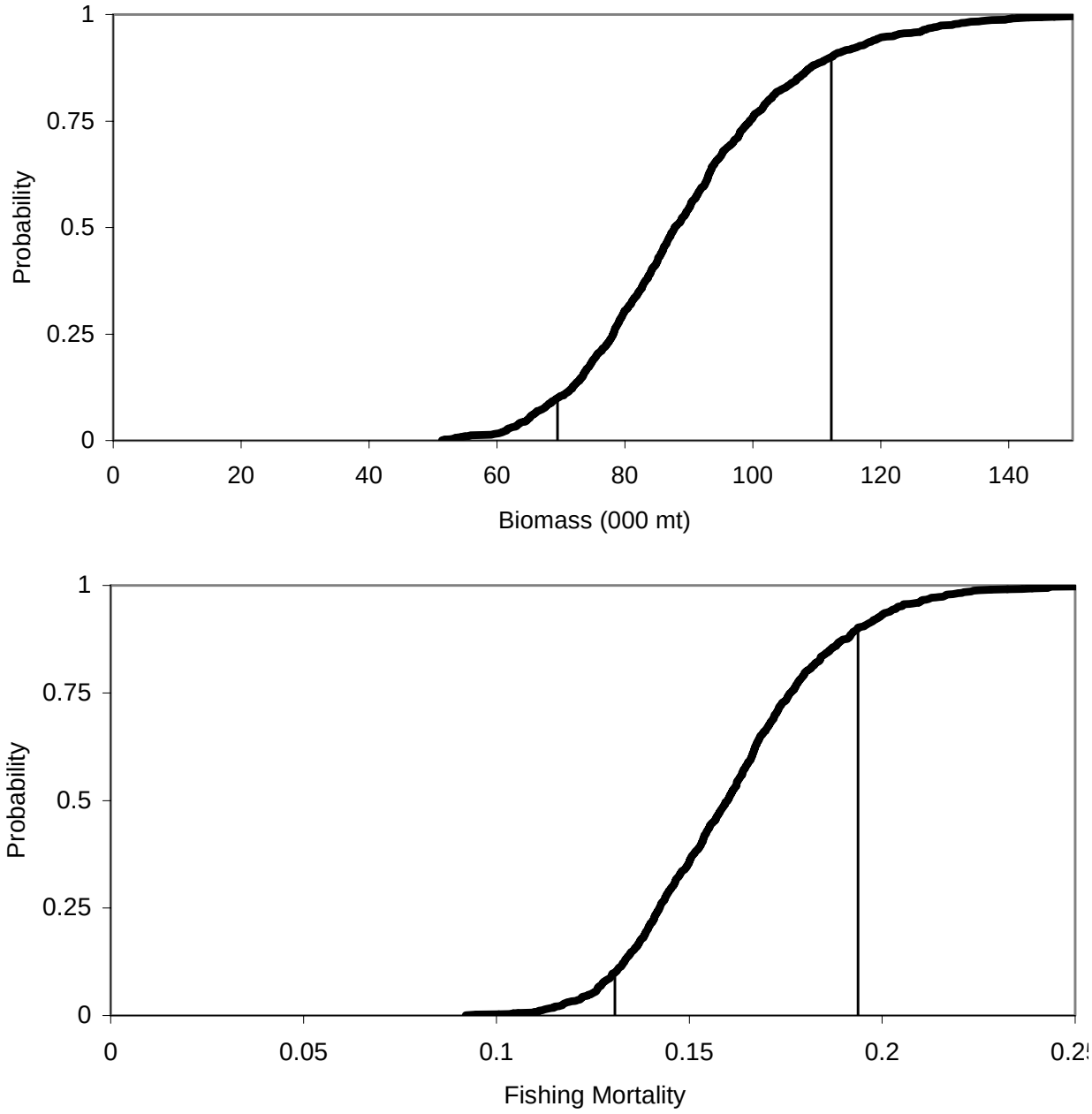

Figure 28. Confidence distribution with 80% confidence intervals for 2004 5Zjm haddock ages 3+ biomass (000 mt) and 2003 ages 4+ fishing mortality.

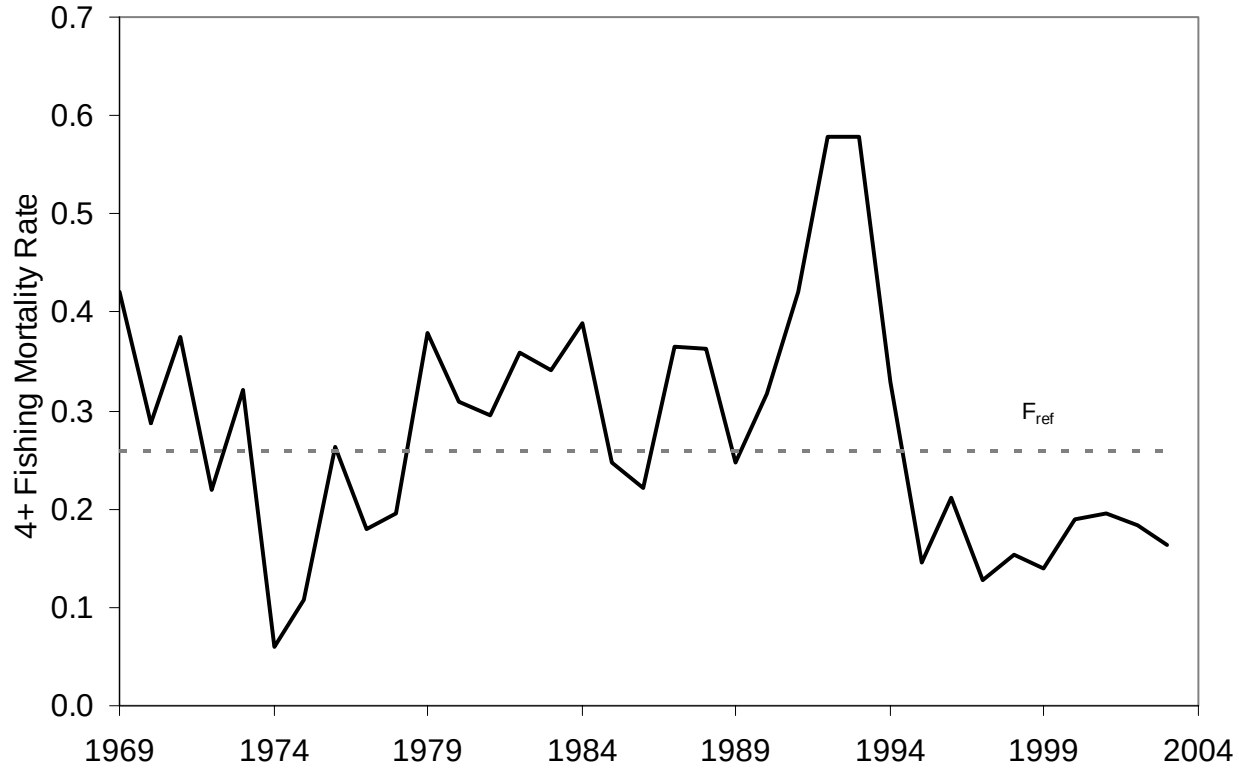

Figure 29. Fishing mortality rate for haddock ages 4+ in unit areas 5Zjm and the fishing mortality threshold reference established at F_{ref} = 0.26 during 1969-2003.

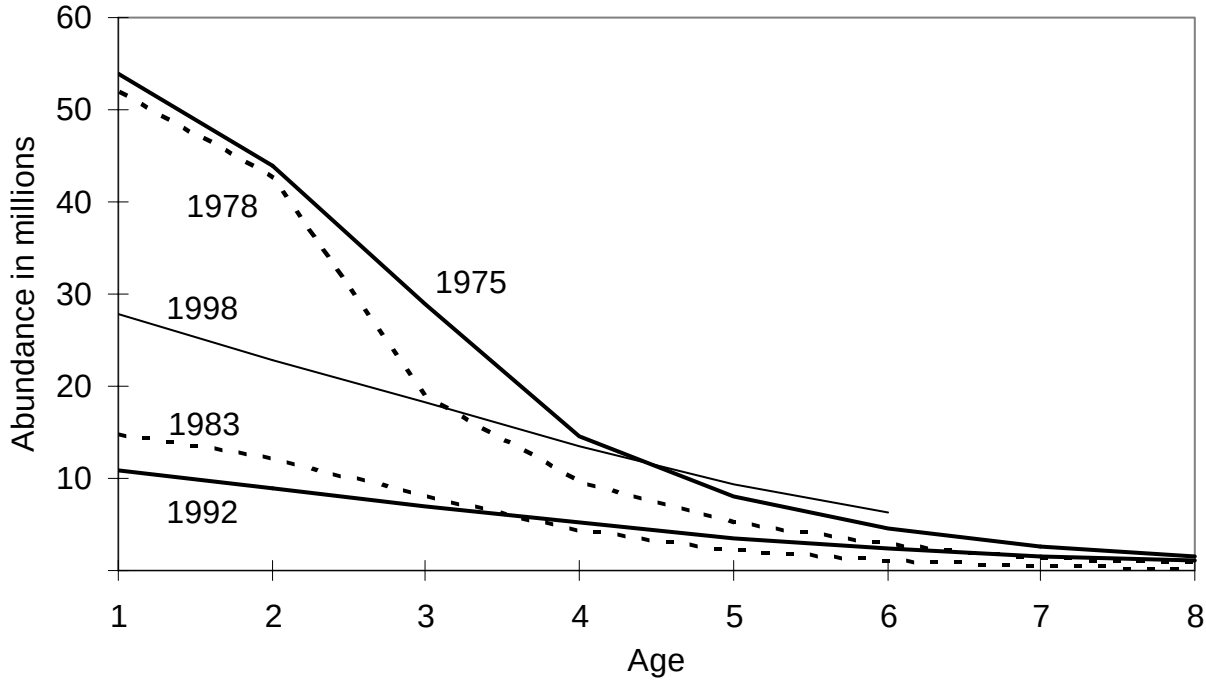

Figure 30. Decline in abundance of selected year-classes of the 5Zjm haddock population.

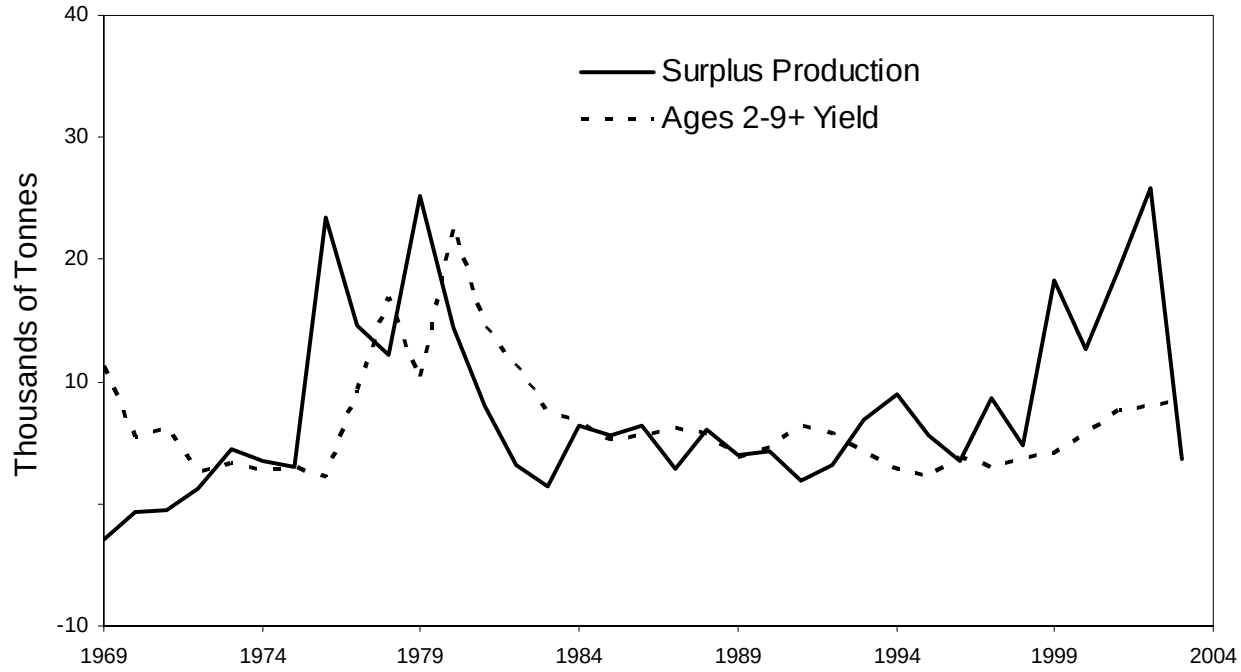

Figure 31. Surplus production of 5Zjm haddock available to the commercial fishery compared to the harvested yield during 1969-2003.

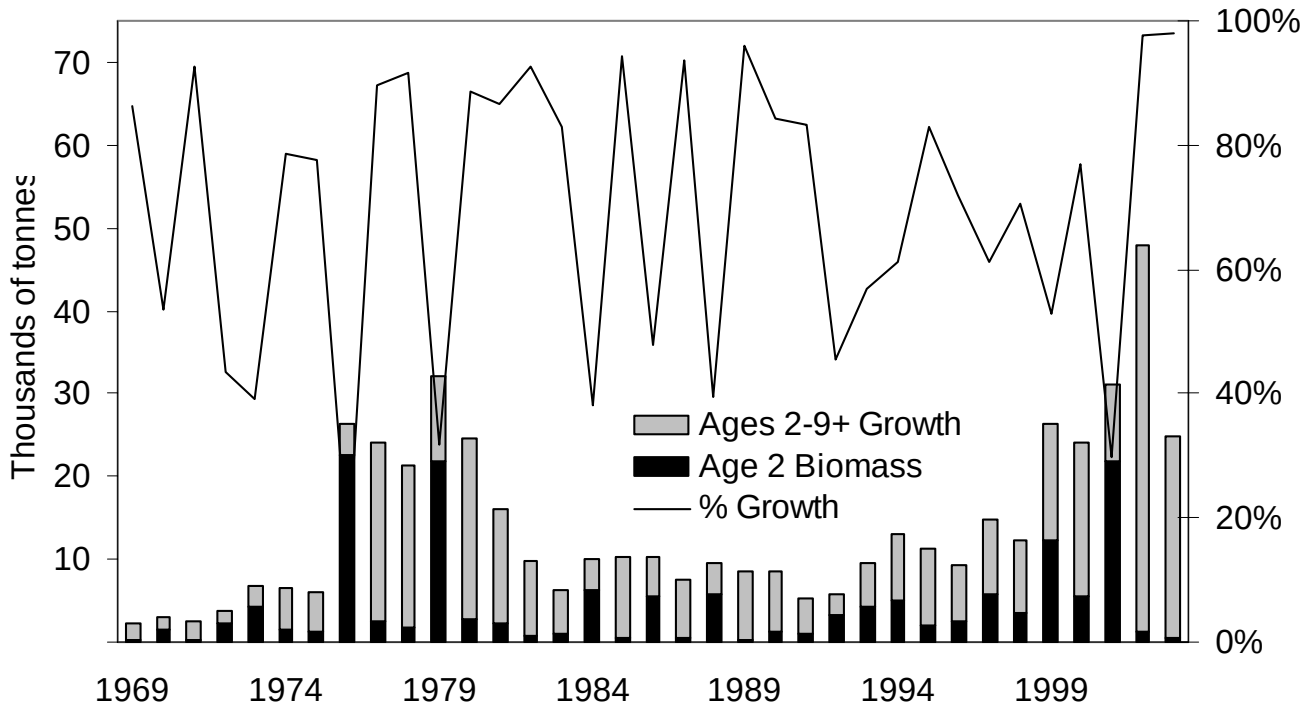

Figure 32. Amount of productivity attributible to growth (ages 2 to 9+) of 5Zjm haddock and the amount contributed by recruitment (age 2) during 1969-2003.

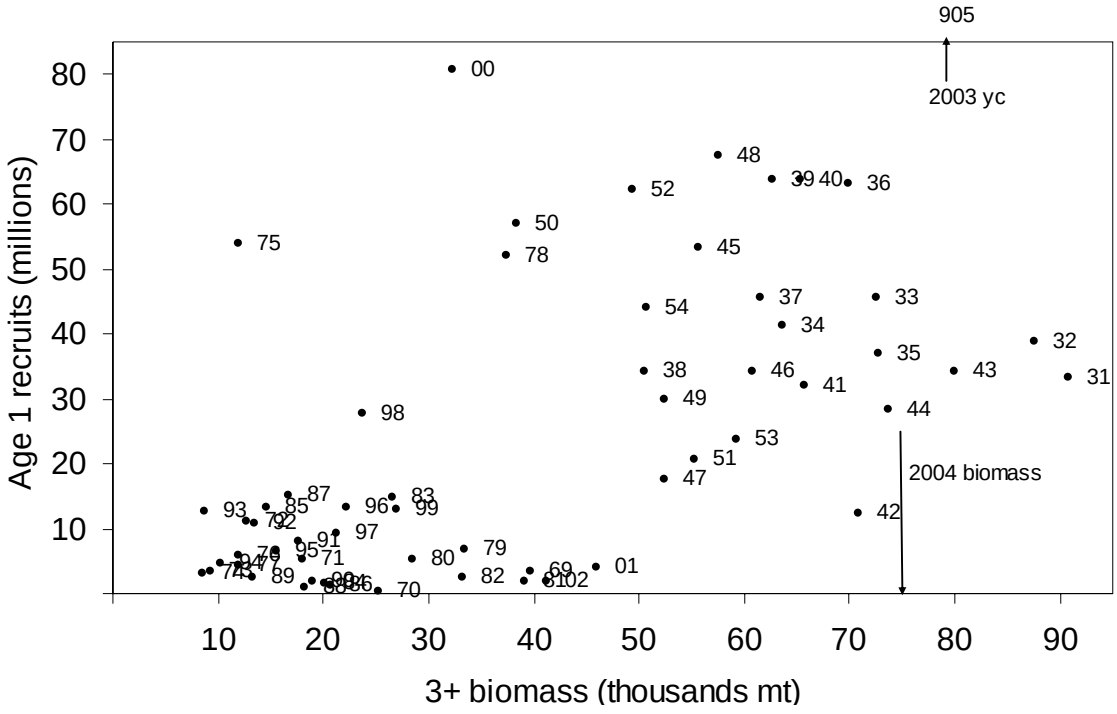

Figure 33. Relationship between adult (ages 3+) 5Zjm haddock biomass and recruits at age during 1931-1955 and during 1969-2003.

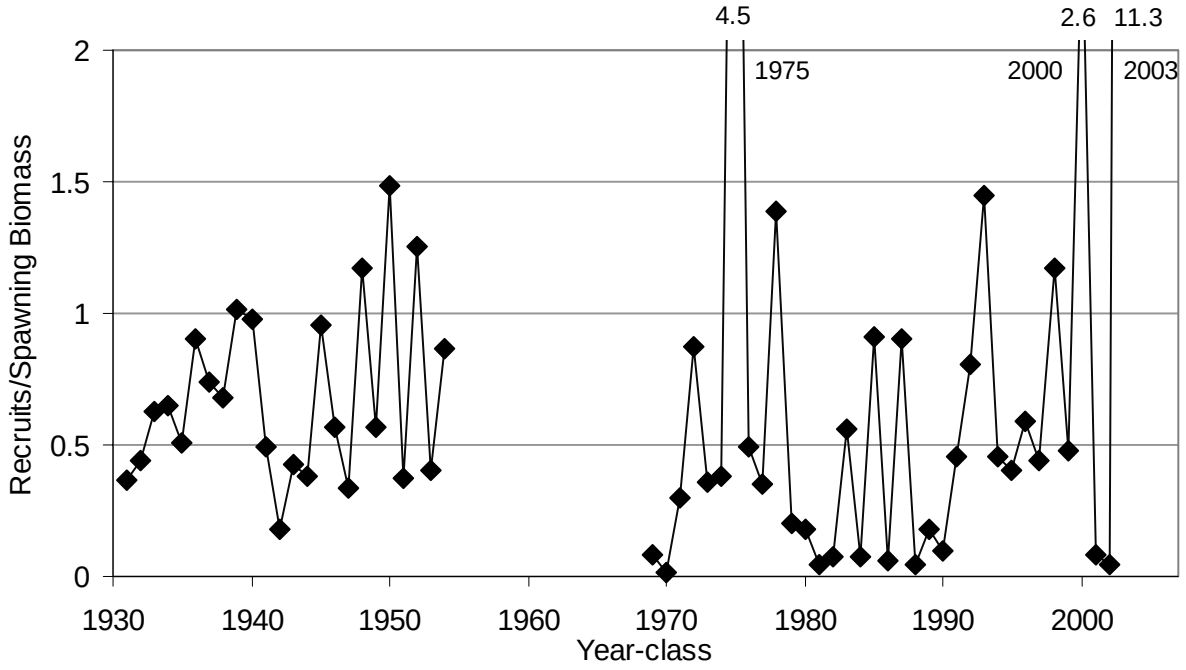

Figure 34. Ratio of recruits (numbers at age 1) to spawning biomass (kg) for 5Zjm haddock during 1931-1955 and during 1969-2003.

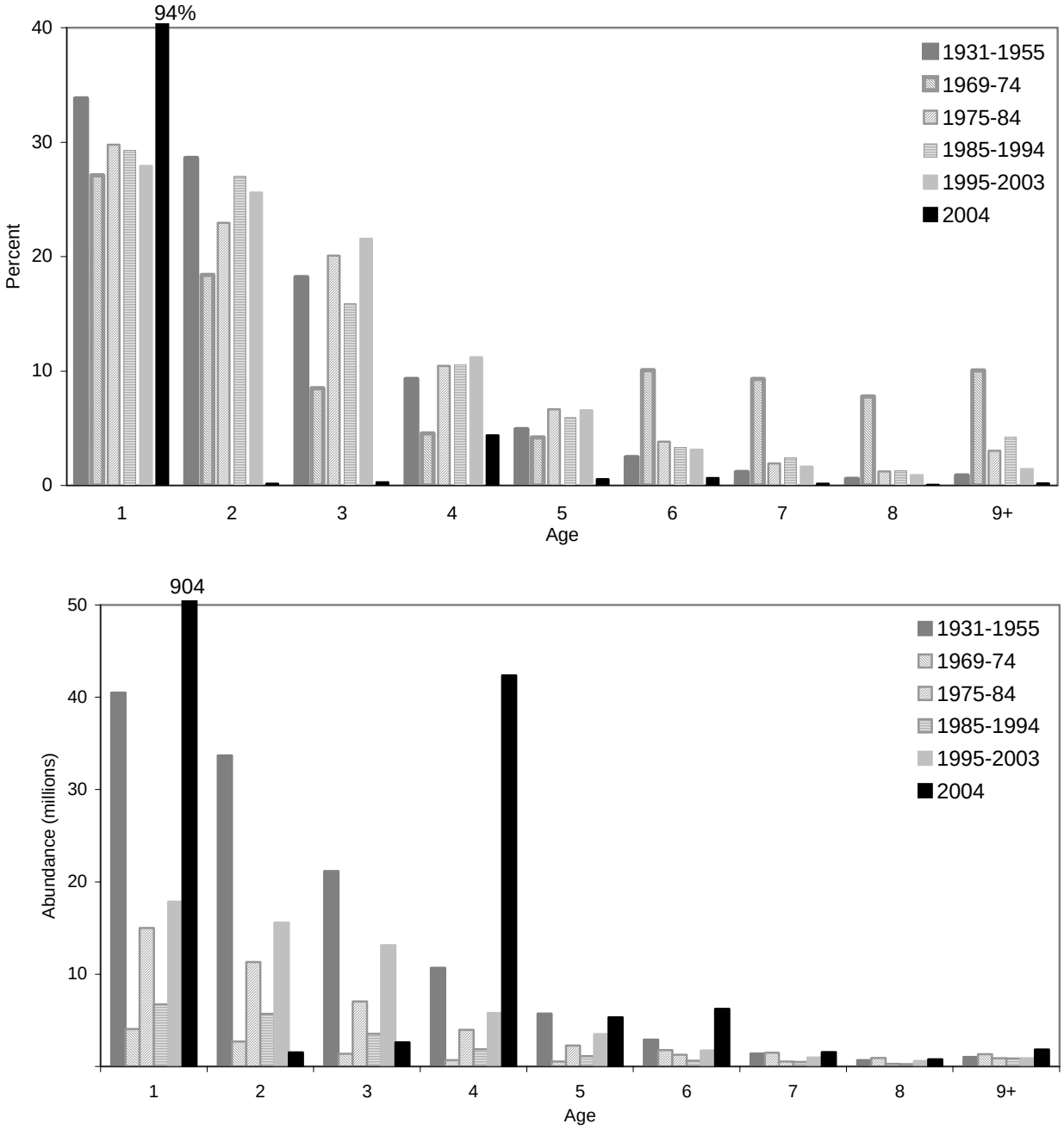

Figure 35. The age composition and absolute abundance at age of the 5Zjm haddock population in 2004 compared to averages during 1931-1955, 1969-1974, 1975-1984, 1985-1994, and 1995-2003.

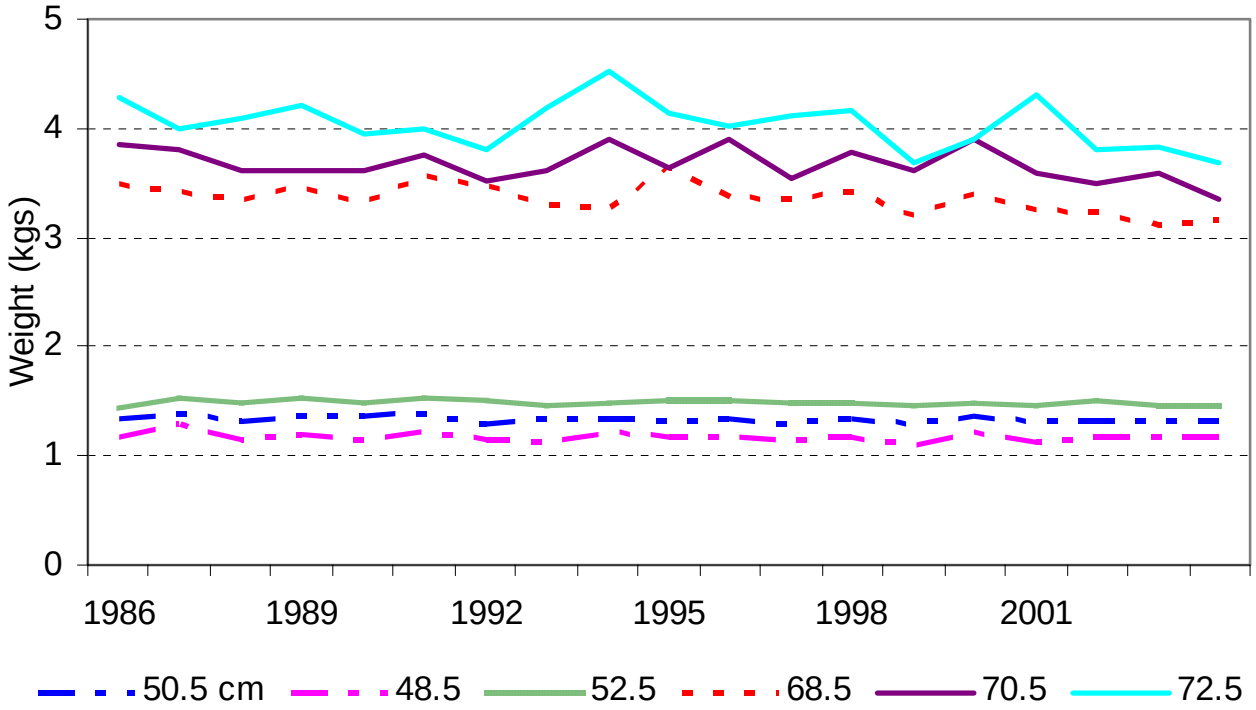

Figure 36. Weights at lengths for haddock in 5Zjm for six 2 cm length groupings during 1986-2004.

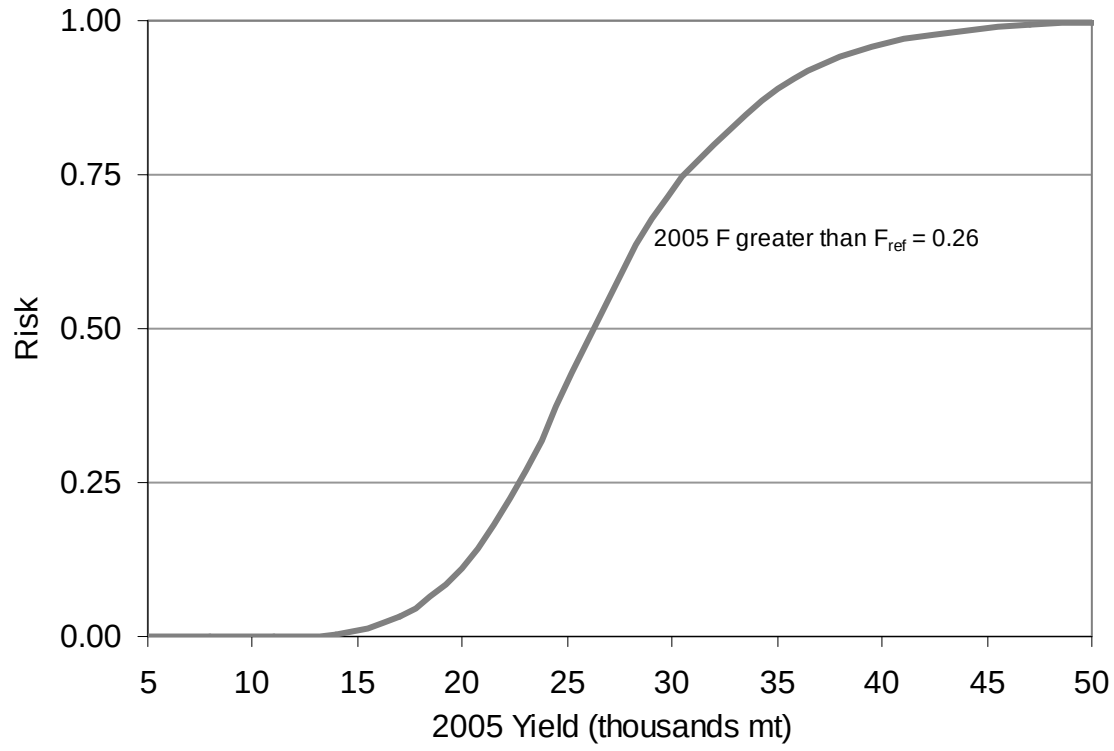

Figure 37. Risk of 2005 fishing mortality exceeding F_{ref} = 0.26 for 5Zjm haddock for catch quotas ranging from 5,000 mt to 50,000 mt.

Appendix A

Estimation of haddock discards from the Canadian scallop fishery for 1996 to 2003

Management measures established in 1996 prohibited the landing of groundfish (except monkfish) by the Canadian scallop fishery. No records of discards from this fishery are available. The only data available to estimate haddock discards is from a limited number of observed trips. The approach used to estimate discards was to prorate the observed haddock catch per unit of effort (CPUE) to the total effort by the fleet.

In 1994, 1995 and 1998 there were 8 monitored trips which were used to estimate discards for 1996 to 2000. These trips took place in January, March and June and were designated as occurring either in 5Zj or 5Zm (Table A1). The catch and effort data could be disaggregated to area and, since haddock show seasonal migrations and are not distributed homogenously thoughout the fishing area, it was considered appropriate to calculate haddock bycatch rates by area, although the data were far from satisfactory in their ability to discern area differences. As temporal coverage was limited to 3 months in the first half of the year, it was not possible to calculate the haddock CPUE on a monthly or quarterly basis. Also, the data precluded the calculation of yearly CPUE estimates so two, area specific CPUEs were calculated by dividing the sum of the haddock catches by the sum of the effort for each area from all observed trips. The resultant annual CPUEs for 5Zj and 5Zm were used with annual area specific scallop fishery effort data (pers. com. Ginette Robert 2004) to estimate the annual total haddock bycatch for 1996 to 2000 (Table A2). Estimated bycatch rates for 5Zj were considerably higher than for 5Zm but total haddock bycatch was very low and was in the range of 21 to 54 mt per year based on the calculations described above. Subsequent to the review of this data by the Transboundary Resource Assessment Committee it was noted that the reported haddock catch for monitored trips was only for observed tows while the effort was for the entire trip (generally about 80% of tows might be observed), therefore the discard estimates should be adjusted upward in future. Since set location is available, and trips may fish in both areas, the subsequent revisions will be done using detailed set by set information.

In response to a Fisheries Resource Conservation Council recommendation, a monitoring program was conducted by the Canadian offshore scallop industry in 2001 and 2002 to gather data on bycatches of yellowtail flounder and monkfish. Additionally, bycatches of cod, haddock and pollock were also documented. The haddock bycatch estimates from these trips were used to estimate haddock bycatch for 2001 to 2003. Twelve trips were observed which covered all months except January and October (Table A3). One trip was exclude from the analysis as no effort data were available for this trip. Although some area information was available for these trips, examination of the positional data showed that most of the effort occurred in or very close to 5Zj and, since the haddock bycatch from the observed trips was not available by area, area specific CPUE was not derived. The haddock bycatch from observed sets was prorated upward to account for all sets and the CPUE was calculated by quarter (Table A3). The resulting quarterly CPUEs (sum of haddock catches per quarter divided by sum of effort per quarter) were then applied to the total quarterly effort of the scallop fleet. Total haddock discards for 2001 to 2003 were estimated to be 50, 36 and 78 mt, respectively (Table A4).

The 7 to 9 mt of haddock bycatch, depending upon which method was used, estimated for May to December 2001 by Kenchington (2002), which pro-rates to 11.6 to 14.0 mt for the whole year, is substantially lower than the estimates reported here. The difference in bycatch is due to several factors. The Kenchington estimates use only the 2001 observed trips. The use of the additional data from the 3 trips observed in 2002 increases the average bycatch per trip by almost double. The quarter 1 catch rates were comparable to the quarter 4 catch rates which were substantially greater than quarters 2 and 3 (Table B3). Bycatch for quarter 1 is not

included in the Kenchington report and prorating using the average bycatch rate for May to December produces lower values than when prorating using the higher quarter 1 rate obtained from the 2002 observed trips. The Kenchington estimates were obtained by prorating using trip as the effort measure or they were prorated using the scallop landings. The results presented here were prorated using hours as the effort measure. The average total trip effort in hours for the observed trips was substantially less than the average for the unobserved trips. The May to December trips were about 30% longer while the January to April trips were almost double. This difference in trip length results in the observed bycatch rate being applied to a substantially greater number of hours for the method presented here. A final factor is that the Kenchington estimate is for scallop management zone 'a' only while this estimate includes zone 'b' as well. Scallop fishing effort in zone 'b' in 2001 occurred from January to June and appears to be substantial (DFO 20002).

Literature Cited

DFO, 2002. Georges Bank scallop. DFO Science Stock Status Report C3-17 (2002).

Kenchington, T.J. 2002. Finfish bycatch I the offshore scallop fishery: analysis of 2001 observer data. Prepared by "Gadus Associates: for the Offshore Scallop Operators Group. 18 p.

Table A 1. Catch, effort and haddock bycatch CUPE from observed 5Zjm scallop fishery trips used to estimate total haddock discards from the Canadian scallop fishery in 1996 to 2000 (effort data: personal communication, Ginette Robert).

Year	Month	Haddock catch (mt)	Total Trip Effort (hrs)	Area	Haddock CPUE (mt/hr)
1994	Mar	0.050	138	5Zm	0.000362
1994	Mar	0.068	127	5Zm	0.000535
1994	Mar	0.079	106	5Zm	0.000745
1995	Mar	0.099	130	5Zm	0.000762
Total 5Zm		**0.296**	**501**		**0.000591**
1995	Jan	0.201	143	5Zj	0.001406
1995	Mar	0.072	120	5Zj	0.000600
1995	Mar	0.231	127	5Zj	0.001819
1998	June	0.050	132	5Zj	0.000379
Total 5Zj		**0.554**	**522**		**0.001061**

Table A 2. Haddock discards from the Canadian 5Zjm scallop fishery estimated from catch per unit effort (CPUE) by unit area for 1996 to 2000 (effort data: personal communication, Ginette Robert).

Year	Effort (hrs)		Haddock Discards (mt)		Haddock Discards (mt)
	5Zj	5Zm	5Zj	5Zm	Total
1996	29468	2429	31.275	1.435	32.710
1997	32759	2076	34.767	1.227	35.994
1998	47278	7142	50.176	4.219	54.395
1999	28957	4117	30.732	2.432	33.164
2000	17463	4562	18.534	2.695	21.229

Table A 3. Calculation of the Canadian 5Zjm scallop fishery haddock bycatch CPUE by quarter from 11 trips observed in 2001 and 2002. The "observed" data is from the subset of tows which the observer actually examined. The observed catch was pro-rated to the total number of sets for the trip and the total trip effort applied to the estimated total haddock catch to obtain haddock bycatch rates for 2001 to 2003.

Month	Year	Observed sets (%)	Haddock catch (mt)		Effort (hrs)	Haddock CPUE mt/hr
			Observed	Pro-rated		
Feb	2002	0.87	0.193	0.223	43	0.005189
Mar	2002	0.76	0.025	0.033	39	0.000843
Quarter 1				**0.256**	**82**	**0.003122**
Apr	2002	0.77	0.089	0.116	120	0.000963
May	2001	0.72	0.028	0.039	33	0.001178
June	2001	0.84	0.006	0.007	124	0.000058
Quarter 2				**0.162**	**277**	**0.000583**
July	2001	0.86	0.025	0.029	125	0.000233
August	2001	0.81	0.003	0.004	108	0.000034
August	2001	0.86	0.012	0.014	68	0.000205
Sept	2001	0.76	0.004	0.005	47	0.000112
Quarter 3				**0.052**	**348**	**0.000149**
Nov	2001	0.82	0.088	0.107	16	0.006707
Dec	2001	0.84	0.053	0.063	33	0.001912
Quarter 4				**0.170**	**49**	**0.003478**

Table A 4. Haddock discards from the Canadian 5Zjm scallop fishery for 2001 to 2003 by quarter using data from 11 scallop fishing trips observed in 2001 and 2002. Haddock bycatch rates estimated from the observed trips were applied to the total scallop fishery effort (effort data: personal communication, Ginette Robert) per quarter for 2001 to 2003.

	2001		2002		2003	
Quarter	Effort (hrs)	Discards (mt)	Effort (hrs)	Discards (mt)	Effort (hrs)	Discards (mt)
Q1	7453	23.269	3311	10.337	7797	24.343
Q2	14415	8.411	9878	5.763	15645	9.128
Q3	9909	1.480	4610	0.689	15647	2.338
Q4	4882	16.979	5392	18.752	12188	42.387
Totals	**36660**	**50.139**	**23191**	**35.542**	**51277**	**78.197**

Appendix B

Intra and inter reader ageing tests

Table B1. Intra-reader ageing agreement matrices for the DFO haddock ager, L. Van Eeckhaute (LVE), using haddock ageing material from the 2003 DFO survey and the 2002 Canadian Fishery in 5Zjm.

NED2003002 LVE vs LVE		Second Reading												
		1	2	3	4	5	6	7	8	9	10	11	Null	Total
Production Age	1	10												10
	2		5											5
	3			12										12
	4				2									2
	5			1		5							1	7
	6						1							1
	7							2						2
	8						1		1					2
	9									3				3
	10										2			2
	11											1		1
	Null						1	1					1	3
	Total	10	5	13	2	5	3	3	1	3	2	1	2	50
Percent agreement (excluding nulls) = 44 / 46 = 95 %														

Fishery 2002 LVE vs LVE		Second Reading													
		1	2	3	4	5	6	7	8	9	10	11	12	15	Total
Production Age	1	1													1
	2		12	2											14
	3			1											1
	4				5					1*					6
	5					3									3
	6						7								7
	7							1							1
	8								2						2
	9									4					4
	10										6				6
	11											2	1		3
	12												1		1
	13													1	1
	Total	1	12	3	5	3	7	1	2	5	6	2	2	1	50
Percent agreement = 45 / 50 = 90 %														* wrong otolith read	

Table B2. Summary of NMFS intra-reader ageing tests for 5Z haddock by S. Sutherland.

Source Material	Number aged	% Agreement	CV	Comments
NMFS 5Z Surveys				
Fall 200306	48	96	0.75	Dominated by 2003 year class
Spring 200402	50	84	3.67	Tendency to underage in 2nd reading
2003 USA Commercial Fishery				
Q1	34	82	2.20	Tendency to underage in 2nd reading
Q2	40	88	1.71	Tendency to underage in 2nd reading
Q3	33	76	2.58	
Q4	35	89	1.71	

Table B3. Intra-reader ageing agreement matrices for the NMFS haddock ager, S. Sutherland (SJS), using haddock ageing material from the 5Z NMFS 2003 fall and 2004 spring surveys and the 2003 USA fishery in 5Z. Tests using commercial fishery material were performed on a quarterly basis and are combined below.

2003 USA Commercial Fishery

		NMFS Test Age (SJS)												
		0	1	2	3	4	5	6	7	8	9	10	11	Total
Reference Age	0													
	1													
	2													
	3			1	7									8
	4				1	2	1							4
	5					3	53	2						58
	6						3	7						10
	7						1	3	13					17
	8									15	2			17
	9									2	11			13
	10										2	8	1	11
	11										1		3	4
	Total			1	8	5	58	12	13	17	16	8	4	142

Percent agreement = 119 / 142 = 84% Slightly biased towards underaging.

Table B3. (Continued.)

NMFS 2003 Fall Survey														
		NMFS Test Age (SJS)												
		0	1	2	3	4	5	6	7	8	9	10	11	Total
Reference Age	0	13												13
	1		2											2
	2			2										2
	3				13	1								14
	4					6	1							7
	5						5							5
	6													
	7								2					2
	8													
	9													
	10											1		1
	11												2	2
	Total	13	2	2	13	7	6		2			1	2	48
Percent agreement = 46 / 48 = 96%														

NMFS 2004 Spring Survey									
		NMFS Test Age (SJS)							
		0	1	2	3	4	5	6	Total
Reference Age	0	6							6
	1		16						16
	2			4					4
	3			1	10				11
	4				2	2			4
	5				2	2	4		8
	6						1		1
	Total	6	16	5	14	4	5		50
Percent agreement = 42 / 50 = 84% Biased towards underaging.									

Table B4. Inter-reader ageing agreement matrix for the DFO hadock ager, L. Van Eeckhaute (LVE), and the NMFS haddock ager, Sandy Sutherland (SJS), using haddock ageing material from the 2003 DFO and NMFS spring surveys and the 2002 Canadian fishery.

2003 DFO Survey & 2002 Canadian Fishery: SJS vs LVE

		DFO LVE														
		1	2	3	4	5	6	7	8	9	10	11	12	15	Total	OMIT
NMFS SJS	1	8													8	
	2	3	17	2											22	
	3			13											13	
	4				4										4	
	5			1	2	6									9	2
	6					2	8			1					11	
	7						2	2							4	
	8							2	3						5	
	9									5					5	
	10									1	8		1		10	
	11									1		2			3	
	12											1	1		2	
	Total	11	17	16	6	8	10	4	3	8	8	3	2	0	96	
	OMIT				1									1		

Percent agreement = 77 / 96 = 80% (with a bias)

2003 NMFS Spring Survey: SJS vs LVE

		DFO LVE														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
NMFS SJS	1	5														5
	2		6													6
	3			17												17
	4			1	2	1										4
	5					7	2									9
	6						2	1								3
	7							1	1							2
	8															0
	9															0
	10										1					1
	11											2				2
	12															0
	13															0
	14													1		1
	Total	5	6	18	2	8	4	2	1	0	1	2	0	1	0	50

Percent agreement = 43 / 50 = 86% (slight bias)