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Assessment of Haddock on Eastern Georges Bank

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ABSTRACT

Haddock catches from eastern Georges Bank fluctuated around 5,000 t from early 1980s to 1993. Under restrictive management measures, catches declined to a low of 1,1000 t in 1995 and increased to 3,700 t in 1996. The 1991, 1992, and 1993 year-classes comprised about 87% of the 1996 fishery catch by weight. An increasing trend in survey adult abundance was observed from 1992 to 1996. Survey indices indicate that the 1992 year-class was the strongest since the 1983, 1985, and 1987 year-classes but abundance of the 1994-96 year-classes is low.

The adaptive framework was used to calibrate the sequential population analysis to the research survey trends. Since 1993, the biomass has steadily increased to about 24,000 t in 1996 and declined slightly to 23,000 t in 1997. The recent increase was enhanced by increased survivorship of young haddock from reduced capture of small fish in the fisheries. The abundance of the 1992 year-class was estimated at about 15 million, comparable to the 1983, 1985, and 1987 year-classes. The 1991 and 1993 year classes were estimated at about 7 and 10 million respectively, while the incoming 1994, 1995, and 1996 year-classes appear relatively weak at about 5 million. The exploitation rate declined in 1994 and again in 1995 reaching a level below the $F_{0.1}$ target where it remained for 1996.

Combined Canada/U.S.A. projected yield at $F_{0.1} = 0.28$ in 1997 would be about 6,300 t. If fished at $F_{0.1}$ in 1997, the biomass for ages 3 and older is projected to decrease slightly from 20,500 t to about 19,250 t at the beginning of 1998. The 1992 year-class would comprise about one-quarter of age 3+ biomass and almost half the forecast yield. A risk analysis showed that a combined Canada/U.S.A. yield of 4,000 t in 1997, about what was caught in 1996, decreases the chance that the $F_{0.1}$ is exceeded to less that 10% and increases the chances that the biomass for ages 3 and older will increase between 1997 and 1998 to about 70%.

RÉSUMÉ

Du début des années 80 à 1993, les prises d'aiglefin dans le secteur est du banc Georges ont atteint dans les 5 000 t. Suite à l'application de mesures de gestion rigoureuses, elles ont chuté à 2 100 t en 1995, pour ensuite remonté à 3 700 t en 1996. Les classes de 1991, 1992 et 1993 représentaient, en poids, environ 87 % des prises de 1996. Les relevés effectués de 1992 à 1996 ont montré une tendance à la hausse de l'abondance des adultes. Les indices ainsi obtenus indiquent que la classe de 1992 était la plus abondante depuis celles des années 1983, 1985 et 1987, et que l'abondance des classes de 1994 à 1996 était faible.

On a utilisé le cadre adaptif pour étalonner l'analyse de population séquentielle en fonction des tendances des relevés de recherche. À partir de 1993, la biomasse a régulièrement augmenté, atteignant environ 24 000 t en 1996, puis a légèrement diminué à 23 000 t en 1997. La récente augmentation est le résultat d'un taux accru de survie des jeunes aiglefins, moins soumis à la pêche. L'abondance de la classe de 1992 a été estimée à environ 15 millions d'individus, ce qui se compare aux classes de 1983, 1985 et 1987. L'abondance estimative des classes de 1991 et 1993 s'élève à environ 7 millions et 10 millions d'individus, respectivement, tandis que l'abondance des classes de 1994, 1995 et 1996, en voie d'être recrutées à la pêche, semble relativement faible, n'atteignant que 5 millions d'individus environ. Le taux d'exploitation a diminué en 1994 et en 1995, se situant à un niveau inférieur à la cible de $F_{0,1}$, où il est demeuré en 1996.

Le rendement prévu combiné Canada-États-Unis à $F_{0,1} = 0,28$ s'élèverait à environ 6 300 t. Si elle est pêchée à $F_{0,1}$ en 1997, la biomasse d'aiglefin de 3 ans et plus devrait en principe diminuer légèrement pour passer de 20 500 t à environ 19 250 t au début de 1998. La classe de 1992 constituerait environ 25 % de la biomasse d'aiglefin de 3 ans et plus et presque la moitié du rendement prévu. Une analyse des risques a révélé qu'un rendement combiné Canada-États-Unis de 4 000 t en 1997, soit environ la quantité récoltée en 1996, réduirait à moins de 10 % les chances que le $F_{0,1}$ soit dépassé et accroîterait les chances que la biomasse d'aiglefin de 3 ans et plus augmenterait de 1997 à 1998 à environ 70 %.

DESCRIPTION OF THE FISHERY

The haddock on Georges Bank have supported a commercial fishery since the early 1920's (Clark et al. 1982). Since 1990 Canada has used eastern Georges Bank, fishery statistical units 5Zj and 5Zm (Fig. 1), as the basis for a management unit. Record high landings were reported in the 1960s, reaching about 60,000t. Catches dropped rapidly to 2,600t by 1972 and subsequently increased to a high of 25,000t in 1980. Since then, catches have declined to a low of 2,100t in 1995 and increased to 3,700t in 1996 (Table 1, Fig. 2).

The predominantly USA fishery was joined by Canadian and distant water fleets notably the USSR and Spain by the early 1960s. In 1953, the International Commission for the Northwest Atlantic Fisheries (ICNAF) implemented a minimum mesh size of 114 mm in the body and codend of towed gear. A Total Allowable Catch was introduced in 1970 by ICNAF in an attempt to curb rapidly declining abundance. Seasonal closures of haddock spawning areas were also instituted in that year as an adjunct and have been retained by Canada and the USA (Halliday 1988). Both the season and the area closed have gone through several modifications. Following the declaration of economic zones to 200 mi by coastal states in 1977, only Canada and the USA continued haddock fisheries on Georges Bank. After the establishment of a maritime boundary in 1984 by the International Court of Justice, the Canadian and USA fisheries have been restricted to their respective jurisdictions. Canada has retained a quota regulatory system and uses ancillary measures to augment management. Fishermen now pay for access to the fishery, for dockside monitoring and contribute to the costs of at sea observer coverage. The USA has not regulated catch by quotas since 1977 but has relied on other measures (area closures, trip limits, fish size, etc.) and has recently instituted an effort regulatory system. Further details of regulatory measures since 1977 are summarized in Table 2.

Under increasingly restrictive management, total Canadian landings decreased from about 3,700t in 1993 to about 2,400t in 1995 and increased in 1996 to 3,600t. Most fishery sectors in 1995 and 1996 did not catch their haddock quota as the fishery was closed when the cod quota was reached. Prior to 1994, allocations to fishery sectors in recent years have either been exceeded or have not been restrictive.

Fishery Sector	1992		1993		1994		1995		1996	
	Quota	Catch	Quota	Catch	Quota	Catch	Quota	Catch	Quota	Catch
Fixed gear <65'	1185	1377	1508	1216	791	784	592	357	1085	919
Mobile gear <65'	2535	1704	2212	1646	1439	1206	1268	1175	2280	1713
Fixed gear 65'-100'	50	5	50	8	30	8	25	0	45	49
Mobile gear 65'-100'	50	55	32	32	30	33	25	27	189	181
Vessels >100'	1180	853	1198	826	710	290	590	444	921	513
Totals	5000	3994	5000	3728	3000	2411	2500	2003	4500	3375

Catches are from quota reports and may not correspond exactly with statistics.

The majority of the catch is taken by otter trawlers and longliners which are less than 65 ft. Landings by both gear sectors declined from 1992 to 1995 and increased in 1996 (Table 3). For 1995 and 1996, vessels on individual quotas were not eligible to depart for a trip on Georges Bank with less than 2t of cod and 8t of haddock quota remaining. Since 1994, fixed gear vessels have been required to choose between and designate either Georges Bank or Division 4X for their fishery during June to September. A small fish protocol (fisheries would be closed if an unacceptably high proportion of the catch was comprised of small fish) with increased at-sea monitoring was also implemented during 1994 to protect incoming recruitment and has been continued. The level of at sea monitoring was further increased in 1996 and about 20% of all fishing activity was monitored. Since 1994,the traditional spawning closure during March 1 to May 31 has included January and February. Prior to that substantial catches were taken during January and February (Table 4). Landings in recent years have generally peaked during June. Dragger fishermen reported that in an effort to avoid cod in 1996, a large portion of their effort was in June and December when haddock were more abundant on the bank. Discarding and mis-reporting was considered to be limited, especially since 1992, after the introduction of dockside monitoring, mandatory 130 mm square mesh for draggers and elimination of conditions of license to fish in either Divisions 4X or 5Z.

The USA fishery is almost exclusively an otter trawl fishery, the majority of vessels being tonnage classes 3 and 4 (Table 5). Since 1985, the majority of USA landings have been taken in the first half of the year, peaking in June (Table 6). USA catches for 1994-96 were updated. Mandatory log books were introduced in 1994, replacing the existing interview system for obtaining catch and effort information. Prior to 1994, information on the catch quantity by market category was derived from reports of landings transactions submitted voluntarily by processors and dealers coupled with data on fishing effort and location obtained for a subset of trips through interviews. Beginning in 1994 a new mandatory reporting system was initiated and data on fishing effort and location were obtained from logbooks and coupled with dealer reports when possible. USA catches for 1995 and 1996 were significantly reduced as a result of an expansion of the seasonal spawning area closure to the south and west and an extension to the whole year since late 1994. Effort in the USA fishery was regulated using Days-at-Sea limits during 1996. Aiming to limit targeting of haddock, a 500 lb trip limit was implemented early in 1994, continued in 1995 and was raised to 1,000 lb in mid-1996. The trip limits resulted in a high discard rate, especially in 1994. USA landings and discards for 1994 to 1996 in 5Zj,m were estimated from dealer data and vessel trip reports at 291t, 40t and 76t respectively (pers. comm. R. Brown, NMFS).

CATCH AND WEIGHT AT AGE

The catch and weight at age for the commercial fishery from 1969 to 1995 from Gavaris and Van Eeckhaute (1996) were augmented with the 1996 catch at age for the Canadian fishery and the updated 1994 to 1996 catch at age for the USA fishery based on revised catch and sampling information The 1995 catch at age for the Canadian fishery was revised to exclude the longline survey length frequencies.

Catch and weight at age for 1996 were calculated by applying age length keys to length frequencies using the methods described by Gavaris and Gavaris (1983). Growth patterns of haddock do not appear to differ between the two unit areas 5Zj and 5Zm or between catches by gears participating in the fishery. Accordingly, age length samples were pooled to construct keys by quarter for each country where information was available. Length compositions of catches can vary between gears, therefore, length frequency samples were pooled within gears and applied to the respective landings before being aggregated to the level of age length keys. When landings occurred in a month-gear category for which samples were not available, suitable adjacent samples were used (Table 7). Survey samples were aged by 2 readers and intra and inter-reader tests were conducted. The commercial fishery samples were aged by only one reader and verified with intra-reader tests only. Examination of comparative interpretation of ages from otolith samples did not reveal any problematic inconsistencies (Annex A).

Sampling for length and age composition by at sea observers in 1996 substantially augmented the available port sampling of the Canadian fishery resulting in coverage of all principal gears and seasons (Fig. 3). Comparison of length frequencies from the 2 sources for comparable gear/season strata showed that the results were similar and there was no indication of discarding (Fig. 4), therefore samples from the two sources were pooled. The observer samples were obtained on a set by set basis and these were pooled to the trip level to make them compatible with port samples before being combined with them. The calculations were done using the length-weight relationship which was derived from commercial fishery samples (Waiwood and Neilson 1985) ; $weight(\text{kg round}) = 0.0000158 length(\text{cm})^{2.91612}$.

Length composition of the catch for the principal sectors in the 1996 Canadian fishery were fairly similar. The inshore and offshore otter trawl catches peaked at 52 cm and 54 cm, respectively, the longline catches peaked at 52 to 56 cm while the gillnet catches peaked at about 58 cm (Fig. 5).

With decreasing landings for the USA fishery, few samples were available and these were pooled and applied over broader season/area blocks than has been common practice in the past. Although the size and age composition of the USA fishery was not well characterized, this did not result in a high impact on the total catch at age because of the low USA catch levels.

Catch at age and weight at age by year for 1969-96 are summarized in Tables 8 and 9 and detailed quarterly results are given in Annex B. Ages 3, 4 and 5 made up 87% of the 1996 catch weight, with age 4, the 1992 year-class, contributing the most (Fig. 6). Reduced effort in recent years most likely accounted for increased survival of these year-classes. Few age 2 haddock were caught, in part due to the use of larger mesh (over 130 mm square in Canada and 152 mm diamond in USA) by otter trawlers and changing fishing practices by all sectors. Fishery weights at age exibited a downward trend in recent years. This pattern resulted largely from the presence of the 1989 and 1990 year-classes which had higher than average weights at age. Subsequent year-classes showed more characteristic average weights.

ABUNDANCE INDICES

Commercial Catch Rate

The catch and effort data from tonnage classes 2 and 3 otter trawlers and longliners for 1993 to 1996 were summarized (Fig. 7). Only those vessels which fished during 1994 and reported more than 1t of landings for the year were selected for inclusion in these comparisons. Further, only trips or sub-trips where gadoid (cod, haddock and pollock) catch was 90% or more of the total catch were included to avoid counting yellowtail or hake/cusk directed effort. For otter trawlers, the catch rate was computed as the catch per hour aggregated by month and tonnage class, while for longliners, the aggregate catch per trip was used since days fished were not available for 1994. The trends suggest that both otter trawl and longline catch rates increased progressively from 1993 to 1995 with 1996 values similar to 1995. Catch rates in June of 1995 and 1996 were very high and were corroborated by fishermen who reported that they were able to target haddock and avoid cod at this time of year. The catch rates did not increase in December in 1996 as they had in 1995, however. As in the past, catch rates from the commercial fishery were considered only for qualitative corroboration of results due to concern regarding comparability over years when fishing practices were changing.

Industry/Science Surveys

A survey of the Georges Bank area was completed by five longliners in July of 1995. In 1996 the survey was repeated but the same protocol was not followed, therefore trends were not comparable.

Research Surveys

Annual surveys have been conducted by the USA National Marine Fisheries Service (NMFS) in the spring since 1968 and in the fall since 1963 (Fig. 8) and by Canada Department of Fisheries and Oceans (DFO) in the spring since 1986 (Fig. 9). All surveys use a depth stratified random design covering depths to 100 fathoms. Two vessels, the *Albatross IV* and the *Delaware II* have participated in the NMFS survey series and a conversion coefficient of 0.82 has been calculated for the *Delaware II* to make it comparable to the *Albatross IV* (Table 10). In 1985, it was necessary to change the trawl doors used on the USA bottom trawl surveys from a BMV door to a polyvalent door. Experiments conducted to evaluate the impact of the door change on survey catchability resulted in a conversion coefficient of 1.49 to make BMV door catch results by number comparable to those obtained with the polyvalent door. Table 10 shows how the conversion factors to account for vessel and door changes were applied to the USA surveys as suggested by O'Brien and Brown (1996).

The distribution of haddock for 3 age groupings as observed from the three surveys are shown in Figs. 10, 11 and 12. The catches from the most recent surveys, 1996 for the NMFS and 1997 for DFO, are compared to the 1991 to 1995 long term averages (1992 to 1996 for the DFO survey). The general pattern is for larger catches of haddock on the northeast peak in spring but with some catches throughout the 5Zjm area while in the fall the distribution is almost exclusively on the northeast peak. Age 0 in the fall and age 1 in the spring are generally somewhat more widely distributed than the older aged fish and somewhat more prevalent on the southeast flank of the bank. The distribution of catches for the most recent surveys of each series is very similar to the distribution over the previous 5 year period though the NMFS spring 1996 distribution shows some larger catches further west than had been observed.

The percent of biomass, ages 3-8, on the Canadian side of 5Zjm from the three surveys was summarized for the most recent years:

	Spring		Fall
Year	DFO	NMFS	NMFS
1992	68	78	100
1993	67	43	99
1994	99	100	100
1995	98	62	100
1996	96	17	100
1997	92	N/A	N/A

During the NMFS fall survey almost all of the biomass occurred on the Canadian side. During the DFO spring survey, generally conducted in late February, most of the biomass was on the Canadian side though the percentage was lower in 1992 and 1993. During the NMFS spring survey, generally conducted in late March, the percentage on the Canadian side was typically lower but these results were very variable. The 1996 NMFS spring survey indicates that an unusually low percentage of the biomass was on the Canadian side, however, survey coverage on the Canadian side was very poor that year.

Abundance trends for ages 3-8 increased during the late 1970s after declining to their lowest in the early 1970s. Following a rapid decline in the early 1980s, abundance remained stable at relatively low levels through the mid to late 1980s before declining again in the early 1990s, approaching the lowest levels observed. An increasing trend was observed between 1992 and 1996 which was driven largely by the 1992 year-class (Tables 11-13, Fig. 13). This trend did not continue as recruitment since 1993 has been rather poor. Note that the fall surveys are graphed at the beginning of the subsequent year for the respective year-classes. Survey results for ages 1 and 2 identified the strong 1975 and 1978 year-classes and the moderate 1983, 1985, 1987 and 1992 year-classes. Recruitment since the 1993 year-class has been poor.

Abundance estimates for ages 1 to 4 from the 1995 fall NMFS survey increased substantially from the previous year's estimates of the same cohorts (Table 13). This may have resulted from the distribution of sampling locations as there were proportionately more sets in areas where abundance is higher, i.e. near the north and east edge of the bank. In 1996, the estimates for these cohorts were down substantially.

ESTIMATION OF STOCK PARAMETERS

The adaptive framework, ADAPT, (Gavaris 1988) was used to calibrate the sequential population analysis with the research survey abundance trend results. The model formulation employed assumed that the error in the catch at age was negligible. The error in the survey 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. A model formulation using as parameters the ln population abundance at the beginning of the year following the terminal year for which catch at age is available was considered (Gavaris 1993). The following model parameters were defined:

$\theta_{a,1997}$ = ln population abundance

for ages a = 1 to 8 at the beginning of year 1997

$\kappa_{s,a}$ = ln calibration constants

for each survey source s and relevant ages a.

ADAPT was used to solve for the parameters by minimizing the sum of squared differences between the ln observed abundance indices and the ln population abundance adjusted for catchability by the calibration constants. The objective function for minimization was defined as

$$\Psi_{s,a,t}(\theta,\kappa) = \sum_{s,a,t}\left(\ln I_{s,a,t} - \kappa_{s,a} + \ln N_{a,t}(\theta)\right)^2$$

for time t.

For convenience, the population abundance $N_{a,t}(\theta)$ is abbreviated by $N_{a,t}$. At the beginning of the year 1997, i.e. $t = 1997$, the population abundance was obtained directly from the parameter estimates, $N_{a,1997} = e^{\theta_{a,1997}}$. For all other times, the population abundance was computed using the virtual population analysis algorithm which incorporates the exponential decay model

$$N_{a+\Delta t,t+\Delta t} = N_{a,t}e^{-(F_{a,t}+M_a)\Delta t}.$$

Year was used as the unit of time, therefore ages were expessed as years and the fishing and natural mortality rates were annual instantaneous rates. The fishing mortality rate exerted during the time interval t to $t+\Delta t$, $F_{a,t}$, was obtained by solving the catch equation using a Newton-Raphson algorithm

$$C_{a,t} = \frac{F_{a,t}\Delta t N_{a,t}\left(1-e^{-(F_{a,t}+M_a)\Delta t}\right)}{\left(F_{a,t}+M_a\right)\Delta t}$$

for $C_{a,t}$ = the catch at age a during the time interval t to $t+\Delta t$.

The fishing mortality rate for age 8 in the last time interval of each year was assumed equal to the population weighted arithmetic average for ages 4 to 7 during that time interval,

$$F_{8,t} = \sum_{a=4}^{7} N_{a,t} F_{a,t} \Big/ \sum_{a=4}^{7} N_{a,t} .$$

The data used were quarterly catch at age (see Annex B for details),

$C_{a,t}$ = catch

for ages $a = 0,\ 1,\ 2 \ldots\ 8$ and for $t = 1969.0,\ 1969.25,\ 1969.5 \ldots\ 1996.75$

and bottom trawl survey abundance indices

$I_{s,a,t}$ = abundance index

for $s =$ DFO spring survey, ages $a = 1\ ,2 \ldots\ 8$, time $t = 1986.16,\ 1987.16 \ldots\ 1996.16,\ 1997.0$
$s =$ NMFS spring survey, ages $a = 1,\ 2 \ldots\ 8$, time $t = 1969.29\ ,1970.29 \ldots\ 1996.29$
$s =$ NMFS fall survey, ages $a = 0,\ 1 \ldots\ 5$, time $t = 1969.69,\ 1970.69\ \ldots\ 1996.69$

Since forecast projections were required for the entire year 1997, the DFO spring survey in 1997 was designated as occurring at time 1997.0 instead of 1997.16. NMFS fall survey indices for ages 6 and 7 were not included because of frequent occurrences of zero catches and the large variation in the relationships with population abundance. All other available data since 1968 were used except when the indices were 0 (logarithm not defined). During years when discarding was high, survey information was used along with interviews to obtain estimates of the USA catch. This lack of complete independence between catch and survey data does not influence population estimates but may deflate variance estimates marginally.

In previous assessments (Gavaris and Van Eeckhaute 1996), annual instead of quarterly catch at age was used and the spring survey results were compared to beginning of year population abundance in the same year while the fall survey results were compared to beginning of year population abundance in the following year for the respective cohort. The present approach accounts explicitly for changes in seasonal distribution of the catch and more accurately reflects the time of year during which surveys were conducted. However, terminal population abundance estimates and year-class abundance estimates at age 1 were only marginally different between the two approaches (Annex B).

The magnitude of the residuals is large, particularly for younger ages in the NMFS fall surveys. The table below shows the average of squared residuals for each series.

Survey	Age								
	0	1	2	3	4	5	6	7	8
Can. Spring	-	0.59	0.91	0.35	0.21	0.52	0.65	1.02	0.61
NMFS Spring	-	1.05	0.81	0.60	0.33	0.56	1.03	2.28	1.10
NMFS Fall	1.34	1.82	1.18	0.61	0.50	0.68	-	-	-

Though several large residuals occur (Fig. 14), the respective observations do not appear to be influential and should not unduly distort parameter estimates. For example, the Canadian survey observation for age 1 in 1987 appears low but the calibration line appears to fit the other observations. The residuals for the most recent year of observation are generally small except for the DFO spring survey at age 3 where it is one of the larger negative residuals for that series. There was a tendency for greater positive residuals in earlier years for NMFS surveys, particularly the spring survey. This pattern was investigated further in relation to the change in trawl doors in 1985 (Annex C), however no firm conclusions were reached.

Myers and Cadigan (1995) reported that correlated errors among ages within a survey can be sufficiently large to produce model mis-specification biases in estimates of population parameters from standard assessment methods. Their simulation however, showed that maximum likelihood estimators from models which ignored correlation performed similar to those from models which incorporated correlation when the correlated errors were small, e.g. $\rho = 0.15$. An estimate of the correlation among ages within a survey was computed using the standard sample estimator for the coefficient of linear correlation where the pairs of observations were the residuals from each abundance index source: $(e_{i,t}, e_{j,t})$ for all ages $i \neq j$ and all times t. For the three survey sources used in this assessment, the correlation was found to be small; DFO spring survey $\hat{\rho} = 0.01$, NMFS spring survey $\hat{\rho} = 0.16$ and NMFS fall survey $\hat{\rho} = 0.19$. Accordingly, no further corrective measures were taken to account for bias from this type of model mis-specification for this stock.

The variance and bias of population abundance estimates and corresponding projection results were derived using an analytical approximation (Gavaris 1993). The population abundance estimates show a large relative error and substantial bias at ages 1 and 2 reflecting the variability in the abundance indices (Table 14). Results from assessments for several other stocks have identified a discrepancy between past estimates of stock status and current estimates using additional data (retrospective pattern). Examination of bias adjusted year-class abundance estimates obtained using the same assessment model while successively eliminating the last year of catch and survey observations did not reveal persistent trends (Fig. 15). These results indicate that this stock assessment does not suffer from a retrospective pattern. The examination of parameter estimates and diagnostics, the evaluation of assumptions and the examination of retrospective consistency indicate that the results from the traditional calibration model using all data from 1969 should provide a reasonable basis for interpretation of stock status and for forecasting projections.

ASSESSMENT RESULTS

For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias and used to construct the history of stock status. Gavaris and Van Eeckhaute (1996) considered that this approach for bias adjustment, in the absence of an unbiased point estimator with optimal statistical properties, was preferable to using the biased point estimates (Tables 15-16). The weights at age from the Canadian spring survey (Table 17) were used to calculate beginning of year population biomass (Table 18). A weight of 2.6 kg was used for age 7 in 1995.

For 1969-85, the 1986-97 average weight at each age was used. A weight of 3.4 kg was used for age 9 in all years.

Population biomass had decreased to its lowest recorded level by the mid 1970s following heavy exploitation by foreign distant water fleets (Fig. 16). Biomass subsequently increased as the strong 1975 and 1978 year-classes recruited. However, biomass again 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 fluctuated around 17,000t during the late 1980s, before declining to about 12,000t in 1993. Over this period, biomass was supported by the 1983, 1985 and 1987 year-classes which were estimated to be the most abundant since the strong 1975 and 1978 year-classes. Since 1993 the biomass has steadily increased to about 24,000t in 1996 and declined slightly to 23,000t in 1997. The recent increase, due principally to the 1992 year-class, but also supported by the 1991 and 1993 year-classes, was enhanced by increased survivorship of young haddock from reduced capture of small fish in the fisheries. The biomass trend for ages 3 and older is similar.

The strength of the 1992 year-class was estimated to be about 15 million (Fig. 17), comparable to the 1983, 1985 and 1987 year-classes, while those during 1988-90 were less than 3 million. The 1991 and 1993 year-classes were estimated at about 7 and 10 million respectively while the incoming 1994, 1995 and 1996 year-classes appear to be relatively weak at about 5 million.

Exploitation rates for ages 4 and older have generally exceeded the $F_{0.1}$ target of 22% ($F_{0.1} = 0.28$) and increased markedly between 1989 and 1992 to almost 50%, amongst the highest levels observed (Fig. 18). The previous occasion when the exploitation rate exceeded 30% was during the early 1970s when abundance was at its lowest. The exploitation rate declined in 1994 and again in 1995 reaching a level below the $F_{0.1}$ target where it remained for 1996. Reduced fishing mortality in recent years has resulted in increased survival of incoming year-classes. There were about twice as many haddock of the 1992 year-class surviving to age 5 than for the 1983, 1985 and 1987 year-classes which were of comparable strength (Fig. 19).

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

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

PROGNOSIS

Yield projections were done using the bias adjusted 1997 beginning of year population abundance estimated from ADAPT. The abundance of the 1997 year-class was assumed to be 6 million at age 0. Following Gavaris and Van Eeckhaute (1996) the partial recruitment to the fishery for ages 1, 2 and 3 were assumed to be 0, 0.05 and 0.5 respectively. Projections were conducted using the 1996 fishery weights at age rather than the average over the past 3 years as was done last year. The trend towards lower average weights at age was the cause for much of the discrepancy between the projected biomass at the beginning of 1997 made in last year's assessment and what was estimated in this year's assessment.

Combined Canada/USA projected yield at $F_{0.1} = 0.28$ in 1997 would be about 6,300t (Table 19). If fished at F0.1 in 1997, the biomass for ages 3 and older is projected to decrease slightly from 20,500 t to about 19,250 t at the beginning of 1998 (Fig. 20). The 1992 year-class would comprise about one quarter of age 3+ biomass and almost half the forecast yield. With the current state of the stock, the 1992 year-class makes a relatively large contribution to the projected yield. As the 1992 year-class gets fished down and with the indications of weak incoming recruitment, the biomass is expected to decline until there is better recruitment.

Uncertainty regarding the abundance of year-classes gets translated to the projection results. The calculations of uncertainty are based on approximations of bias and precision which assume linearity near the solution. They do not include variations in weight at age, partial recruitment and natural mortality, or systematic errors in data reporting and model mismatch, but should provide rough guidelines. Probabilities were computed for the inverse of the exploitation rate but they were expressed in terms of fishing mortality for convenience. The normal distribution was assumed for both the inverse of exploitation rate and the biomass difference. A combined Canada/USA yield of 4,000t in 1997, about what was caught in 1996, decreases the chance that the $F_{0.1}$ is exceeded to less than 10% and increases the chances that the biomass for ages 3 and older will increase between 1997 and 1998 to about 70% (Fig. 21).

MANAGEMENT CONSIDERATIONS

To get an appreciation of the current situation relative to historical production from this resource during the two decade period between the early 1930s and the early 1950s, an illustrative population analysis was conducted. Although total catch of haddock from unit areas 5Zj and 5Zm is considered reliable, only an approximate age composition of the catch could be obtained by prorating the 5Z catch at age with the 5Zjm:5Z landings ratio. These results should therefore be considered as a rough indicator. They show that the current total biomass is still less than a third of the average sustained over those two decades (Fig. 22). Examination of the pattern of recruitment against mature biomass indicates that the chance of observing a strong year-class is significantly lower for biomass below about 40,000 t while the chance of observing a weak year-class is very high (Fig. 23). Since 1969, only the 1975 and 1978 year-classes have been near the long term average abundance.

Increasing the number of age groups contributing to the yield should lead to greater precision in the advice, reduced fluctuations in biomass caused by recruitment variability, and result in more stable yield between years. A larger spawning biomass could enhance recruitment by capitalizing on the opportunities for greater egg and larval survival when environmental conditions are favorable. With biomass expected to decrease as the moderately strong 1992 year-class is fished down, continuing conservation efforts such as low exploitation and fishing practices which permit recruits to realize their growth and reproductive potential are needed to sustain the rebuilding of the population biomass and to expand the age structure.

COMPARISON OF RESULTS FOR CANADIAN AND USA MANAGEMENT UNITS

When considering the consistency of Canadian and USA management, there was interest expressed in comparisons of the similarities and differences of the stock status in respective management units. Fisheries management units are geographical areas in which a suite of regulatory measures can be applied to achieve objectives. For management to be effective, it is generally necessary that there be limited movement of fish into and out of the regulated unit, although a management unit may encompass more than one self sustaining biological population. On Georges Bank, the existence of two centers of aggregation associated with distinct spawning components has long been recognized (Fig. 24). One aggregation spawns on the Northeast Peak in the spring and migrates to the bank slopes on the Northeast Edge and Peak as the waters warm in the summer. The other component spawns around the Nantucket Shoals in the spring and migrates to the bank slopes around the Great South Channel as the waters warm in the summer. We refer to the former as the Eastern component and the latter as the Western component. There is evidence for limited but poorly quantified exchange between the two components. Haddock from the Western component are characterized by faster growth.

The USA conducts fisheries for haddock on both the Western and Eastern components. A consistent management strategy is applied to the USA haddock fisheries on Georges Bank and accordingly, the USA defines a management unit encompassing both Eastern and Western components of the Georges Bank haddock resource, specifically NAFO Division 5Z (small amounts of haddock caught in NAFO Subarea 6 are included). Canada conducts fisheries for haddock on the Eastern component only and is concerned with regulatory measures which could be applied to it in order to achieve benefits. Accordingly, Canada defines unit areas 5Zj and 5Zm as a management unit.

Recent management measures including Canadian TACs, year round USA closed areas, increases in regulated mesh size and effort control strategies in conjunction with improved recruitment, have resulted in increased biomass and reduced F on the Western and especially the Eastern components of the resource. Between 1969 and 1985, catches from 5Zjm averaged about 56% of the total catches from 5Z, ranging between 44% and 67%. Since 1985 however, catches from 5Zjm have consistently been above 83% of the total catches from 5Z, averaging about 88% (Fig. 25). Over this period, the total biomass ratio between the two management units was similar to the ratio for the catch. The biomass in 5Z declined from 93,000t in 1980 to 15,000t in 1993 and has since increased to 29,000t in 1997 (Fig. 26). In 5Zjm, the biomass declined from 48,000t in 1980 to 12,000t in 1993 and has reached about 23,000t in 1997. Since 1985, the biomass in 5Zjm has consistently been over 80% of the total 5Z biomass.

The 1975 and 1978 year-classes were the most abundant on Georges Bank since 1969. The abundance at age 1 for these two year-classes was about 104 million and 83 million respectively for all of 5Z and about 53 million and 52 million in 5Zjm (Fig. 27). Subsequent year-classes have been considerably weaker with the strongest among them being the 1983, 1985, 1987 and 1992 year-classes. The abundance at age 1 of these year-classes was 17,15,16 and 16 million respectively for all of 5Z and 15,13,15 and 16 million in 5Zjm. The 1968 through 1980 year-classes in 5Zjm averaged about 60% of the abundance for all of 5Z while those after 1980, with the exception of 1994 and 1995, have comprised over 70% of the total for 5Z, averaging about 80%.

The fishing mortality rates in 5Zjm and in all of 5Z are fairly similar over the entire time period from 1969 to 1996 showing a decline between the early and mid 1970s followed by an increase until 1980 (Fig. 28). Between 1980 and 1990, the fishing mortality rate fluctuated between about 0.3 and 0.4. It then increased rapidly to about 0.55 in 5Z and 0.7 in 5Zjm by 1993 and subsequently declined to below 0.2 in both 5Zjm and 5Z by 1995.

Between 1969 and 1985, the contribution to production by the Eastern and Western components was roughly equivalent, and both components appeared to have been exploited to the same degree. Since 1985 however, over 80% of the production on Georges Bank was attributed to the Eastern component. The biomass level of the Eastern component is presently at almost half of the level observed during the late 1970s and early 1980s while Georges Bank as a whole has increased to only about a third of its respective biomass level. There is evidence that the production from the Western component is improving over the last few years. The 1994 and 1995 year-classes were estimated to be about equally represented in both components. These divergences in the population dynamics of the Western and Eastern components of Georges Bank haddock are at the root of differences in the assessment results of the 5Z management unit and the 5Zjm management unit.

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

Year	Canada	USA	Others	Total
1969	3941	6622	695	11258
1970	1970	3153	357	5480
1971	1610	3534	770	5914
1972	609	1551	502	2662
1973	1565	1396	396	3357
1974	462	955	573	2747[1]
1975	1353	1705	29	3087
1976	1355	973	24	2352
1977	2871	2429	0	8266[1]
1978	9968	4724	0	16223[1]
1979	5080	5211	0	10291
1980	10017	5615	0	23189[1]
1981	5658	9077	0	14735
1982	4872	6280	0	11152
1983	3208	4454	0	7662
1984	1463	5121	0	6583
1985	3484	1683	0	5167
1986	3415	2200	0	5615
1987	4703	1418	0	6121
1988	4046[2]	1693	0	5739
1989	3059	787	0	3846
1990	3340	1189	0	4529
1991	5446	931	0	6377
1992	4061	1629	0	5690
1993	3727	421	0	4148
1994	2411	33	0	2702[3]
1995	2064	22	0	2104[3]
1996	3656	36	0	3732[3]

[1] Includes 757t, 2966t, 1531t and 7557t in 1974, 1977, 1978 and 1980 respectively for USA discards.

[2] 1895t excluded because of suspected area misreporting.

[3] Includes 258t, 19t and 41t in 1994,1995 and 1996 respectively for USA discards.

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 1/2"** mesh size,. **Areas** 1 and 2 closed during February-May.	
1989		**Combined** cod-haddock-pollock quota for 4X-5Zc
1990		**5Zjm** adopted as management unit. **For** MG < 65 ft. - trip limits with a 30% by-catch of haddock to a maximum of 8 trips of 35,000 lbs per trip between June 1 and Oct. 31 and 130 mm square mesh required. **Fixed** gear required to use large hooks until June
1991	**Established** overfishing definitions for haddock.	**MG** < 65 ft similar to 1990 but mesh size increased to 145 mm diamond.
1992		**Introduction** of ITQs and dockside monitoring.
1993	**Area** 2 closure in effect from Jan 1-June30.	**OT** fishery permitted to operate in Jan. and Feb. **Increase** in use square mesh.
1994	Jan.: **Expanded** Area 2 closure to include June and increased extent of area. **Area** 1 closure not in effect. **500** lb trip limit. **Catch** data obtained from mandatory log books combined with dealer reports (replaces interview system). May: **6"** mesh restriction. Dec.: **Area** 1,2 closed year-round.	**Spawning** closure extended to Jan. 1 to May 31. **Fixed** gear vessels must choose between 5Z or 4X for the period of June to September. **Small** fish protocol. **Increased** at sea monitoring. **OT** > 65 could not begin fishng until July 1. **Predominantly** square mesh by end of year.
1995		**All** OT vessels using square mesh. **Vessels** with a history since 1990 of 25t or more for 3 years of cod, haddock pollock, hake or cusk combined can participate in 5Z fishery. **ITQ** vessel require at least 2t of cod and 8t of haddock quota to fish Georges.
1996	July: **Additional** Days-at-Sea restrictions, trip limit raised to 1000 lbs.	**Fixed** gear history requirement dropped.
1997	May: **Additional** scheduled Days-at-sea restrictions.	

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

Year	Otter Trawl						Longline			Other	Total
	Side	Stern									
		2	3	4	5	Total	2	3	Total		
1969	777	0	1	225	2902	3127	2	21	23	15	3941
1970	575	2	0	133	1179	1314	6	72	78	2	1970
1971	501	0	0	16	939	955	18	129	151	3	1610
1972	148	0	0	2	260	263	23	169	195	3	609
1973	633	0	0	60	766	826	23	80	105	0	1565
1974	27	0	6	8	332	346	29	59	88	1	462
1975	222	0	1	60	963	1024	25	81	107	0	1353
1976	217	0	2	59	905	967	48	108	156	15	1355
1977	370	92	243	18	2025	2378	43	51	94	28	2871
1978	2456	237	812	351	5639	7039	121	47	169	305	9968
1979	1622	136	858	627	1564	3185	190	80	271	2	5080
1980	1444	354	359	950	6254	7917	129	51	587	69	10017
1981	478	448	629	737	2344	4159	331	99	1019	2	5658
1982	115	189	318	187	3341	4045	497	187	712	0	4872
1983	106	615	431	107	1130	2283	593	195	815	4	3208
1984	5	180	269	21	149	620	614	192	835	3	1463
1985	72	840	1401	155	348	2745	562	33	626	41	3484
1986	51	829	1378	95	432	2734	475	98	594	35	3415
1987	48	782	1448	49	1241	3521	854	113	1046	89	4703
1988[1]	72	1091	1456	186	398	3183	428	200	695	97	4046
1989	0	489	573	376	536	1976	713	175	977	106	3059
1990	0	928	890	116	471	2411	623	173	853	76	3340
1991	0	1610	1647	81	679	4018	900	271	1309	119	5446
1992	0	797	1084	56	645	2583	984	245	1384	90	4061
1993	0	535	1179	67	699	2490	794	156	1144	94	3727
1994	0	495	911	79	112	1597	498	47	714	100	2411
1995	0	510	896	14	214	1647	261	69	389	28	2064
1996	1	836	1405	166	270	2689	559	107	944	21	3656

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

Table 4. Monthly catch (t) of haddock by Canada in unit areas 5Zjm.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	105	74	6	291	588	691	559	580	551	360	102	34	3941
1970	2	105	0	1	574	345	103	456	242	103	26	12	1970
1971	0	9	1	0	400	132	283	278	97	246	141	21	1610
1972	0	119	2	0	2	111	84	116	98	68	7	2	609
1973	4	10	0	0	0	184	198	572	339	232	22	4	1565
1974	19	0	1	0	0	58	63	53	96	61	92	19	462
1975	4	14	0	0	0	166	256	482	100	166	118	45	1353
1976	0	7	62	68	60	587	152	190	186	26	9	7	1355
1977	102	177	7	0	23	519	1059	835	13	59	56	22	2871
1978	104	932	44	22	21	319	405	85	642	5433	1962	0	9968
1979	123	898	400	175	69	1393	885	396	406	261	53	22	5080
1980	38	134	14	29	223	2956	2300	965	1411	1668	104	176	10017
1981	38	481	568	4	254	1357	1241	726	292	82	378	239	5658
1982	129	309	1	11	46	1060	769	682	585	837	398	44	4872
1983	32	67	29	47	60	1288	387	483	526	195	88	6	3208
1984	3	5	81	88	73	433	219	254	211	71	25	0	1463
1985	1	11	33	99	26	354	392	1103	718	594	61	93	3484
1986	11	28	79	99	40	1339	1059	369	233	139	12	8	3415
1987	24	26	138	70	12	1762	1383	665	405	107	97	14	4703
1988[1]	39	123	67	79	15	1816	1360	315	130	65	13	24	4046
1989	32	94	48	7	20	1398	356	566	141	272	108	18	3059
1990	35	14	50	0	7	1179	668	678	469	199	18	22	3340
1991	144	166	49	26	21	1928	1004	705	566	576	123	137	5446
1992	118	205	97	152	36	1381	619	414	398	401	209	28	4061
1993	466	690	96	78	25	723	505	329	202	198	230	185	3727
1994	1	3	1	2	0	398	693	373	375	220	211	134	2411
1995	1	1	1	1	0	762	326	290	281	109	197	96	2064
1996	0	0	0	0	0	1067	672	700	358	278	191	391	3656

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

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

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

Table 6. Monthly catch (t) of haddock (excluding discard estimates) by USA in unit areas 5Zjm.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	525	559	976	1825	670	809	204	219	249	226	203	157	6622
1970	169	219	242	375	608	374	324	333	179	219	61	50	3153
1971	155	361	436	483	668	503	338	152	147	165	58	68	3534
1972	150	196	91	90	239	261	97	164	84	63	52	64	1551
1973	90	111	77	85	138	365	217	196	37	3	22	55	1396
1974	135	70	47	70	122	160	165	43	27	6	19	91	955
1975	152	123	32	116	388	489	138	95	57	24	52	39	1705
1976	116	147	83	106	323	162	7	6	5	2	3	13	973
1977	75	211	121	154	374	372	434	191	73	52	146	226	2429
1978	336	437	263	584	752	750	467	221	245	426	194	49	4724
1979	274	329	352	548	766	816	588	659	224	202	281	172	5211
1980	632	1063	742	784	711	461	324	254	221	91	110	222	5615
1981	550	1850	634	627	882	1326	1233	873	321	284	242	255	9077
1982	425	754	502	347	718	1801	757	145	201	216	276	138	6280
1983	492	931	272	181	310	1145	231	178	187	110	227	190	4454
1984	540	961	366	281	627	1047	370	302	250	196	92	89	5121
1985	165	190	254	300	352	206	60	47	1	24	41	43	1683
1986	184	396	334	479	496	221	31	6	12	6	6	29	2200
1987	225	52	43	307	233	342	67	30	24	4	23	68	1418
1988	196	152	207	245	366	316	30	19	6	1	45	110	1693
1989	114	56	47	164	161	145	15	8	1	5	25	46	787
1990	148	21	155	274	214	306	23	3	5	5	16	19	1189
1991	105	28	76	133	89	434	1	20	6	0	19	19	931
1992	253	81	51	149	353	669	20	20	17	3	2	12	1629
1993	15	12	16	55	84	209	6	3	3	7	2	8	421
1994													33
1995													22
1996													36

Table 7. Derivation of catch at age for the 1996 5Zjm Canadian haddock fishery.

Country	Qtr.	Length Frequency Samples										Aged Samples			
		Gear	Month	Observer		Port		Landings (kg)	Combinations			Observer		Port	
				Samples	Measured	Samples	Measured					Samples	Aged	Samples	Aged
Canada	2	OTB IN	June	21	12,506	7	1,623	882,120	Jun OTB IN						
		Misc.	June					219							
		OTB OF	June	3	2,411	1	199	172,578	Jun OTB OF		Qtr 2	8	92	8	252
		GN	June	1	95	(plus July & Aug.samples)		984	Jun GN						
		LL	June	Qtr3 LL				10,625	Jun LL						
	3	OTB IN	July	4	1,477	4	839	261,921	Jul OTB IN	Qtr3 OT IN					
		OTB IN	Aug	12	4,966	5	1,049	340,353	Aug OTB IN						
		OTS IN	Aug					337							
		OTB IN	Sept			1	230	203,187	Sept OTB IN						
		OTB OF	July					101,883							
		OTB OF	Aug	1	544	1	230	102,521		Qtr3 OT OF					
		OTS OF	Aug					776			Qtr 3				
		OTB OF	Sept					36,308				7	74	14	366
		GN	July	1	63	(plus June sample)		7,182		Qtr3 GN					
		GN	Aug	1	131			3,428							
		LL	July	14	5,764	3	650	292,789	Jul LL						
		HL	July					8,049							
		LL	Aug	11	6,162	2	384	252,183	Aug LL	Qtr3 LL					
		HL	Aug					648							
		LL	Sept	5	2,970	1	220	118,220	Sept LL						
	4	OTB IN	Oct	5	1,253	4	864	113,954	Oct OT IN						
		OTB IN	Nov	3	505			117,323	Nov OT IN	Qtr4 OT IN					
		OTB	Nov					1,441							
		OTB IN	Dec	1	757	4	915	332,714	Dec OT IN						
		OTB OF	Oct					1,491							
		OTB OF	Nov	Used Qtr 3 OT OF				1,014		Qtr4 OT OF	Qtr 4	1	6	7	195
		OTB OF	Dec					20,657							
		LL	Oct	5	3,831	2	440	162,372	Oct LL						
		HL	Oct					4							
		LL	Nov	2	1,311	1	211	71,019	Nov LL	Qtr4 LL					
		LL	Dec					37,211							
	Totals			90	44,746	36	7,854	3,655,511				16	172	29	813

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

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

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1969		18	1441	260	331	2885	819	89	279	6123
1970	25	82	7	347	147	126	1140	364	189	2425
1971		1182	247	31	246	157	159	756	407	3185
1972	259	1	376	71	21	92	37	16	431	1303
1973	1015	1722	6	358	37	10	37	8	163	3358
1974	17	2105	247		31	3		29	57	2488
1975		270	1428	201	5	34	1	2	28	1969
1976	73	149	166	814	125		19		17	1363
1977		7836	64	178	303	162		15	14	8571
1978	1	285	9831	161	169	302	80	10	9	10848
1979		15	199	4250	362	201	215	43	14	5300
1980	3	17561	342	299	2407	191	129	51	12	20995
1981		660	6687	393	494	1234	119	33	7	9627
1982		713	1048	2799	201	377	723	62	65	5988
1983		140	648	546	1629	207	104	402	34	3710
1984		76	249	341	264	1120	186	165	314	2716
1985		2063	374	176	189	123	371	53	114	3463
1986	6	38	2557	173	142	122	118	173	41	3369
1987		1990	127	1515	96	56	82	68	108	4042
1988	4	51	2145	121	877	109	36	46	98	3487
1989		1153	78	734	129	320	31	20	45	2510
1990	2	7	1265	126	743	68	163	42	42	2457
1991	6	441	89	2041	88	389	72	145	61	3332
1992	7	230	311	127	1446	89	315	26	90	2640
1993	7	247	343	279	85	635	34	153	74	1856
1994	1	241	737	148	54	48	125	29	39	1423
1995	2	60	525	414	53	25	3	51	16	1149
1996	1	27	468	863	427	61	18	3	72	1940

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

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	1.045	1.513	2.034	2.550	2.751	2.916	3.027
1996	0.576	1.027	1.449	1.807	2.294	2.473	3.321	2.032

Table 10. Conversion factors used in the ADAPT calibration.

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

Table 11. Total estimated abundance at age numbers (000's) of haddock for unit areas 5Zjm from the Canadian spring surveys.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1986	5057	306	8175	997	189	348	305	425	401	16205
1987	46	4286	929	3450	653	81	387	135	1132	11099
1988	971	49	12714	257	4345	274	244	130	686	19671
1989	48	6664	991	2910	247	528	40	36	260	11725
1990	726	108	12302	166	4465	299	1370	144	389	19968
1991	393	2159	137	10876	116	1899	119	507	225	16431
1992	1914	3879	1423	221	4810	18	1277	52	655	14248
1993	3448	1759	545	431	34	1186	19	281	147	7849
1994	4197	15163	5332	549	314	20	915	18	356	26864
1995	1231	3224	6236	3034	720	398	0	729	849	16422
1996	1477	2059	4784	5247	3391	326	246	20	698	18247
1997	1037	1497	957	2725	2767	1511	167	68	361	11090

Table 12. Total estimated abundance at age numbers (000's) of haddock for unit areas 5Zjm from the USA spring surveys. From 1973-81, a 41 Yankee trawl was used while a 36 Yankee trawl was used in other years. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1969	17	35	614	235	523	3232	1220	358	489	6724
1970	478	190	0	560	998	441	3169	2507	769	9113
1971	0	655	261	0	144	102	58	1159	271	2650
1972	2594	0	771	132	25	47	211	27	1214	5019
1973	2455	5639	0	1032	154	0	276	0	1208	10763
1974	1323	20596	4084	0	354	0	43	72	322	26795
1975	528	567	6016	1063	0	218	127	45	208	8773
1976	8279	402	433	1229	582	0	0	0	22	10948
1977	138	25922	294	855	816	586	0	22	98	28730
1978	0	743	20859	641	880	1163	89	23	116	24516
1979	10496	441	1313	9764	475	72	445	42	9	23057
1980	4364	67961	1129	1117	5822	628	381	705	359	82466
1981	3595	3041	27694	2887	719	2389	335	57	21	40738
1982	584	3697	1649	7743	745	447	669	0	0	15534
1983	238	770	686	359	2591	30	0	798	57	5529
1984	1366	1415	996	1001	936	1245	138	89	470	7656
1985	40	8911	1396	674	1496	588	1995	127	483	15709
1986	3334	280	3597	246	210	333	235	560	159	8953
1987	122	5480	144	1394	157	231	116	370	0	8013
1988	305	61	1868	235	611	203	218	178	0	3678
1989	84	6665	619	1343	267	791	58	92	47	9966
1990	1654	70	10338	598	1042	110	182	0	0	13995
1991	740	2071	432	3381	192	203	66	87	25	7198
1992	529	287	214	141	609	32	46	46	0	1905
1993	1870	1116	197	232	195	717	77	35	43	4481
1994	1025	4272	1487	269	184	118	278	28	85	7745
1995	921	2307	4096	1691	259	151	51	269	214	9959
1996	912	1351	3772	3232	1896	235	36	0	496	11931

Table 13. Total estimated abundance at age numbers (000's) of haddock for unit areas 5Zjm from the USA fall surveys. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									
	0	1	2	3	4	5	6	7	8+	Total
1963	106461	49869	14797	5050	7581	6172	2301	599	273	193101
1964	1177	114880	55741	6128	976	2435	502	280	167	182287
1965	259	1512	51521	8360	489	299	148	165	216	62970
1966	9324	751	1742	20324	3631	671	139	133	83	36797
1967	0	3998	73	328	1845	675	140	88	88	7234
1968	55	113	800	28	37	2223	547	177	313	4293
1969	384	0	0	519	63	30	753	458	115	2323
1970	0	6400	336	16	415	337	500	902	578	9483
1971	2626	0	788	97	0	265	27	73	594	4471
1972	4747	2396	0	232	0	0	53	0	276	7703
1973	1345	16797	1606	0	180	1	0	16	16	19961
1974	151	234	961	169	0	6	0	0	69	1589
1975	30365	664	192	1018	222	0	0	0	26	32487
1976	784	132622	456	25	484	71	0	17	36	134496
1977	47	238	26323	445	125	211	84	4	4	27480
1978	14642	547	530	7706	56	42	94	0	0	23617
1979	1573	21117	14	327	1461	44	12	0	0	24549
1980	3581	2817	5877	0	101	1085	109	26	4	13598
1981	616	4617	2585	2752	105	136	297	0	15	11123
1982	62	0	669	460	2576	159	91	469	42	4527
1983	3609	444	324	435	283	396	19	9	79	5598
1984	45	3849	781	221	210	43	254	0	47	5451
1985	12148	381	1646	199	70	68	46	30	21	14610
1986	30	7471	109	961	52	50	72	24	23	8793
1987	508	4	839	28	152	38	22	0	0	1592
1988	122	3983	206	2326	155	400	142	140	38	7513
1989	167	83	2645	112	509	68	73	0	0	3656
1990	1217	1036	24	1474	90	172	21	5	0	4040
1991	705	331	274	68	266	25	10	0	0	1679
1992	3484	1052	172	110	0	95	0	18	18	4948
1993	677	6666	3601	585	0	87	96	30	0	11742
1994	625	782	927	419	96	32	0	24	0	2905
1995	892	1465	6165	3484	547	30	0	0	53	12637
1996	1742	453	570	2302	963	167	0	0	0	6196

Table 14. Statistical properties of estimates for population abundance and survey calibration constants for haddock in unit areas 5Zjm.

Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
			Population Abundance		
1	8279	5967	0.72	2175	0.26
2	3946	1799	0.46	421	0.11
3	3074	1116	0.36	209	0.07
4	5129	1697	0.33	275	0.05
5	5966	1897	0.32	275	0.05
6	1356	490	0.36	60	0.04
7	197	84	0.43	12	0.06
8	97	43	0.44	7	0.07
			Survey Calibration Constants		
Canadian Spring Survey					
1	0.178	0.053	0.300	0.007	0.041
2	0.429	0.126	0.293	0.017	0.039
3	0.821	0.238	0.290	0.032	0.038
4	0.722	0.209	0.290	0.028	0.039
5	0.887	0.257	0.290	0.036	0.041
6	0.699	0.204	0.292	0.030	0.043
7	0.953	0.291	0.305	0.044	0.047
8	0.927	0.270	0.291	0.037	0.039
USA Spring Survey					
1	0.156	0.031	0.196	0.003	0.017
2	0.397	0.076	0.191	0.007	0.017
3	0.516	0.100	0.194	0.009	0.017
4	0.577	0.112	0.194	0.010	0.017
5	0.717	0.137	0.191	0.012	0.017
6	0.559	0.111	0.199	0.011	0.019
7	0.892	0.177	0.198	0.016	0.018
8	0.779	0.161	0.206	0.015	0.019
USA Fall Survey					
1	0.139	0.027	0.194	0.002	0.017
2	0.272	0.054	0.200	0.005	0.018
3	0.207	0.040	0.195	0.004	0.017
4	0.205	0.040	0.195	0.004	0.017
5	0.156	0.032	0.207	0.003	0.021
6	0.136	0.027	0.195	0.003	0.019

Table 15. Beginning of year population abundance numbers (000's) for haddock in unit areas 5Zjm.

Year	Age Group										
	1	2	3	4	5	6	7	8	9	1+	2+	3+
1969	762	161	3994	849	885	8401	2799	177	0	18028	17266	17105
1970	3342	624	115	1982	461	431	4314	1564	66	12899	9557	8933
1971	311	2713	435	88	1313	246	240	2509	955	8810	8499	5786
1972	5154	255	1126	135	45	855	61	56	1383	9070	3916	3661
1973	11029	3977	208	586	46	19	620	17	32	16534	5505	1528
1974	3144	8121	1684	165	152	5	7	474	7	13759	10615	2494
1975	3217	2558	4749	1162	135	98	2	5	363	12289	9072	6514
1976	53815	2634	1842	2592	771	106	50	1	3	61814	7999	5365
1977	5912	43993	2023	1360	1402	520	87	24	0	55321	49409	5416
1978	4209	4841	28865	1600	955	884	285	71	7	41717	37508	32667
1979	51997	3445	3689	14542	1161	631	457	161	50	76133	24136	20691
1980	6643	42572	2806	2838	8104	626	342	185	93	64209	57566	14994
1981	5132	5436	19005	1994	2057	4520	343	168	107	38762	33630	28194
1982	1711	4202	3842	9583	1284	1244	2616	177	109	24768	23057	18855
1983	2625	1401	2778	2203	5323	868	683	1495	90	17466	14841	13440
1984	14872	2149	1016	1683	1312	2912	525	465	871	25805	10933	8784
1985	1544	12176	1691	607	1071	841	1394	267	235	19826	18282	6106
1986	13171	1264	8035	1037	338	708	579	814	171	26117	12946	11682
1987	1287	10779	1000	4292	698	150	471	371	516	19564	18277	7498
1988	14872	1053	7022	705	2153	484	73	312	242	26916	12044	10991
1989	788	12172	817	3812	468	988	300	28	215	19588	18800	6628
1990	2312	645	8926	598	2457	267	523	219	5	15952	13640	12995
1991	2132	1891	522	6160	377	1343	159	282	141	13007	10875	8984
1992	7054	1740	1145	348	3189	228	750	66	101	14621	7567	5827
1993	15665	5769	1213	656	172	1315	109	331	31	25261	9596	3827
1994	9719	12819	4488	680	289	65	515	60	137	28772	19053	6234
1995	4313	7956	10269	2986	420	186	9	306	22	26467	22154	14198
1996	4306	3529	6458	7923	2065	295	130	4	204	24914	20608	17079
1997	6104	3525	2864	4854	5691	1296	184	90	1	24609	18505	14980

Table 16. Fishing mortality rate for haddock in unit areas 5Zjm.

Year	Age Group								
	1	2	3	4	5	6	7	8	4+
1969	0.000	0.132	0.500	0.410	0.519	0.466	0.382	0.788	0.451
1970	0.009	0.161	0.068	0.212	0.430	0.388	0.342	0.293	0.309
1971	0.000	0.679	0.971	0.465	0.230	1.190	1.252	0.396	0.405
1972	0.059	0.003	0.454	0.865	0.692	0.121	1.062	0.355	0.251
1973	0.106	0.659	0.033	1.149	2.062	0.837	0.069	0.748	0.492
1974	0.006	0.336	0.171	0.000	0.244	0.839	0.006	0.067	0.086
1975	0.000	0.129	0.405	0.210	0.037	0.466	0.898	0.520	0.209
1976	0.002	0.064	0.103	0.414	0.194	0.000	0.534	0.000	0.349
1977	0.000	0.221	0.034	0.154	0.262	0.402	0.000	1.061	0.232
1978	0.000	0.072	0.486	0.121	0.214	0.460	0.373	0.165	0.234
1979	0.000	0.005	0.062	0.385	0.418	0.414	0.705	0.346	0.395
1980	0.000	0.606	0.141	0.122	0.384	0.402	0.509	0.348	0.319
1981	0.000	0.147	0.485	0.240	0.303	0.347	0.464	0.235	0.314
1982	0.000	0.214	0.356	0.388	0.191	0.399	0.359	0.478	0.366
1983	0.000	0.121	0.301	0.318	0.403	0.303	0.184	0.340	0.352
1984	0.000	0.040	0.314	0.252	0.245	0.537	0.478	0.482	0.394
1985	0.000	0.216	0.289	0.387	0.215	0.174	0.338	0.243	0.271
1986	0.000	0.034	0.427	0.196	0.610	0.207	0.244	0.256	0.255
1987	0.000	0.228	0.150	0.490	0.165	0.527	0.211	0.226	0.406
1988	0.000	0.054	0.411	0.209	0.578	0.279	0.759	0.171	0.423
1989	0.000	0.110	0.113	0.239	0.360	0.437	0.116	1.603	0.278
1990	0.001	0.012	0.171	0.261	0.404	0.322	0.418	0.236	0.368
1991	0.003	0.302	0.207	0.459	0.301	0.383	0.679	0.828	0.452
1992	0.001	0.161	0.357	0.505	0.686	0.538	0.617	0.548	0.650
1993	0.001	0.051	0.378	0.621	0.764	0.738	0.406	0.683	0.685
1994	0.000	0.022	0.208	0.283	0.239	1.826	0.319	0.800	0.334
1995	0.000	0.009	0.059	0.169	0.152	0.160	0.463	0.206	0.170
1996	0.000	0.009	0.085	0.131	0.266	0.271	0.169	1.860	0.161

Table 17. Average weight at age from the Canadian spring survey.

Year	Age Group							
	1	2	3	4	5	6	7	8
1986	0.135	0.452	0.975	1.444	3.039	2.843	3.598	3.373
1987	0.150	0.500	0.716	1.673	2.011	2.548	3.150	3.147
1988	0.097	0.464	0.932	1.795	1.816	1.917	2.720	3.269
1989	0.062	0.474	0.650	1.392	1.994	2.528	2.155	2.820
1990	0.149	0.527	0.925	1.184	1.863	2.072	2.508	2.819
1991	0.120	0.689	0.801	1.510	1.686	2.427	2.103	3.125
1992	0.122	0.602	1.118	1.061	2.078	2.165	2.708	2.283
1993	0.122	0.481	1.228	1.803	1.270	2.332	2.340	2.738
1994	0.107	0.469	1.047	1.621	1.926	2.154	3.152	2.688
1995	0.086	0.493	0.963	1.556	2.224	2.447		2.994
1996	0.134	0.475	0.878	1.327	1.904	2.501	2.969	3.190
1997	0.135	0.500	0.744	1.187	1.615	2.115	2.423	2.552

Table 18. Beginning of year biomass for haddock in unit areas 5Zjm.

Year	Age Group										
	1	2	3	4	5	6	7	8	9	1+	2+	3+
1969	90	82	3667	1241	1730	19675	7572	508	0	34566	34475	34393
1970	397	320	106	2898	901	1009	11670	4485	224	22009	21613	21293
1971	37	1390	399	129	2566	576	649	7195	3247	16188	16151	14761
1972	612	131	1034	197	88	2002	165	161	4702	9092	8480	8349
1973	1309	2037	191	857	90	44	1677	49	109	6363	5054	3017
1974	373	4160	1546	241	297	12	19	1359	24	8031	7658	3498
1975	382	1310	4360	1699	264	230	5	14	1234	9499	9117	7807
1976	6386	1349	1691	3790	1507	248	135	3	10	15120	8734	7385
1977	702	22534	1857	1989	2740	1218	235	69	0	31344	30642	8108
1978	499	2480	26502	2340	1866	2070	771	204	24	36756	36257	33777
1979	6170	1765	3387	21263	2269	1478	1236	462	170	38200	32030	30265
1980	788	21806	2576	4150	15838	1466	925	530	316	48397	47609	25802
1981	609	2784	17449	2916	4020	10586	928	482	364	40138	39529	36745
1982	203	2152	3528	14012	2509	2913	7077	508	371	33273	33070	30917
1983	311	718	2551	3221	10403	2033	1848	4287	306	25678	25366	24648
1984	1765	1101	933	2461	2564	6820	1420	1333	2961	21358	19594	18493
1985	183	6237	1553	888	2093	1970	3771	766	799	18258	18075	11838
1986	1773	571	7836	1498	1027	2013	2083	2746	581	20128	18355	17784
1987	194	5385	716	7180	1404	382	1483	1167	1754	19666	19472	14087
1988	1446	489	6541	1266	3910	928	199	1020	823	16620	15175	14686
1989	49	5771	531	5307	933	2498	646	79	731	16544	16495	10725
1990	344	340	8256	708	4577	553	1312	617	17	16724	16380	16040
1991	257	1302	418	9304	636	3259	334	881	479	16871	16614	15312
1992	863	1048	1281	369	6625	494	2031	151	343	13205	12342	11294
1993	1910	2776	1490	1183	218	3067	255	906	105	11910	10001	7225
1994	1037	6014	4701	1102	557	140	1623	161	466	15801	14764	8750
1995	371	3925	9888	4645	934	455	24	916	75	21234	20863	16938
1996	576	1677	5671	10516	3933	738	386	13	694	24203	23627	21950
1997	825	1764	2131	5761	9192	2741	446	230	3	23092	22268	20504

Table 19. Projection results at $F_{0.1}$ for haddock in unit areas 5Zjm.

Year	Age Group 1	2	3	4	5	6	7	8	9	1+	2+	3+
Population Numbers (000s)												
1997	6104	3525	2864	4854	5691	1296	184	90	1			
1998	4912	4998	2846	2039	3004	3521	802	114	55			
Fishing Mortality												
1997	0.000	0.014	0.140	0.280	0.280	0.280	0.280	0.280				
Weight at beginning of year for population (kg)												
1998	0.14	0.50	0.74	1.19	1.62	2.12	2.42	2.55	3.40			
Projected Population Biomass (t)												
1998	664	2501	2117	2420	4852	7448	1943	291	189	22424	21760	19259
Projected Catch Numbers (000s)												
1997	0	44	340	1079	1265	288	41	20				
Average weight for catch (kg)												
1997	0.58	1.03	1.45	1.81	2.29	2.47	3.32	2.03				
Projected Yield (t)												
1996	0	46	493	1951	2903	713	136	41		6281		

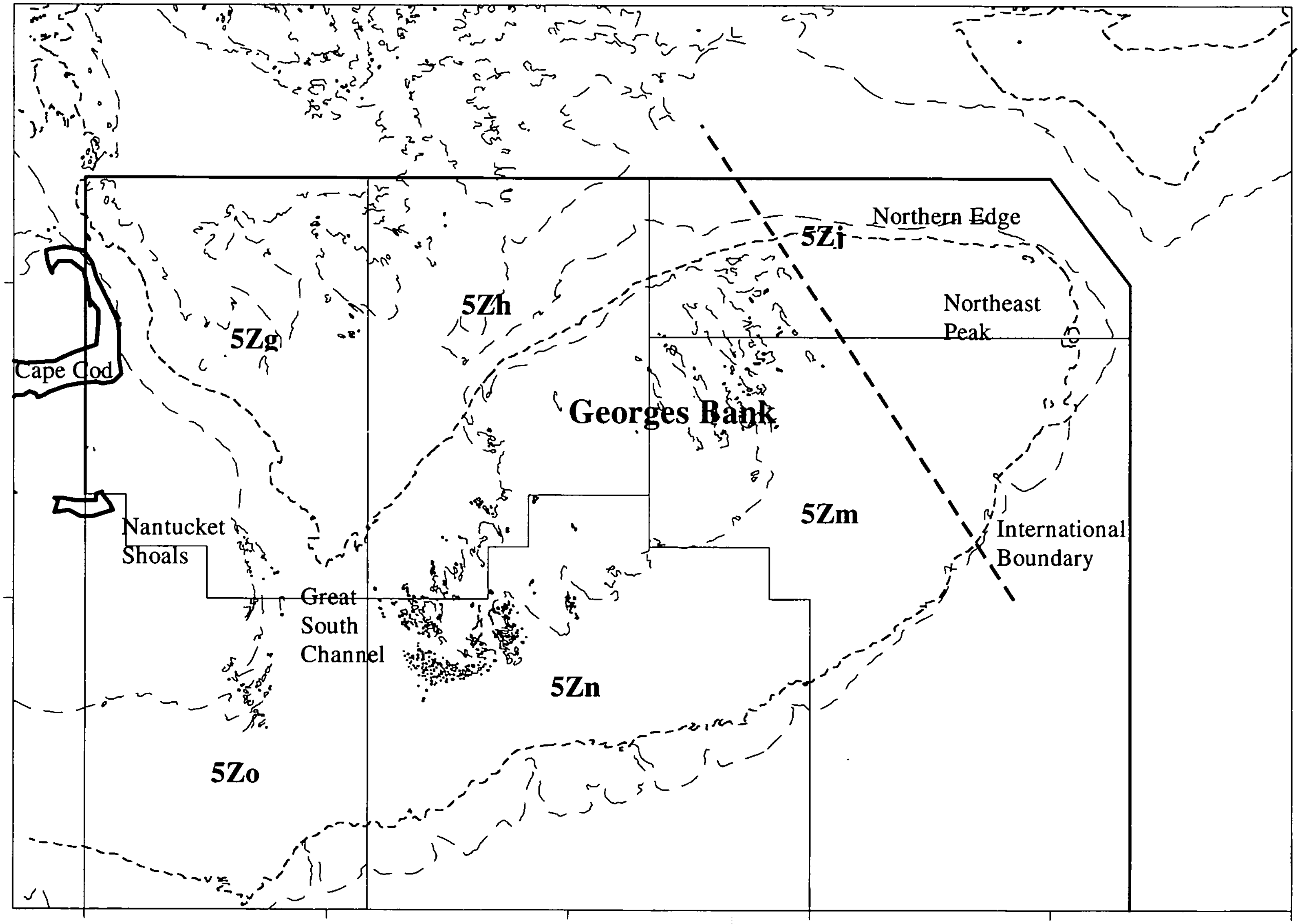


Fig. 1. Fisheries statistical unit areas in NAFO Subdivision 5Ze.

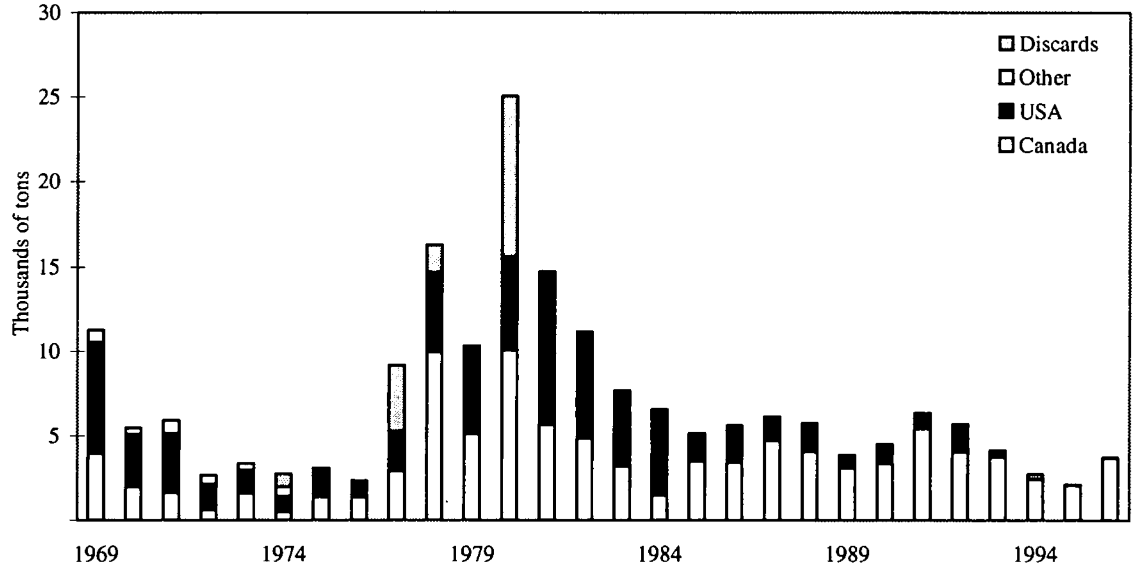


Fig. 2. Nominal catch of haddock in unit areas 5Zjm.

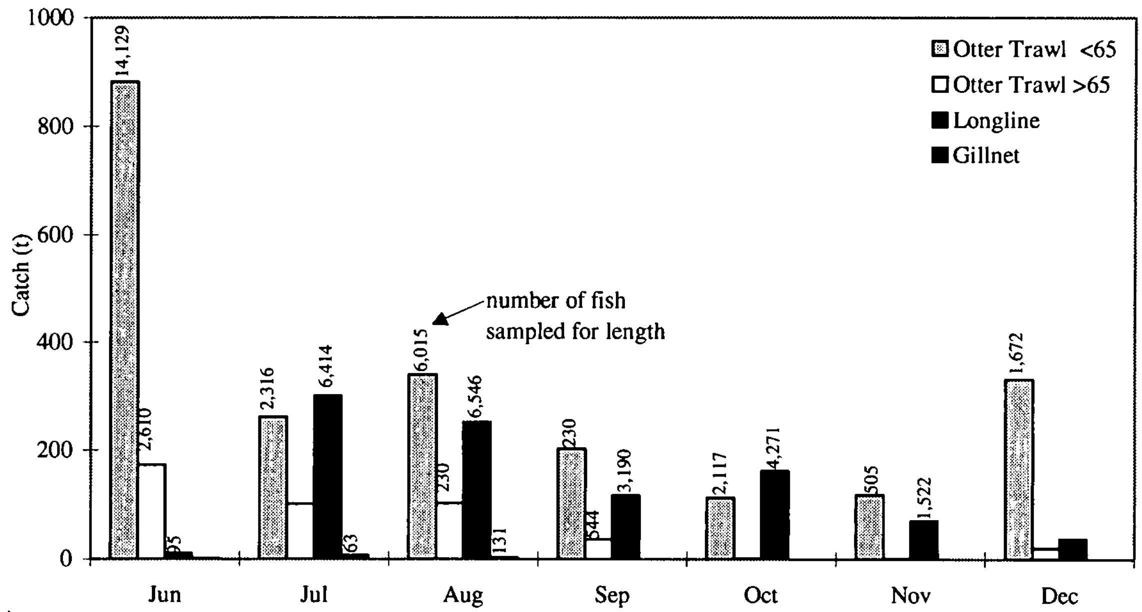


Fig. 3. Haddock landed in 5Zjm by month and gear by the Canadian commercial fishery in 1996 with sampling levels..

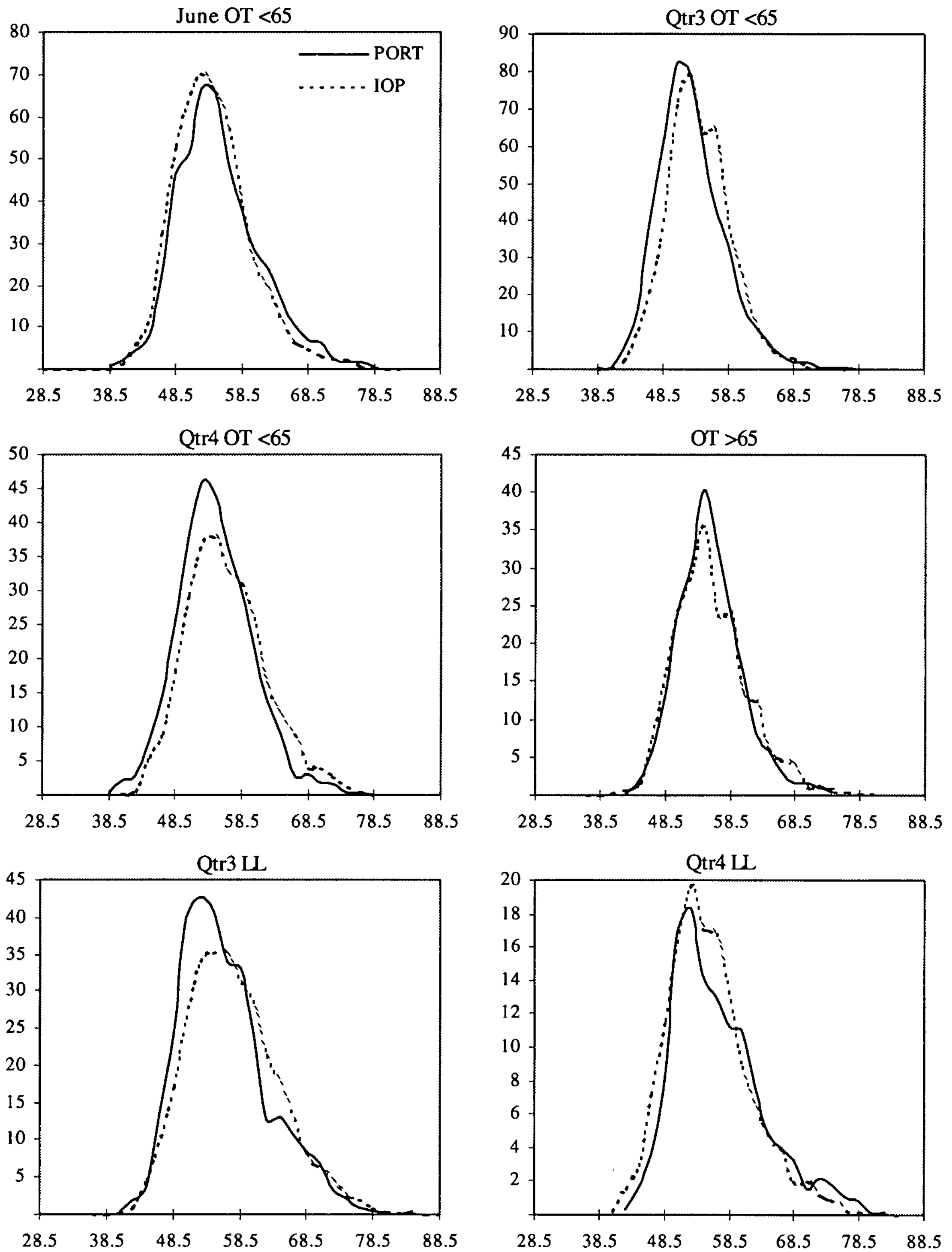


Fig. 4. Comparison of 5Zjm haddock length frequencies obtained by port samplers (PORT) and at sea observers (IOP) from the 1996 Canadian commercial fishery. Both sources exhibit similar distributions indicating that discarding was not a problem. (OT = otter trawl, LL = longline, Qtr = quarter).

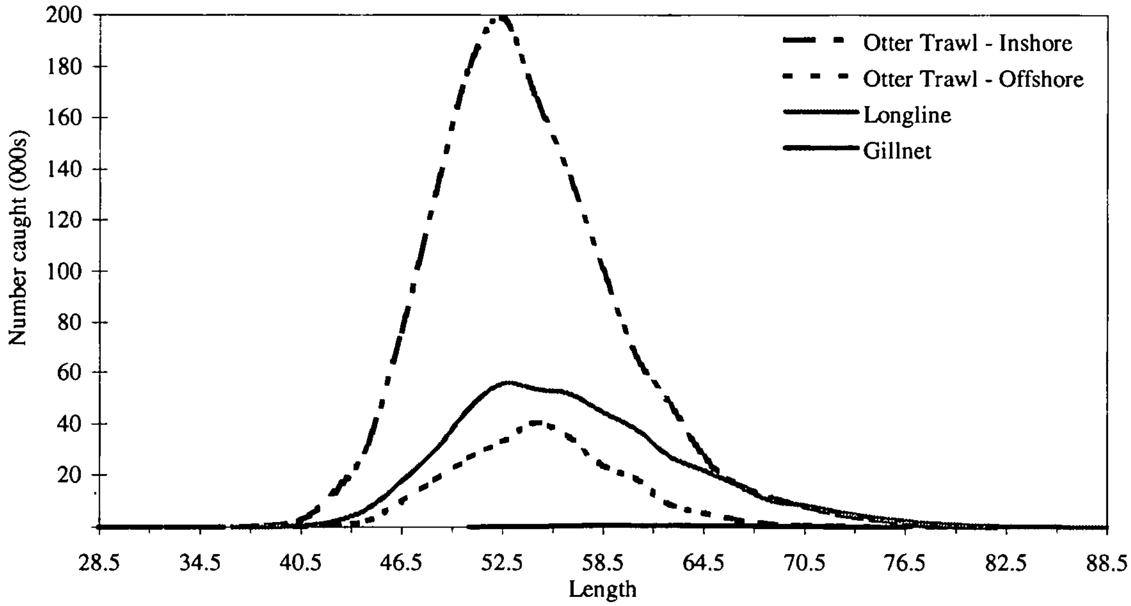


Fig. 5. Length compositions of the principal Canadian 5Zjm commercial haddock fisheries in 1996 are fairly similar but haddock caught by gillnets are somewhat larger than those caught by other gears.

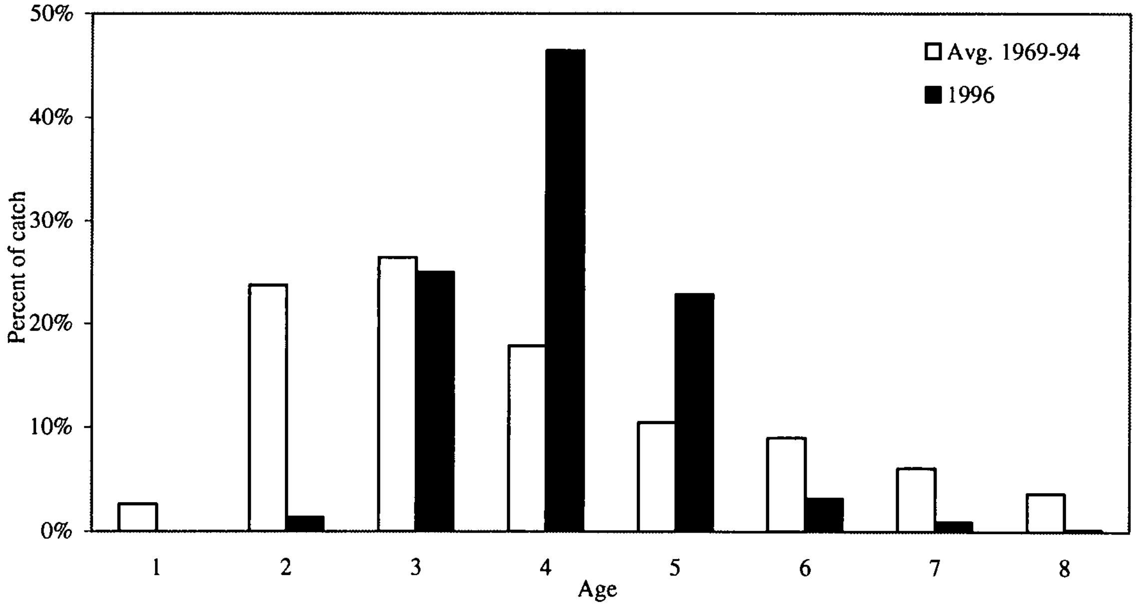


Fig. 6. Age composition of the Canadian 5Zjm commercial fisheries haddock catch in 1996 compared to the long term average . Ages 4 and 5 made up the bulk of the catch, a consequence of lower selection for smaller haddock than in the past and the resulting higher survival of the 1992 year-class.

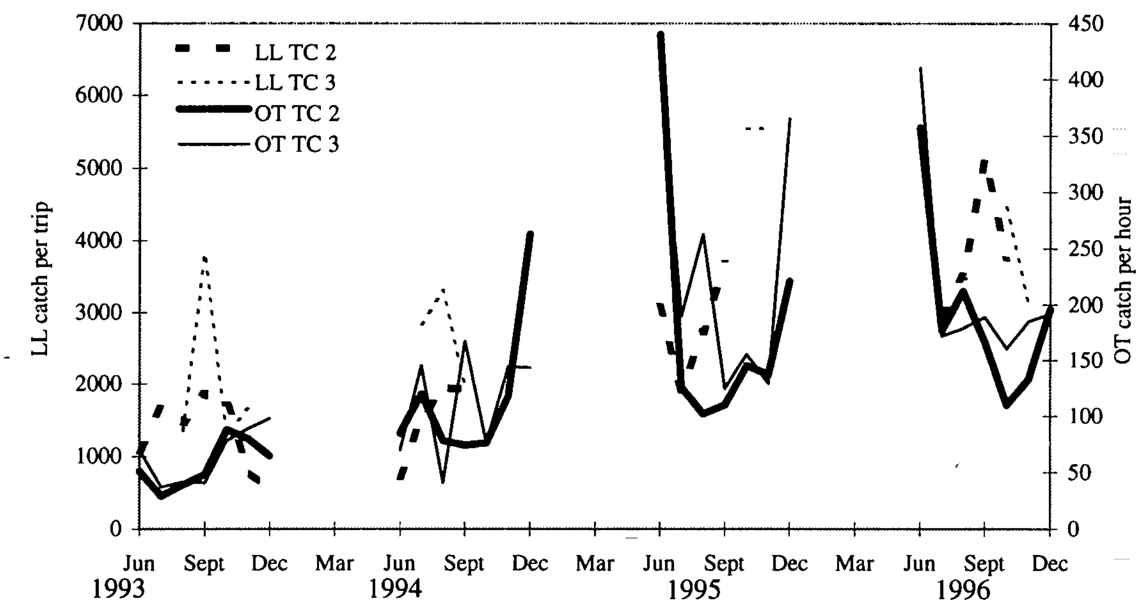


Fig. 7. Catch rates for haddock from Canadian commercial fishery gadoid trips (90% cod, haddock and pollock) in 5Zjm for vessels which fished during 1994 and reported more than 1t of landings. A generally increasing trend is seen from 1993 to 1995 with 1996 values similar to 1995. (LL = longline, OT = otter trawl, TC = tonnage class).

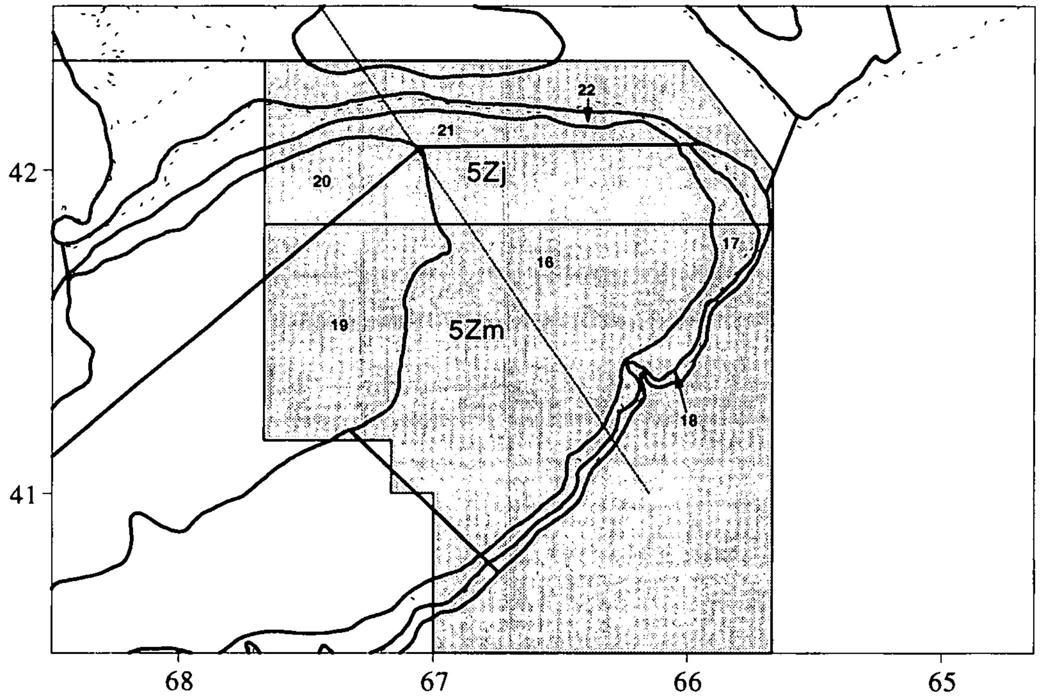


Fig. 8. Stratification scheme used for USA surveys. The 5Zjm management area is indicated by shading.

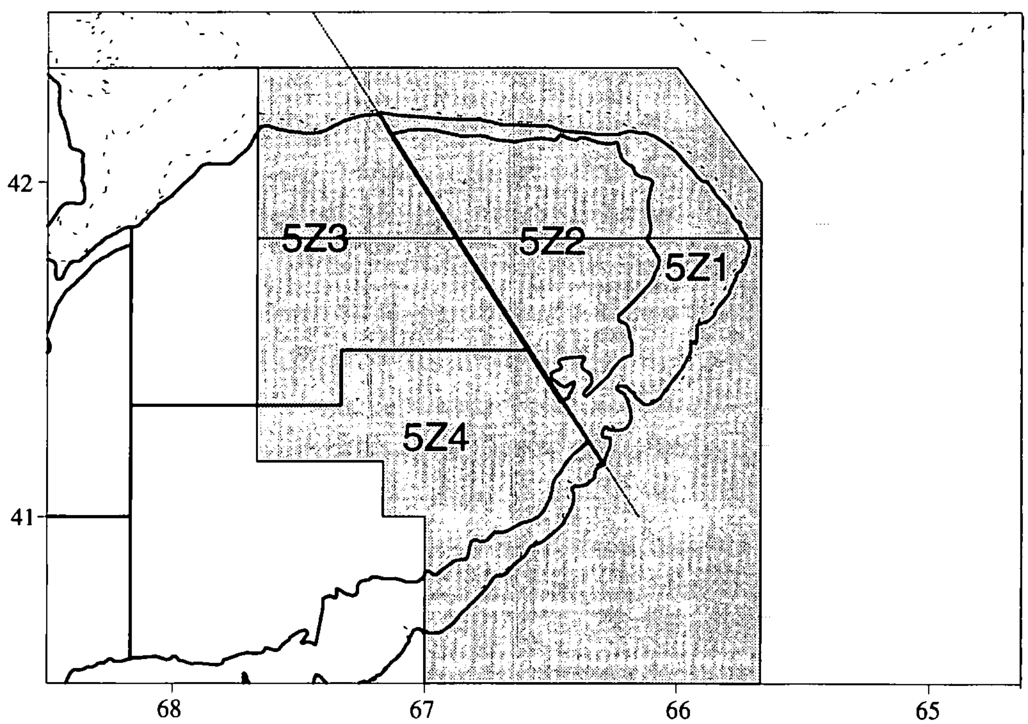


Fig. 9. Stratification scheme used for the Canadian survey. The 5Zjm management area is indicated by shading..

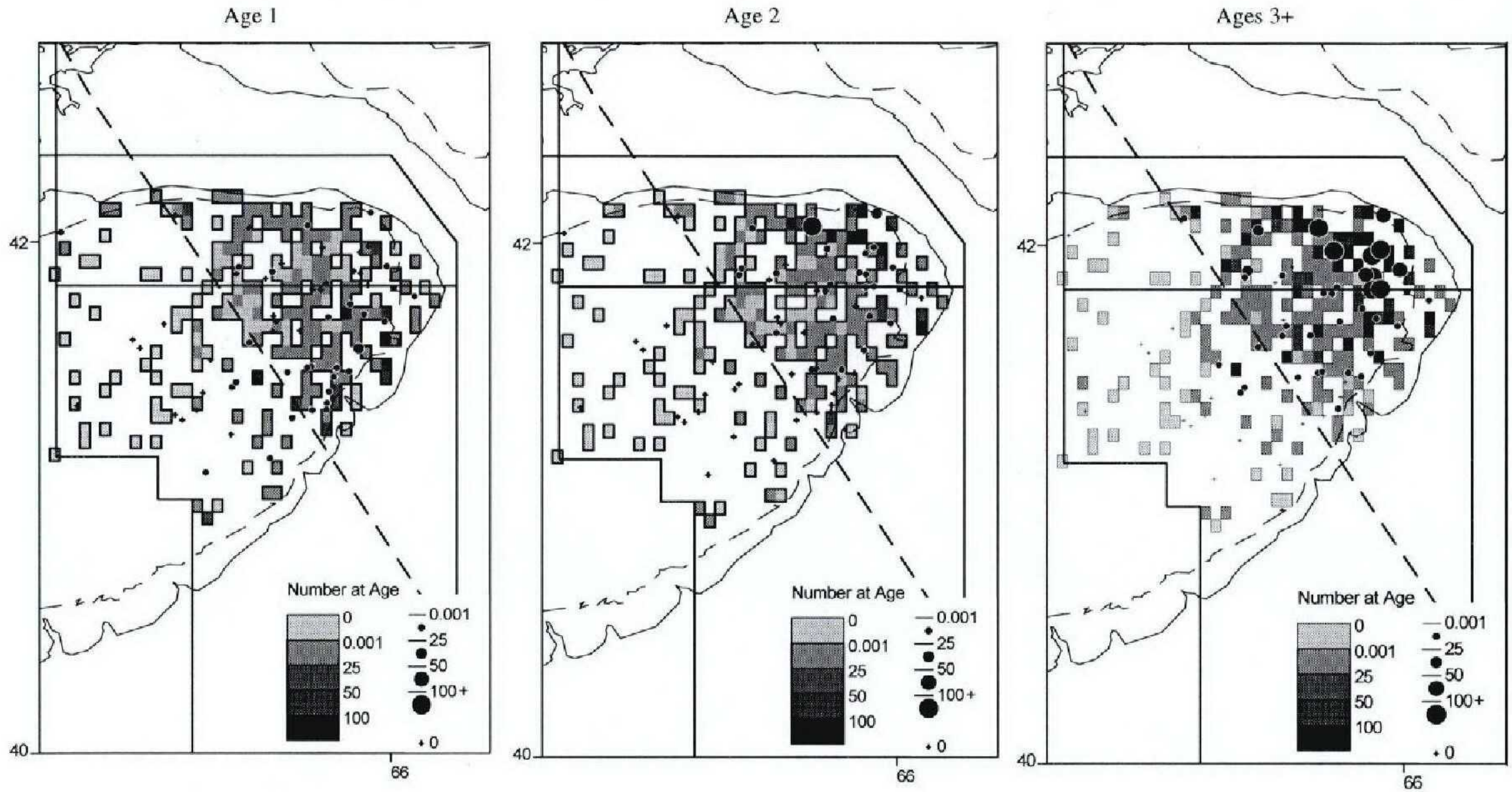


Fig. 10. Distribution of 5Zjm haddock as observed from the **DFO spring** survey. The squares are shaded relative to the average catch for 1992 to 1996. The expanding symbols represent the 1997 survey catches.

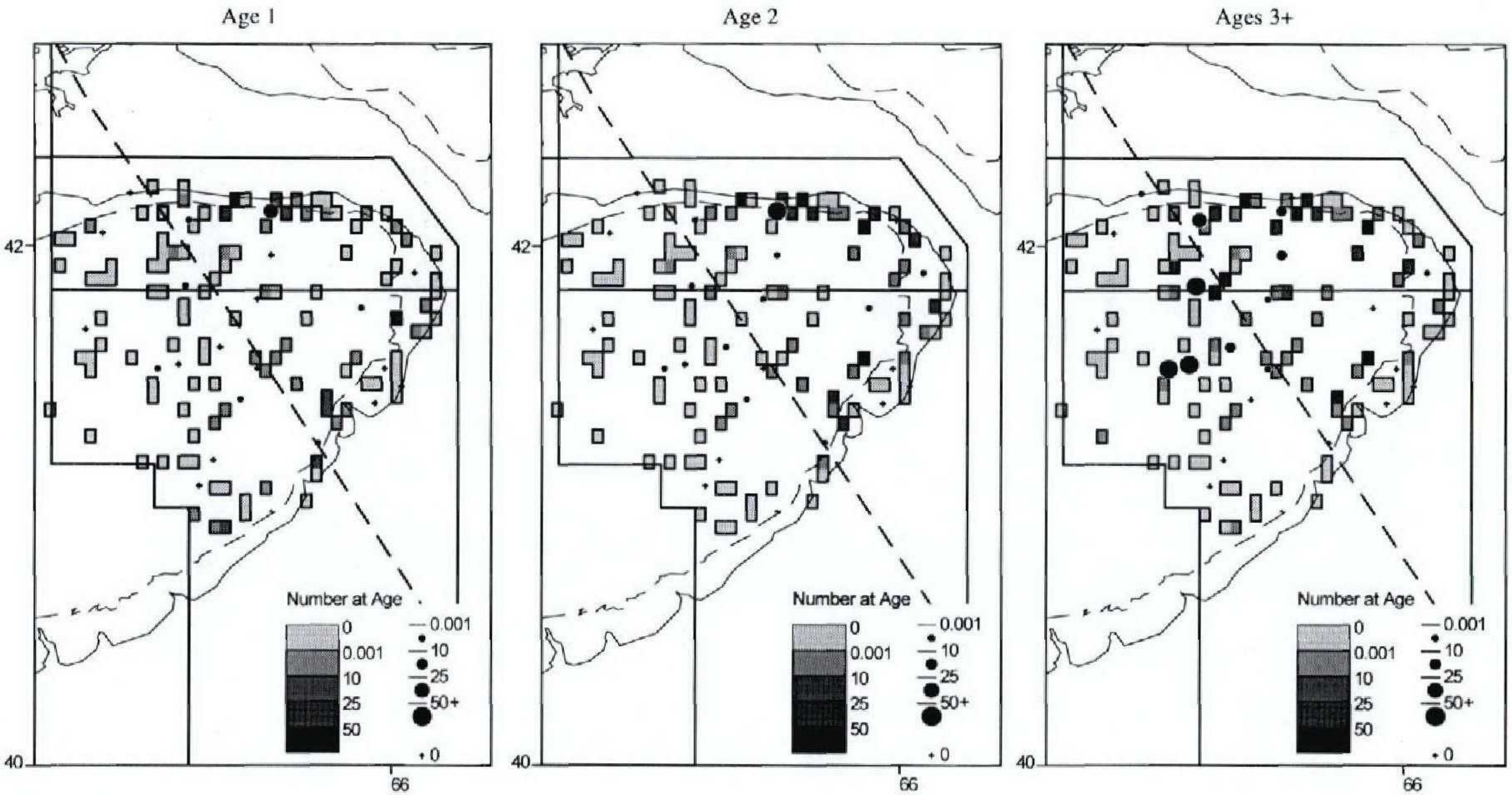


Fig. 11. Distribution of 5Zjm haddock as observed from the **NMFS spring** survey. The squares are shaded relative to the average catch for 1992 to 1996. The expanding symbols represent the 1997 survey catches.

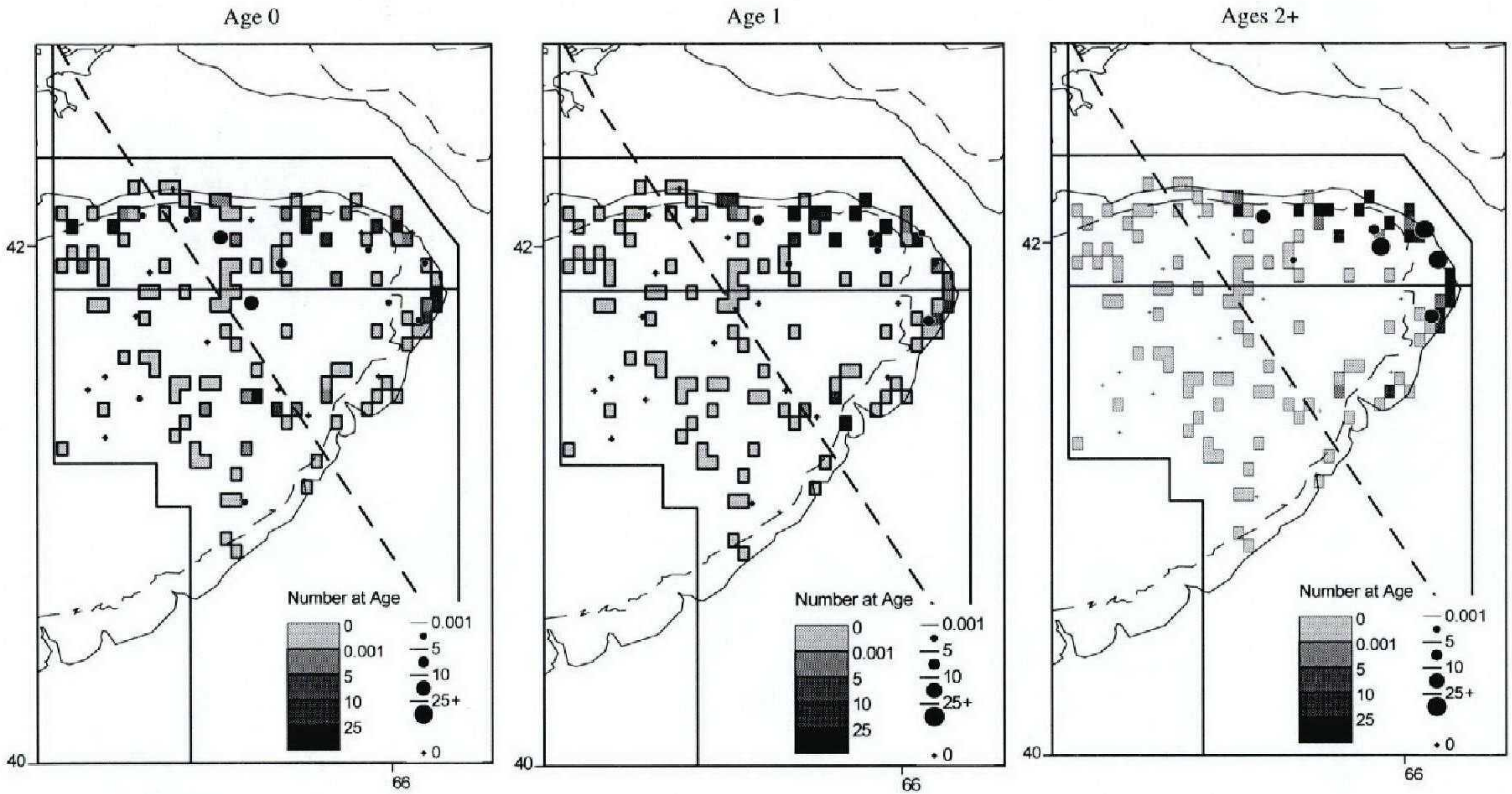


Fig. 12. Distribution of 5Zjm haddock as observed from the **NMFS fall** survey. The squares are shaded relative to the average catch for 1991 to 1995. The expanding symbols represent the 1996 survey catches.

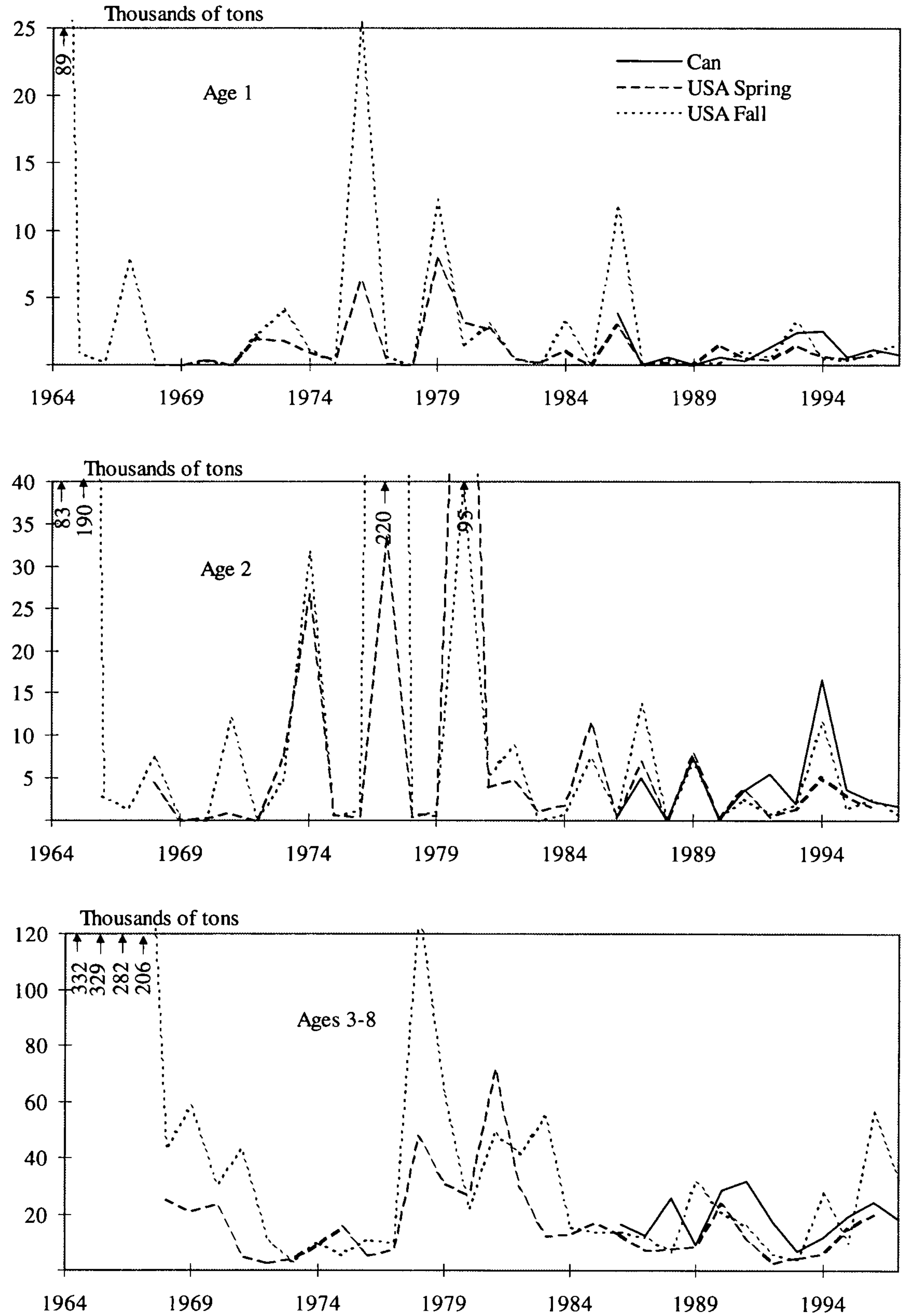


Fig. 13. Beginning of year biomass from research survey indices (adjusted by calibration constants) for haddock in unit areas 5Zjm. Fall values are compared to the beginning of the subsequent year.

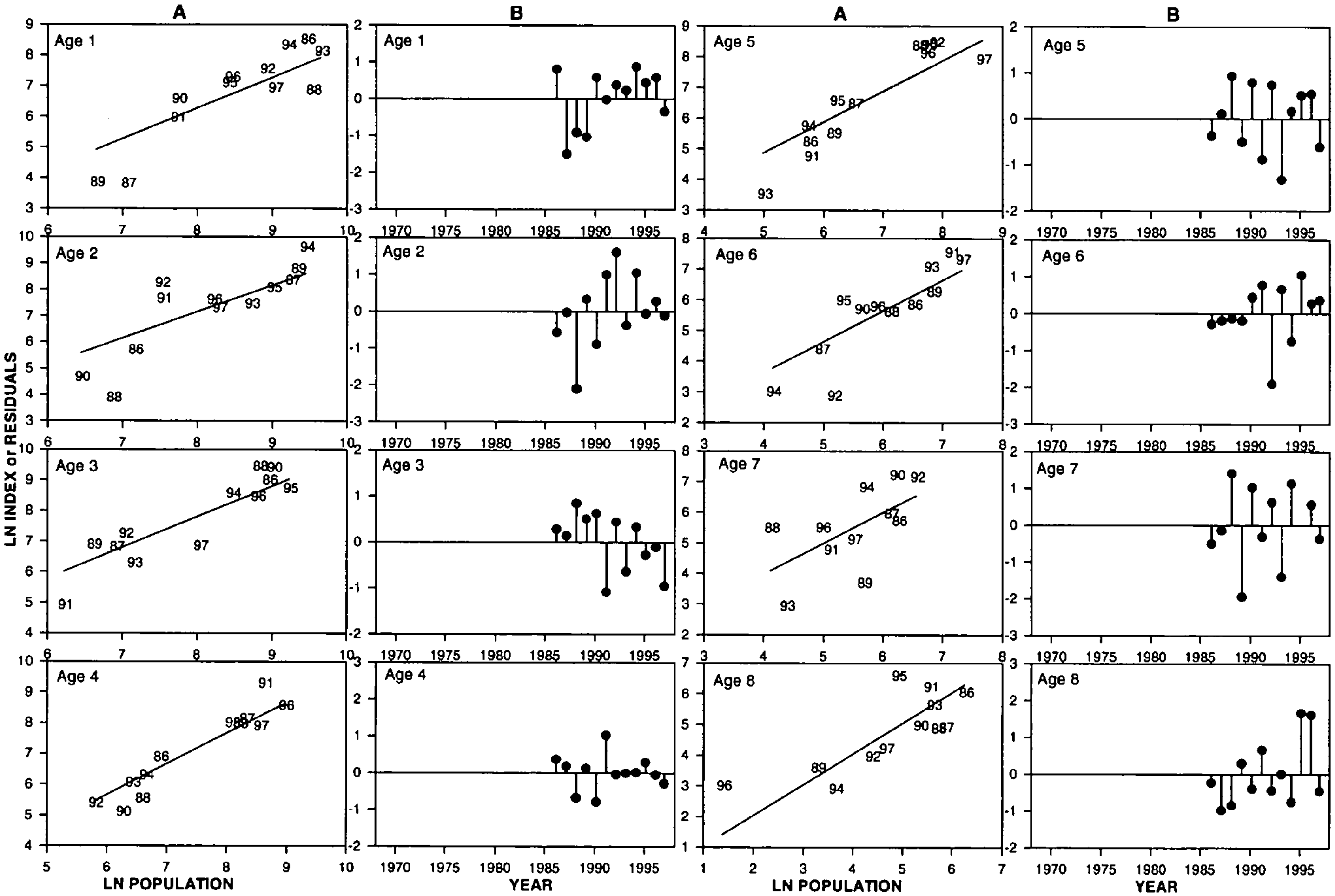


Fig. 14a. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers, and B) residuals plotted against year for haddock in unit areas 5Zj and 5Zm for the **DFO spring** survey.

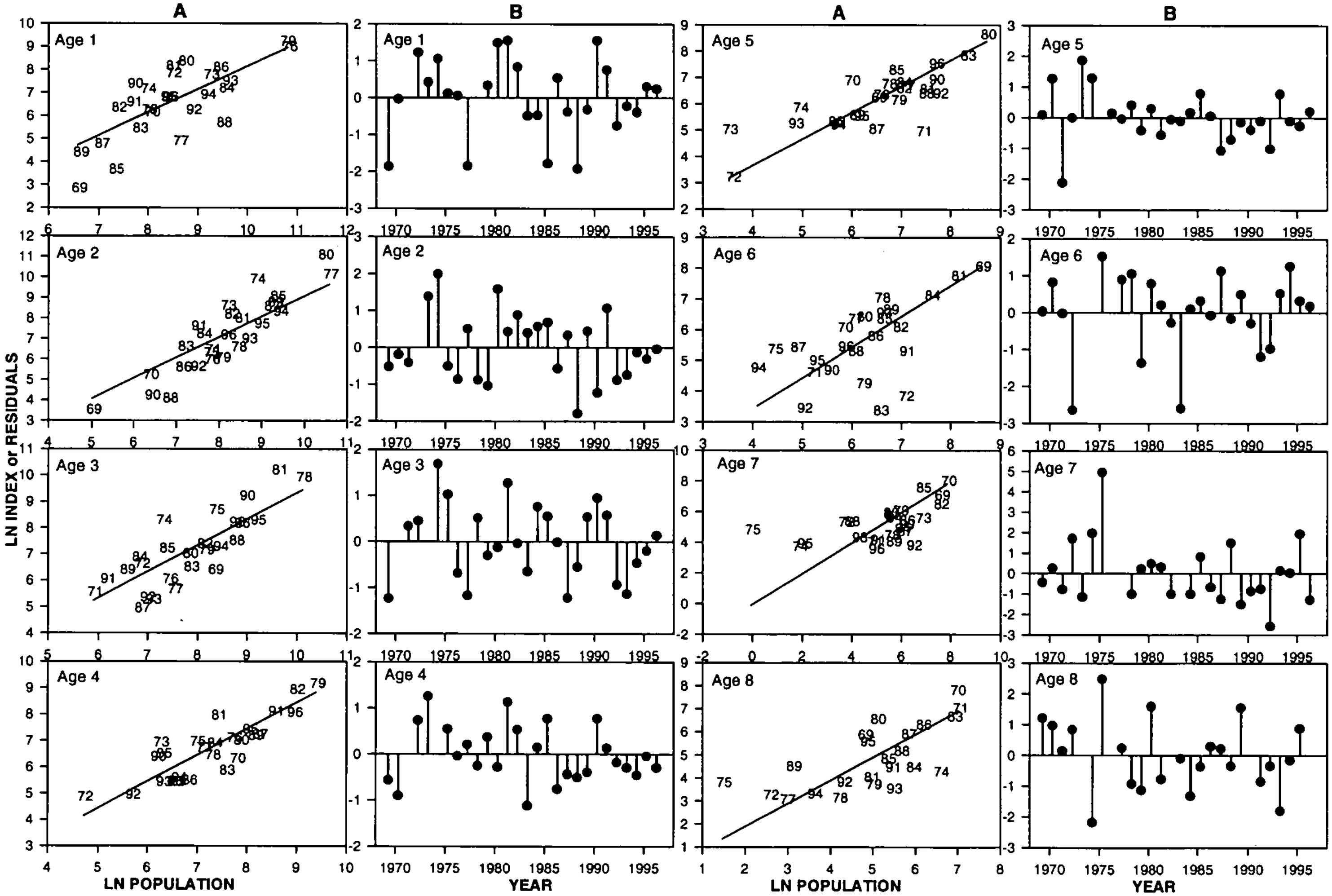


Fig. 14b. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers, and B) residuals plotted against year for haddock in unit areas 5Zj and 5Zm for the **NMFS spring** survey.

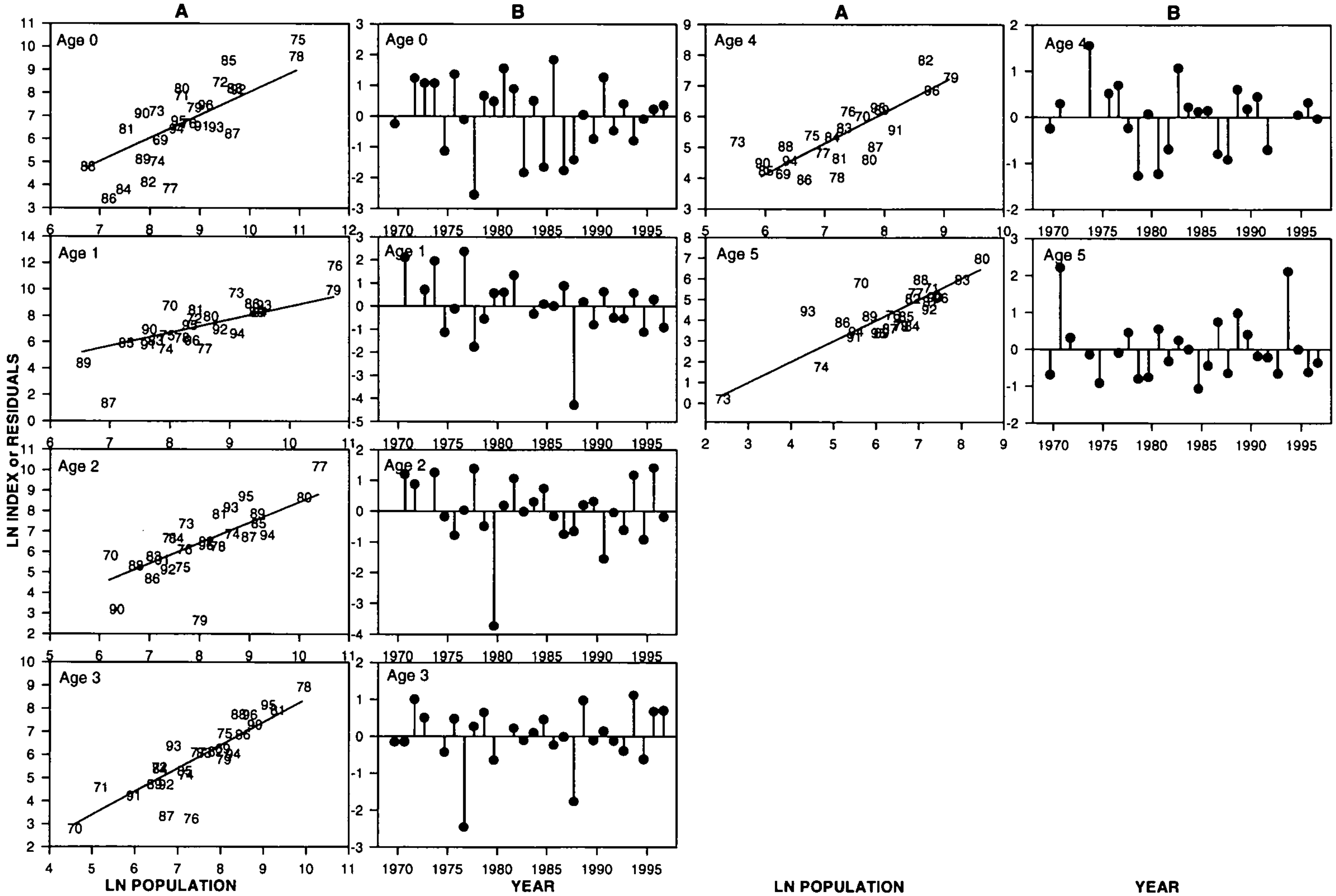


Fig. 14c. Age by age plots of A) the observed and predicted ln abundance index versus ln population numbers, and B) residuals plotted against year for haddock in unit areas 5Zj and 5Zm for the **NMFS fall** survey.

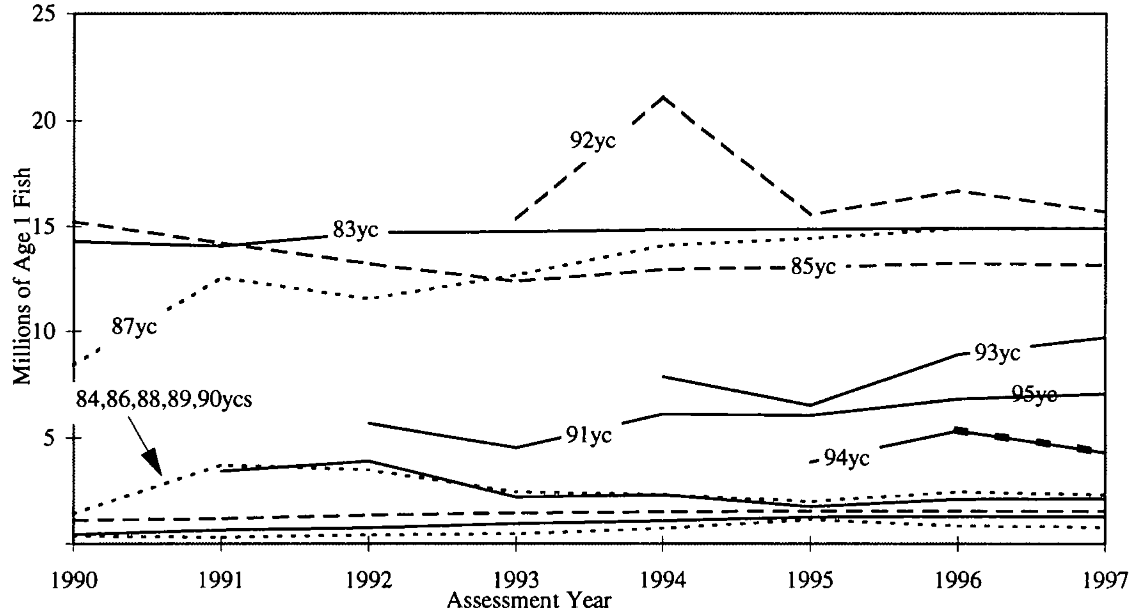


Fig. 15. Successive estimates of year-class abundance as additional years of data were included in the assessment did not display any persistent trends.

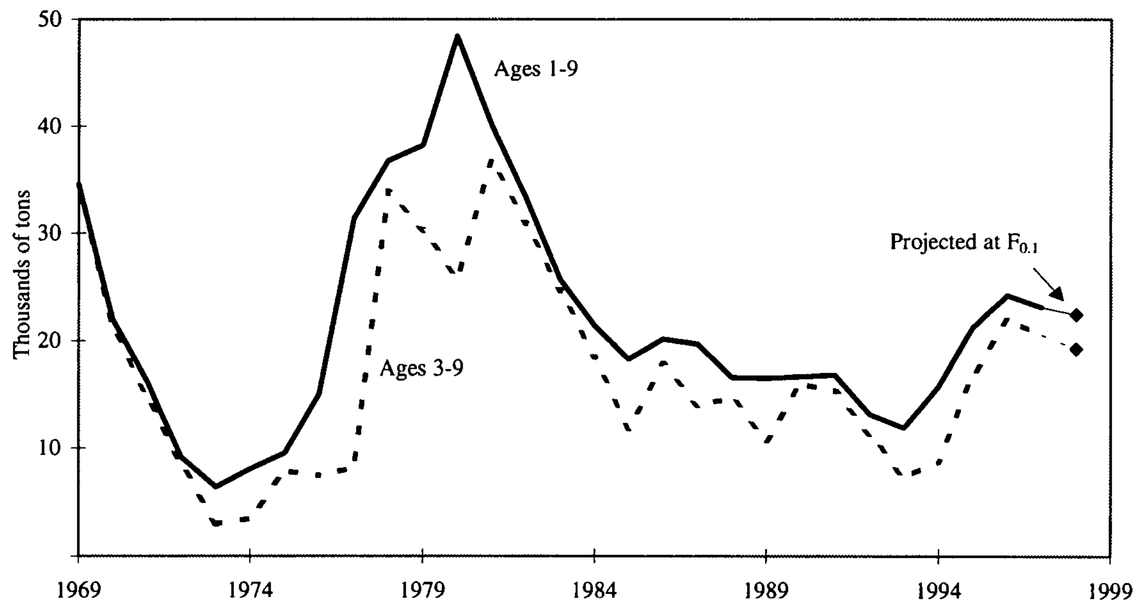


Fig. 16. Beginning of year biomass for haddock in unit areas 5Zjm.

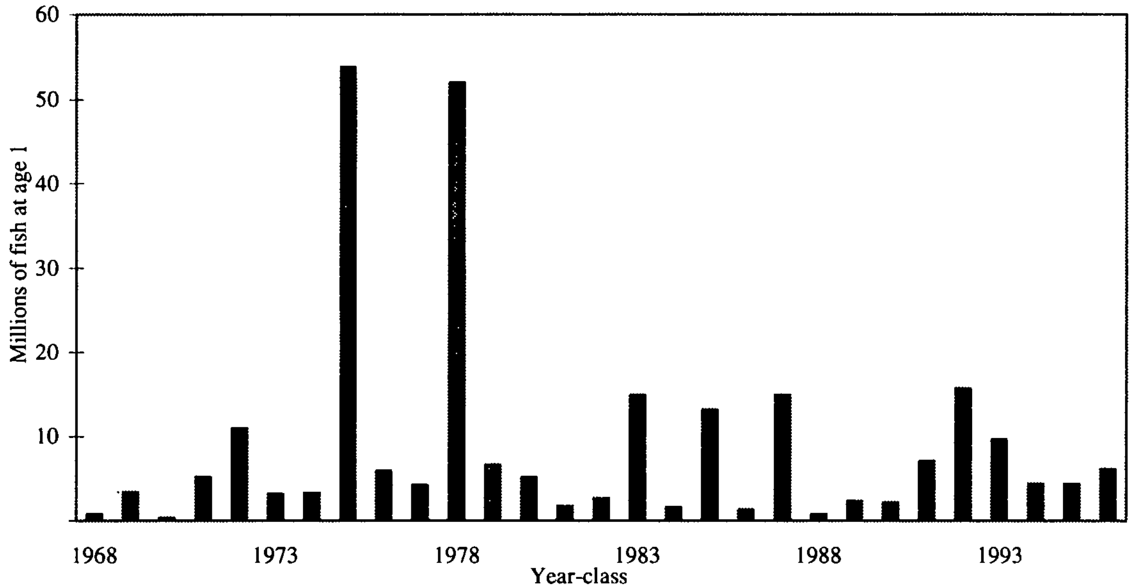


Fig. 17. Number of age 1 recruits for haddock in unit areas 5Zjm.

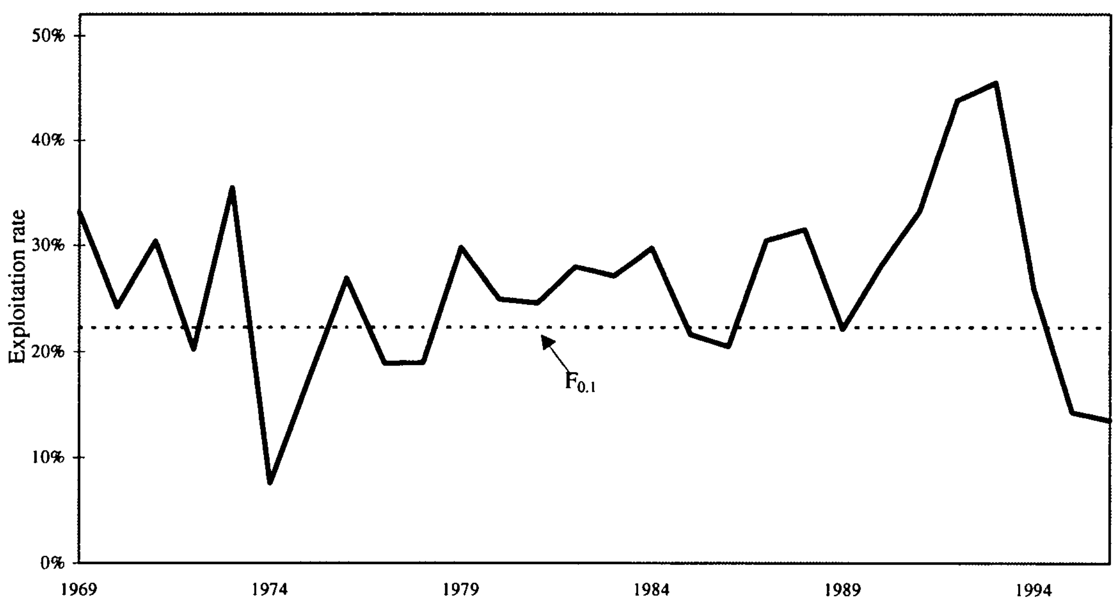


Fig. 18. Fishing mortality rate for haddock ages 4 and older in unit areas 5Zjm.

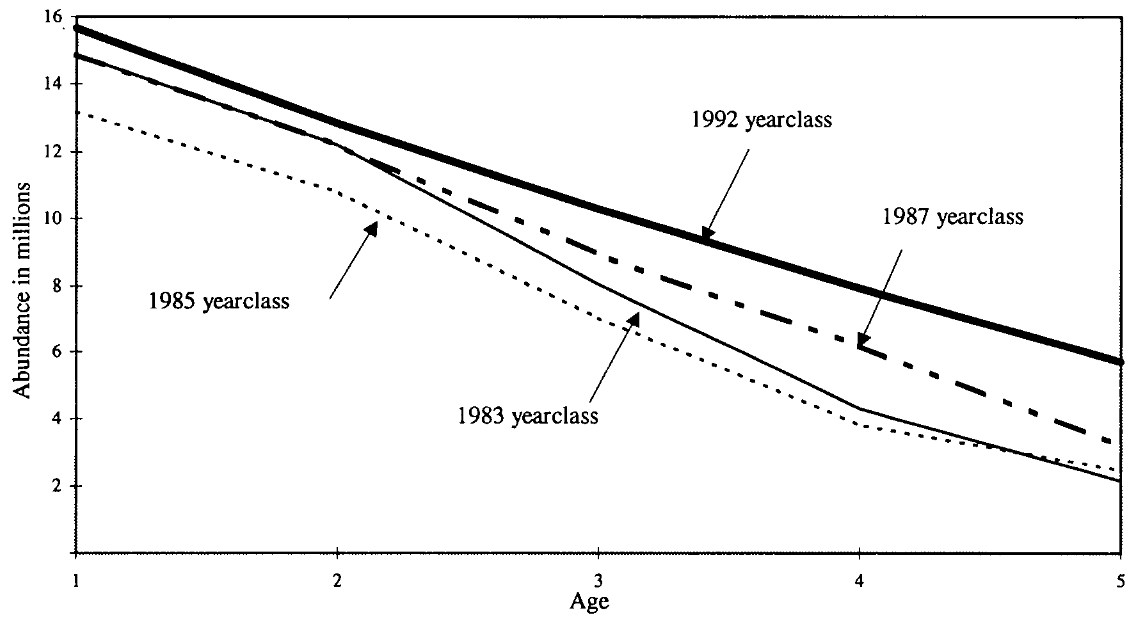


Fig. 19. Decay of the 1992 5Zjm haddock year-class versus the 1983, 1985 and 1987 as they progress through the fishery.

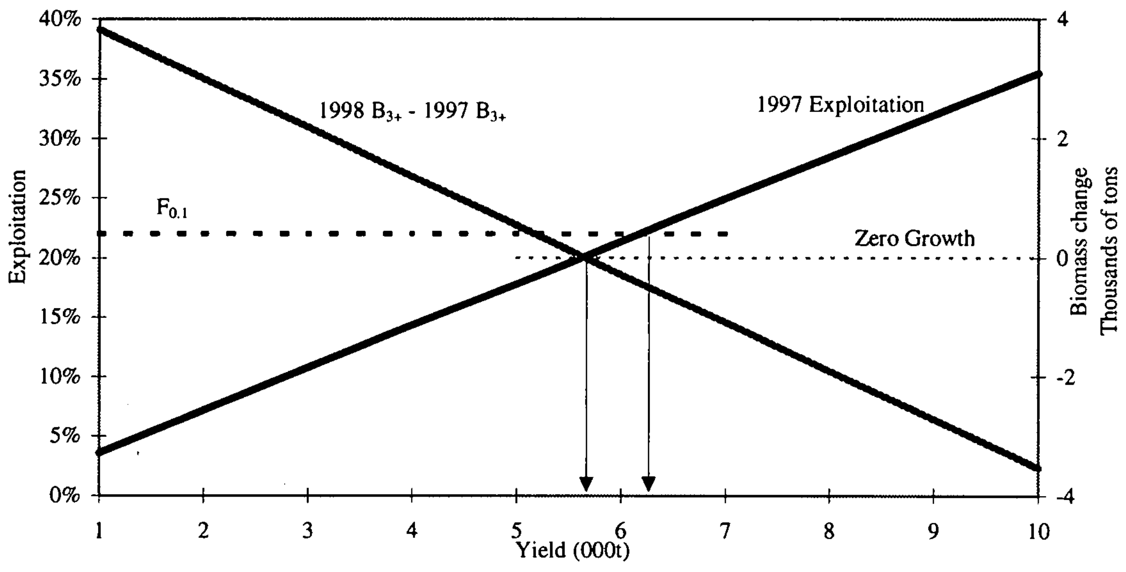


Fig. 20. Projected change in 5Z haddock biomass from 1997 to 1998 at various exploitation rates.

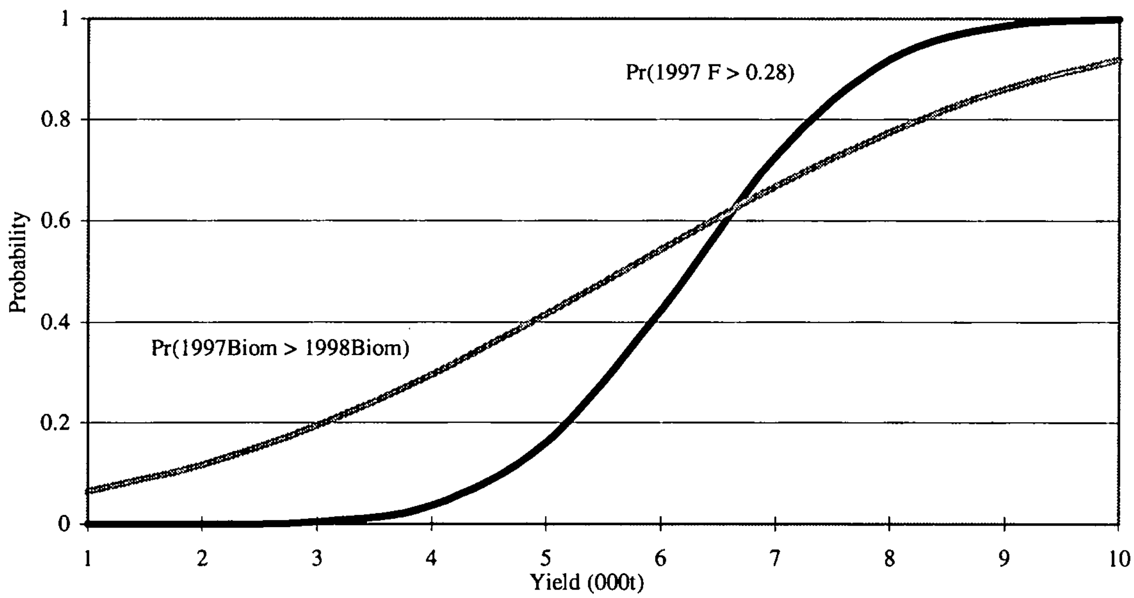


Fig. 21. Probability of the 5Z haddock fishing mortality exceeding the $F_{0.1}$ (=0.28) reference level and of the 1998 biomass being less than that of 1997 for various harvest levels.

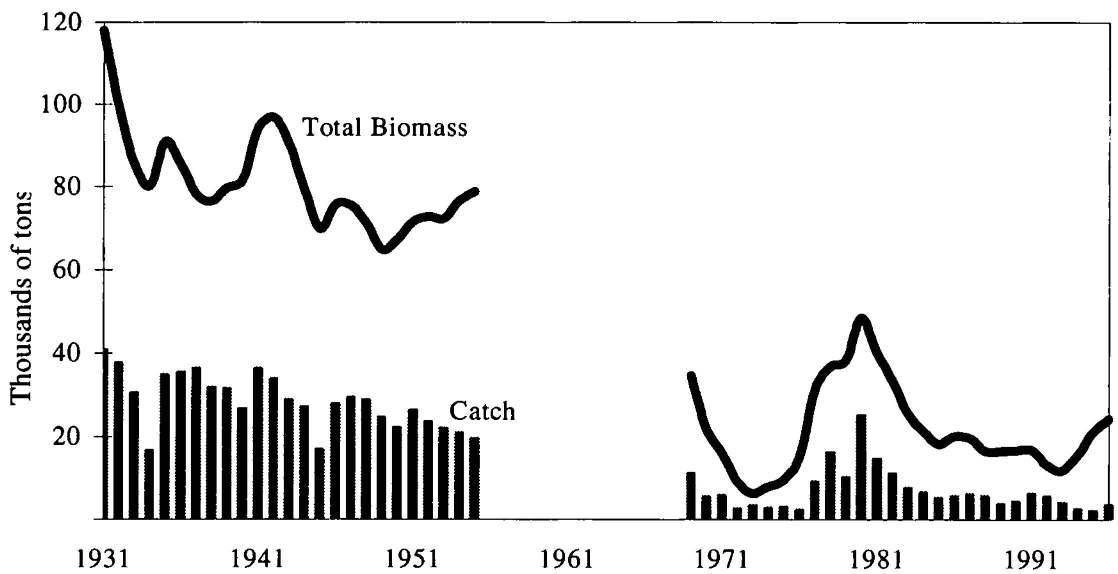


Fig. 22. Historic catch and biomass of haddock in 5Zjm compared to recent catches and biomass.

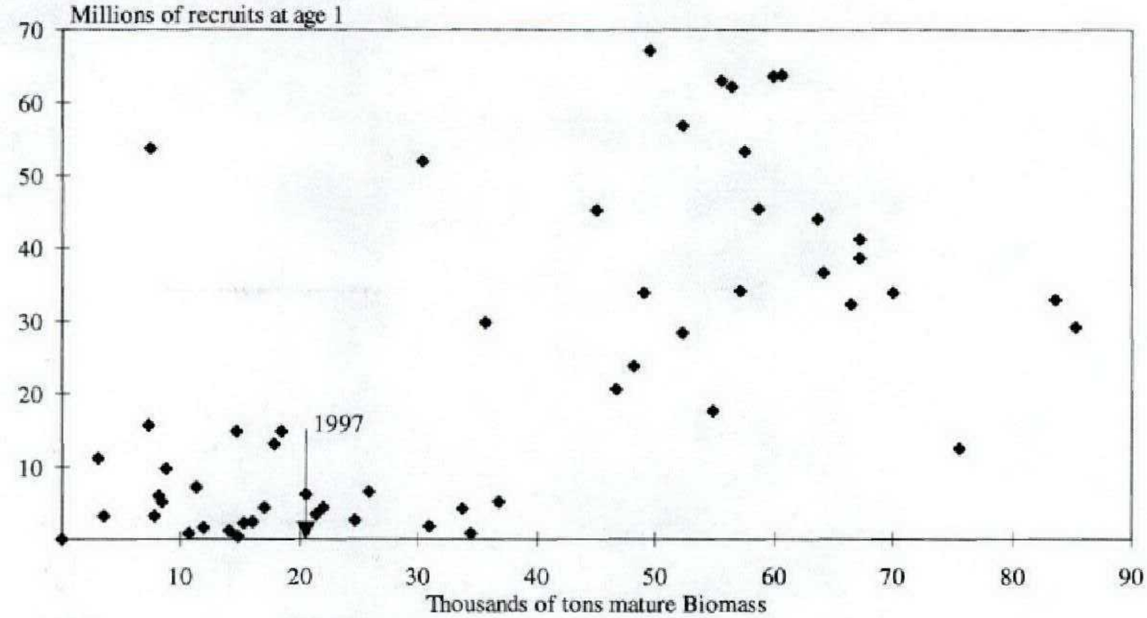


Fig. 23. Relationship between mature (3+) 5Zjm haddock biomass and recruits at age 1 from 1931 to 1955 and 1969 to 1997. The chance of observing a strong year-class when biomass is below about 40,000t is very poor.

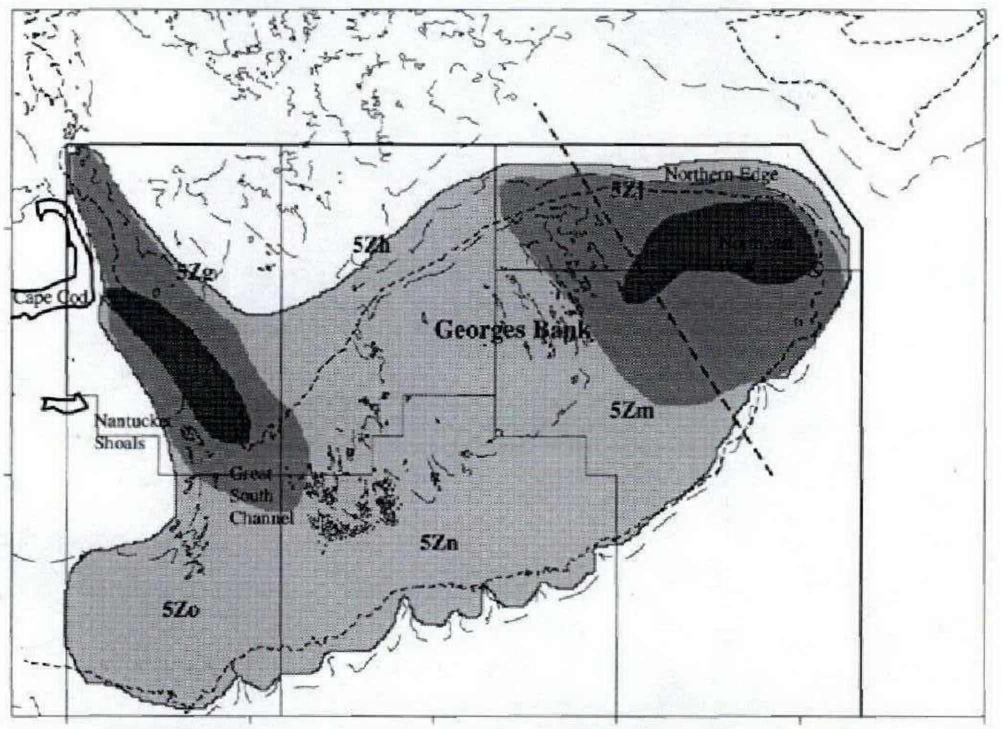


Fig. 24. The spawning components of the Georges Bank haddock stock are comprised of an eastern component on the Northeast Peak and a western component in the Great South Channel. Darker shading indicates higher density of aggregation on average over the year.

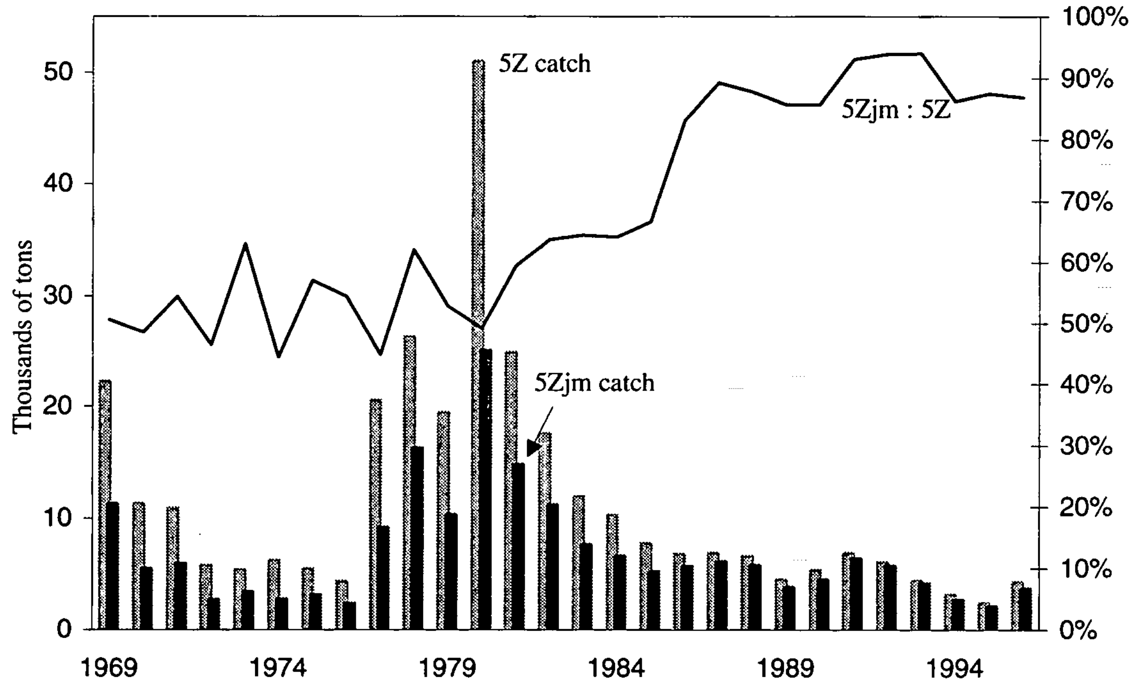


Fig. 25. Comparison of the catches of haddock in 5Z and 5Zjm and the 5Zjm to 5Z catch ratio.

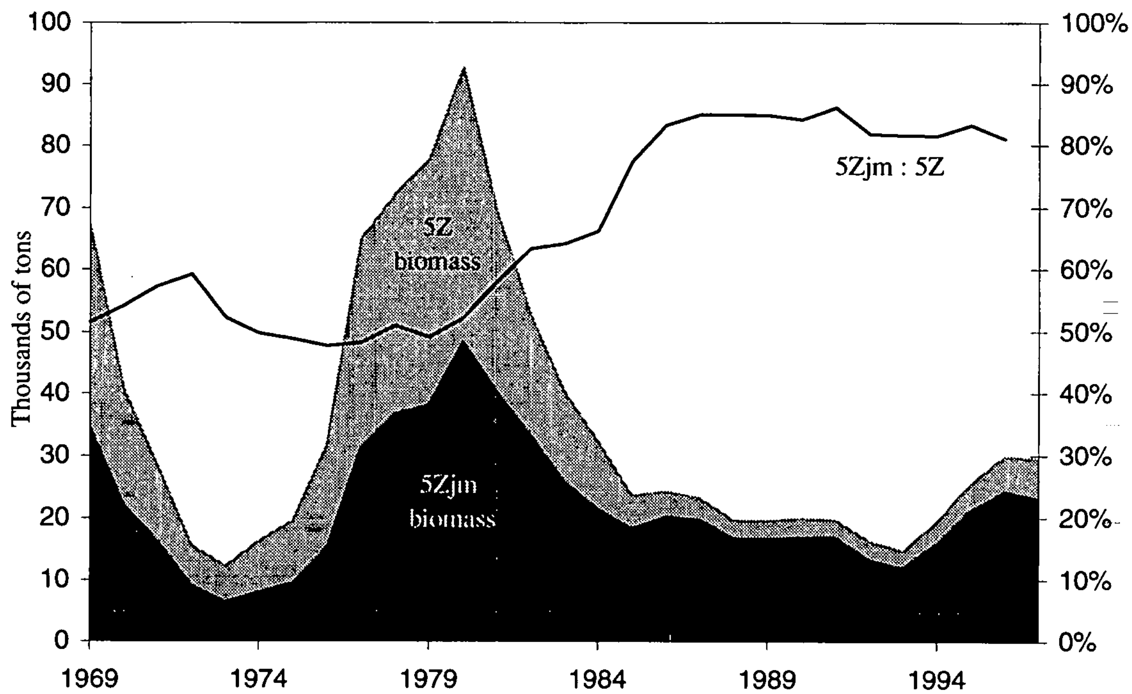


Fig. 26. Comparison of total haddock biomass in 5Z and 5Zjm and the 5Zjm to 5Z biomass ratio.

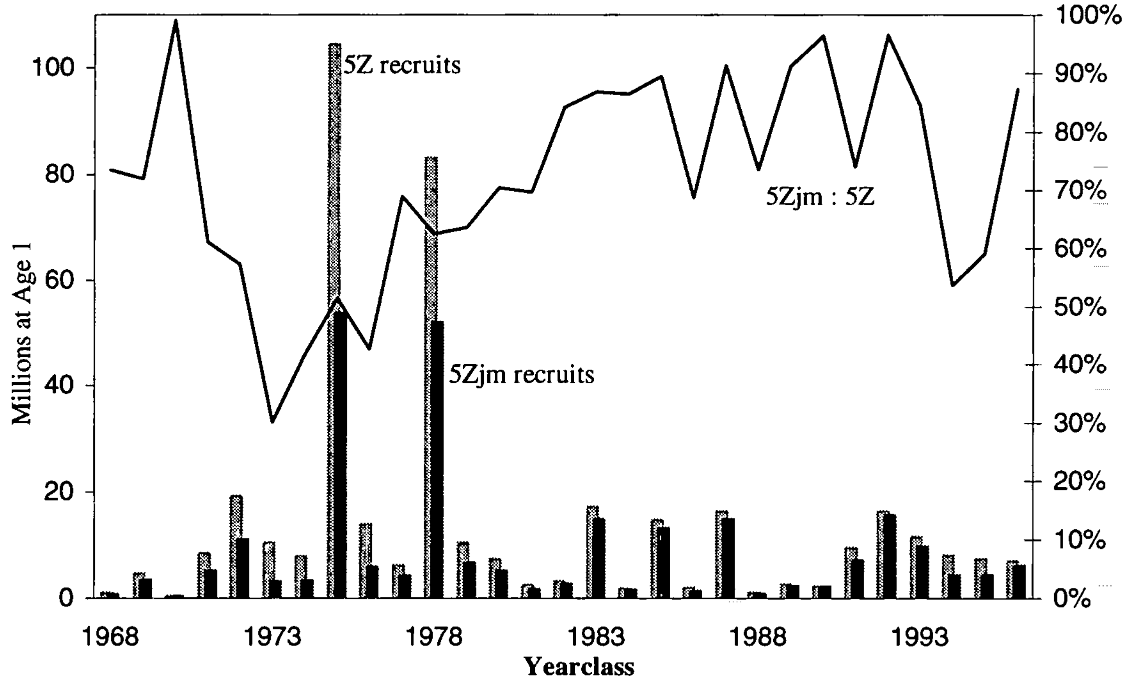


Fig. 27. Comparison of the number of haddock recruits at age 1 in 5Z and 5Zjm and the ratio of 5Zjm to 5Z recruits.

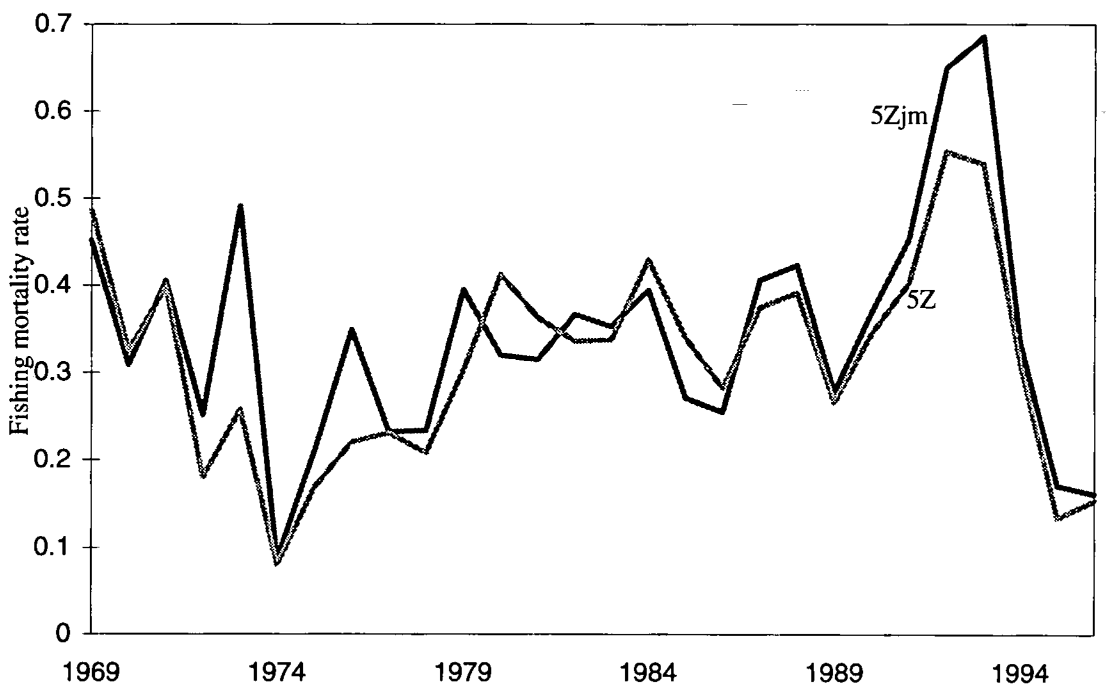


Fig. 28. Comparison of the fishing mortality levels for haddock in 5Z and 5Zjm.

Annex A. *Ageing Tests*

The 1996 Canadian spring survey was aged by L. Van Eeckhaute (LVE, primary age reader) and M. Strong (MS, secondary age reader) and the 1996 commercial fishery samples were aged by L. Van Eeckhaute. Intra-reader tests were completed using the survey and commercial fishery otoliths and an inter-reader test was completed using the survey material. Inter-reader tests between the two Canadian age readers and N. Munroe (NM), the USA age reader responsible for reading Georges Bank haddock, were also completed with 1996 Canadian survey material. Approximately half of the 1997 Canadian spring survey ageing material was aged by L. Van Eeckhaute but time did not permit a within reader test of this material. Test results are summarized in Table A1.

Within reader agreement for about 100 otoliths selected from the survey was 94% for M. Strong and 93% for L. Van Eeckhaute. Agreement between the readers was 85%. Note that otoliths which were not read by either or both readers were excluded from the calculations. Most of the inter-reader disagreement occurred from one reader assigning 20 otoliths to age 3 while the other reader assigned 5 of these to age 4 and 1 to age 5. Any ages from the survey that the secondary ager considered questionable were examined by the primary age reader and changes made to the database as considered appropriate. An intra-reader test of 124 otoliths from the commercial samples resulted in 92% agreement.

Fifty otoliths were used in the inter-reader tests with the USA age reader. Agreement was 84% between the two Canadian age readers, 70% and 72% between the USA age reader and the primary and secondary Canadian age readers, respectively (Tables A2 and A3). Agreement with the USA age reader was somewhat lower than it has been in the past with the USA reader tending to assign higher ages to younger fish and lower ages to older fish. This percent agreement was not expected to significantly affect the assessment results but an effort should be made to increase the percent agreement in the future.

Table A1.

Source	Test	No. of Otoliths	Agreement (%)
1996 Canadian spring survey	LVE vs. MS	100	85
	MS vs MS	111	94
	LVE vs LVE	91	93
1996 Canadian spring survey	LVE vs NM	50	70
	MS vs NM	50	72
	LVE vs MS	50	84
1996 commercial fishery	LVE vs LVE	124	92

Table A2. Ageing agreement matrix between L. Van Eeckhaute and N. Munroe for haddock otoliths from the 1996 DFO survey, N237, on Georges Bank.

	L.V.E.									
N.M	1	2	3	4	5	7	9	11	13	Total
1	5	0	0	0	0	0	0	0	0	5
2	1	6	0	0	0	0	0	0	0	7
3	0	0	6	0	0	0	0	0	0	6
4	0	0	2	10	2	0	0	0	0	14
5	0	0	0	0	7	0	0	0	0	7
6	0	0	0	0	3	2	0	0	0	5
7	0	0	0	0	0	0	1	0	0	1
8	0	0	0	0	0	0	1	1	0	2
9	0	0	0	0	0	0	0	1	0	1
11	0	0	0	0	0	0	0	1	0	1
12	0	0	0	0	0	0	0	0	1	1
Total	6	6	8	10	12	2	2	3	1	50

Agreement = 70%
Number of agreements = 35

Table A3. Ageing agreement matrix between M. Strong and N. Munroe for haddock otoliths from the 1996 DFO survey, N237, on Georges Bank.

	M. S.											
N. M.	1	2	3	4	5	6	7	8	9	10	11	Total
1	5	0	0	0	0	0	0	0	0	0	0	5
2	0	7	0	0	0	0	0	0	0	0	0	7
3	0	0	6	0	0	0	0	0	0	0	0	6
4	0	0	4	8	2	0	0	0	0	0	0	14
5	0	0	0	0	7	0	0	0	0	0	0	7
6	0	0	0	0	2	2	1	0	0	0	0	5
7	0	0	0	0	0	0	0	1	0	0	0	1
8	0	0	0	0	0	0	0	0	1	1	0	2
9	0	0	0	0	0	0	0	0	0	0	1	1
11	0	0	0	0	0	0	0	0	0	0	1	1
12	0	0	0	0	0	0	0	0	0	0	1	1
Total	5	7	10	8	11	2	1	1	1	1	3	50

Agreement = 72%
Number of agreements = 36

Annex B. *Construction of quarterly catch at age.*

Catch at age numbers by quarter for landings by Canada and the USA in 5Zjm, derived from available length frequency and age-length key samples, are given in Tables B1 and B2, respectively.

USA discard numbers in 1974, 1977, 1978 and 1980 for 5Zjm were calculated by applying the ratio of 5Zjm to 5Z USA landings to the 5Z discard numbers (pers. comm. R. Brown, NMFS). The same ratio was applied to the reported discard weights for 5Z (Overholtz et. al. 1983, see Table 2) to obtain discard weights for 5Zjm.

Year	Age	USA landings in 5Z (t)	USA landings in 5Zjm (t)	5Zjm/5Z landings ratio	5Z discard numbers ('000)	5Zjm discard numbers ('000)	5Z discard weight (t)	5Zjm discard weight (t)
1974	2	2,396	955	0.399	2,500	996	1,900	757
1977	2	7,934	2,429	0.306	13,455	4,119	9,688	2,966
1978	3	12,160	4,724	0.389	3,080	1,197	3,942	1,531
1980	2	17,470	5,615	0.321	24,812	7,976	23,513	7,557

Age 2 discard numbers were prorated to quarters using USA total landings by quarter. Age 3 discard numbers were prorated to quarters 1 and 2 only in the same way.

Discards for 1994, 1995 and 1996 were obtained from R. Brown (NMFS). All USA discard at age estimates are shown in Table B3.

Bulgaria, Cuba, the German Democratic Republic, Poland, Romania and the Union of Soviet Socialist Republics reported haddock catches from small mesh gear. S. Clark (pers. comm., NMFS) provided a catch at age for these landings in Div. 5Z by quarter, half-year or yearly. These were prorated to quarters (Table B4) using the NAFO monthly landings data for these countries. Forty percent of the small mesh catch in 5Z was attributed to 5Zjm, based on examination of the Union of Soviet Socialist Republic's fishing atlas.

Foreign regular groundfish gear landings of haddock were reported by Spain, France (St. Pierre and Miquelon), the United Kingdom and Ireland. These landings were prorated to ages using the Canadian plus USA catch at age and to quarters using the NAFO monthly landings data by country. Forty percent of the 5Z foreign landings were attributed to 5Zjm (Table B5).

Table B6 shows the total 5Zjm catch at age by quarter.

Table B1. Catch at age by quarter of haddock caught by the Canadian commercial fishery in 5Zj,m.

Canada	1	2	3	4	5	6	7	8	9+	1+
1969	0	0	18776	3105	4916	50931	15362	2072	4436	99598
1969.25	0	4330	213149	35885	62184	424302	111930	10701	47246	909726
1969.5	0	2977	287073	48870	29487	380496	117945	14204	23467	904518
1969.75	0	0	39237	13155	8487	107033	29636	1382	13865	212795
1970	0	313	0	6297	2046	1415	22218	6315	6722	45326
1970.25	0	1089	2487	69017	25254	23511	193090	77207	33281	424937
1970.5	0	31660	367	50731	27601	16894	164995	38432	18735	349414
1970.75	3978	2399	0	3083	1639	4610	29769	8724	1332	55534
1971	0	163	112	58	382	177	223	1763	1026	3904
1971.25	0	51018	36635	5484	25802	22174	28425	67171	45769	282478
1971.5	0	310712	23395	0	22989	12454	0	64761	22047	456358
1971.75	0	129000	11251	411	18318	6427	4757	39719	15253	225136
1972	0	0	10700	1720	719	6446	557	1572	24698	46413
1972.25	0	0	22918	3010	1243	4919	4360	124	19257	55831
1972.5	71285	0	43397	11288	2193	3611	1234	890	32592	166489
1972.75	18518	0	11274	2932	570	938	321	231	8467	43250
1973	0	4526	0	838	319	69	200	169	1920	8041
1973.25	0	88977	1496	23140	2897	1397	2129	224	16712	136972
1973.5	86897	596495	0	133061	9321	1185	12917	1796	24521	866193
1973.75	20293	139300	0	31074	2177	277	3016	419	5726	202282
1974	0	7687	5074	0	80	118	0	330	1179	14468
1974.25	0	30418	8217	0	3038	0	0	2072	2877	46623
1974.5	0	127617	13958	0	519	0	0	1034	857	143986
1974.75	0	103135	11280	0	420	0	0	836	692	116363
1975	0	0	9752	682	42	276	35	32	419	11238
1975.25	0	3333	69980	19480	538	4024	45	207	2899	100507
1975.5	0	144202	394088	25338	0	229	0	0	0	563858
1975.75	0	56593	154661	9944	0	90	0	0	0	221288
1976	0	4180	7346	21525	2243	0	92	0	599	35985
1976.25	6674	61855	52684	217983	30345	0	5491	0	1879	376910
1976.5	47730	50108	46848	135897	27093	0	3689	0	3646	315012
1976.75	3774	3962	3704	10746	2142	0	292	0	288	24909
1977	0	8422	15190	13795	57348	27485	0	820	458	123518
1977.25	0	503668	3854	10187	7168	3633	0	369	186	529065
1977.5	0	1770078	13545	35800	25189	12768	0	1297	653	1859332
1977.75	0	127269	974	2574	1811	918	0	93	47	133687
1978	0	0	678076	11443	18708	42929	5765	748	1569	759239
1978.25	0	3233	226638	3129	7467	10251	2341	497	694	254250
1978.5	197	32207	658233	11086	3762	6342	3405	0	0	715231

Canada	1	2	3	4	5	6	7	8	9+	1+
1978.75	1286	210450	4301144	72437	24581	41443	22252	0	0	4673594
1979	0	0	7582	632438	24741	39929	27980	5568	1546	739785
1979.25	0	0	33777	618620	71058	37068	29502	1348	398	791771
1979.5	0	4836	42844	649510	73627	11576	19076	8539	793	810802
1979.75	0	2927	12178	143132	3406	430	0	0	0	162073
1980	0	125282	0	2849	53619	900	633	220	7	183509
1980.25	0	2516016	275313	41130	288530	22342	14984	3947	1126	3163389
1980.5	2011	4273838	14433	55300	239513	23800	80	4423	2452	4615849
1980.75	603	1758239	6184	25165	103385	10695	24	1648	1111	1907054
1981	0	30765	483823	40837	32489	107025	9980	512	512	705943
1981.25	0	6779	531323	16809	77726	201262	11969	5372	0	851239
1981.5	0	152339	1028186	69456	57990	74437	10774	0	266	1393447
1981.75	0	51671	329884	21330	16261	21306	2271	0	37	442761
1982	0	4836	52363	143892	2404	19912	22248	550	731	246935
1982.25	0	23499	95717	430651	12072	33143	21474	360	1033	617949
1982.5	0	141715	241732	551329	63909	13832	59586	5462	3671	1081236
1982.75	0	141812	79321	264251	18995	37007	90693	3057	0	635135
1983	0	1683	5926	11977	34701	4175	471	4420	118	63470
1983.25	0	16063	131313	93990	362310	29902	15338	42006	969	691892
1983.5	0	42171	251461	169572	221475	19014	8722	23301	5072	740789
1983.75	0	35635	35833	16864	37431	8759	5669	8689	132	149012
1984	0	17	545	2122	3303	9800	4056	2164	7503	29510
1984.25	0	8768	17547	27380	23926	73878	28749	14880	40222	235350
1984.5	0	1149	15861	24733	29753	137437	12723	18984	30791	271431
1984.75	0	53	499	2274	3310	8554	4771	2183	8685	30331
1985	3	1911	1524	1530	1930	1502	3765	1140	3050	16356
1985.25	175	67469	43266	31954	33144	18799	29779	7758	20708	253052
1985.5	2	1469812	195476	59965	39784	25485	38652	9640	27429	1866244
1985.75	0	482581	64495	20178	13779	9016	14547	3744	10555	618895
1986	68	191	30648	3175	4786	3392	2577	3023	2441	50300
1986.25	3539	4310	845239	61833	26871	21370	10570	9540	2507	985777
1986.5	2078	32279	786675	17810	32216	22443	12317	22961	12858	941637
1986.75	54	846	38290	3188	6421	4490	3438	4281	3452	64461
1987	0	36785	3254	46701	4515	1725	1518	2650	5199	102346
1987.25	0	954555	39857	460315	10410	3543	8080	5612	17949	1500321
1987.5	0	939342	43085	531109	39622	24076	18617	17061	39535	1652447
1987.75	0	54824	3651	50095	4933	2371	1845	2575	5231	125525
1988	50	634	39927	3567	42148	5550	1057	1450	14373	108756
1988.25	19	37243	927081	32494	196987	19694	3667	7902	39538	1264625
1988.5	3783	12379	876136	42919	138052	25627	2404	6040	28105	1135445
1988.75	135	442	34701	2068	12778	1944	289	479	3805	56640

Canada	1	2	3	4	5	6	7	8	9+	1+
1989	0	2858	519	32994	7456	23299	1053	284	6978	75440
1989.25	0	819103	30414	282389	14907	64127	7637	1598	14054	1234229
1989.5	0	160275	18526	231125	28946	103120	3537	5641	15932	567102
1989.75	0	149265	18421	76587	12287	11409	645	161	451	269226
1990	0	293	30984	887	15094	746	5604	720	1334	55663
1990.25	0	3478	367334	10512	178952	8847	66439	8538	15811	659910
1990.5	935	461	629837	42744	261867	2641	39974	19376	13885	1011720
1990.75	650	1855	41668	820	45306	2230	9998	0	2697	105224
1991	0	1578	0	54203	0	39968	3012	26322	9803	134886
1991.25	1524	184440	41786	747693	13250	94151	15652	39639	20094	1158230
1991.5	1188	170820	13151	746756	23484	125099	3914	50252	21030	1155694
1991.75	2895	72241	7140	259980	13163	38104	5105	7043	7013	412685
1992	0	21681	22092	8517	109684	1727	21469	0	11484	196655
1992.25	0	80917	82451	31787	409358	6445	80126	0	42861	733946
1992.5	405	42969	81126	16366	366823	6306	82187	601	23168	619951
1992.75	6095	84610	50914	5505	133836	0	28232	2815	9110	321117
1993	0	7784	58636	87575	28024	213814	3399	72204	40196	511634
1993.25	0	10812	63751	63651	23478	145109	2061	30941	15434	355236
1993.5	0	64275	119862	62387	12304	144384	1816	26591	11000	442620
1993.75	6591	162806	76475	30981	4983	47571	160	13032	2300	344901
1994	0	0	0	0	0	0	0	0	0	0
1994.25	0	13544	81111	27506	13946	5592	44975	1058	10266	197999
1994.5	413	133305	429002	83838	20833	13546	43291	11697	24021	759945
1994.75	0	63600	193073	26041	14235	13720	19188	446	2867	333170
1995	112	386	1283	441	48	44	0	51	9	2373
1995.25	0	9645	170319	150610	24090	18354	0	22447	5310	400774
1995.5	0	32004	225354	188483	15265	4380	794	20999	6903	494182
1995.75	1175	13808	115191	65811	12140	1375	1433	6615	2620	220169
1996	0	0	0	0	0	0	0	0	0	0
1996.25	31	2657	135031	254856	125126	15622	6168	0	21350	560842
1996.5	0	13902	219827	431668	184793	20695	5571	2812	34554	913823
1996.75	87	8150	104512	165225	108832	23425	5403	0	14654	430288

Table B2. Catch at age by quarter of haddock landed by the USA commercial fishery in 5Zj,m.

USA	1	2	3	4	5	6	7	8	9+	1+
1969	0	0	209401	34632	54824	568014	171323	23103	49473	1110769
1969.25	0	9115	448687	75538	130899	893173	235618	22526	99455	1915011
1969.5	0	1182	114026	19411	11712	151134	46848	5642	9321	359276
1969.75	0	0	46361	15544	10027	126466	35017	1633	16382	251431
1970	0	1838	0	37012	12027	8320	130592	37117	39513	266419
1970.25	0	1608	3672	101889	37282	34709	285055	113979	49132	627328
1970.5	0	33001	383	52879	28770	17610	171984	40060	19528	364214
1970.75	9278	5596	0	7190	3823	10750	69425	20346	3106	129514
1971	0	14963	10340	5300	35130	16319	20508	162171	94397	359127
1971.25	0	158301	113671	17016	80059	68801	88197	208419	142015	876480
1971.5	0	300475	22625	0	22231	12044	0	62627	21320	441322
1971.75	0	91929	8018	293	13054	4580	3390	28305	10870	160439
1972	0	0	38663	6216	2598	23291	2013	5682	89242	167707
1972.25	0	0	120193	15784	6517	25800	22864	653	100989	292800
1972.5	82569	0	50267	13075	2540	4183	1430	1031	37751	192844
1972.75	42918	0	26128	6796	1320	2174	743	536	19622	100237
1973	0	92445	0	17106	6522	1406	4089	3462	39210	164239
1973.25	0	283769	4772	73798	9239	4455	6789	714	53299	436835
1973.5	35271	242115	0	54009	3783	481	5243	729	9953	351585
1973.75	6298	43230	0	9643	675	86	936	130	1777	62775
1974	0	99657	65783	0	1031	1531	0	4284	15279	187566
1974.25	0	183274	49512	0	18306	0	0	12486	17335	280912
1974.5	0	179833	11829	0	609	0	0	522	522	193316
1974.75	0	88845	5844	0	301	0	0	258	258	95506
1975	0	0	165778	11602	716	4700	593	538	7126	191053
1975.25	0	19925	418350	116454	3216	24057	271	1240	17331	600845
1975.5	0	31972	143248	11423	0	179	0	0	0	186822
1975.75	0	12635	56611	4514	0	71	0	0	0	73832
1976	0	5466	15708	120555	16523	0	1028	0	7976	167256
1976.25	0	20888	35533	283200	43267	0	7844	0	2718	393450
1976.5	0	632	1076	8573	1310	0	237	0	82	11911
1976.75	0	628	1068	8509	1300	0	236	0	82	11821
1977	0	10018	17539	23549	85441	42589	0	1822	3389	184345
1977.25	0	388516	12820	69172	96967	60396	0	10253	9638	647763
1977.5	0	565339	0	14065	18040	8579	0	0	0	606023
1977.75	0	343460	0	8545	10960	5212	0	0	0	368177
1978	0	0	560632	20860	25496	70966	8983	2070	3211	692220
1978.25	0	10460	1301050	21831	76897	106422	26848	6913	2772	1553194
1978.5	0	16671	528448	11905	7232	13649	5876	0	462	584243

USA	1	2	3	4	5	6	7	8	9+	1+
1978.75	0	11968	379373	8547	5192	9799	4218	0	332	419429
1979	0	0	5329	439823	18057	31020	26150	6417	2144	528939
1979.25	0	0	42447	870512	95738	67241	90007	9378	4533	1179858
1979.5	0	4143	36421	600851	68301	12233	21619	11895	3523	758985
1979.75	0	3417	18676	295589	6929	1178	544	0	1087	327420
1980	0	13617	0	79238	852825	57413	53916	23962	892	1081864
1980.25	0	136695	39462	70395	712168	59240	58094	12246	3247	1091547
1980.5	0	497635	4079	16594	102947	11063	852	2847	1984	638000
1980.75	0	263493	2160	8786	54509	5858	451	1508	1051	337815
1981	0	71637	1572095	135899	72317	293783	36901	8536	3283	2194452
1981.25	0	29162	1185570	29441	154427	408960	32598	18640	0	1858798
1981.5	0	240684	1177046	59753	62665	96574	10652	0	2364	1649738
1981.75	0	77451	378766	19228	20165	31077	3428	0	761	530876
1982	0	61527	168489	254366	13115	82676	210156	17495	25984	833807
1982.25	0	46011	222644	803413	54166	154318	215722	27072	30366	1553712
1982.5	0	210246	156390	246410	28435	9758	46686	4525	3504	705953
1982.75	0	82872	31134	104942	7704	26443	56350	3448	0	312893
1983	0	1859	28267	90941	338350	54735	18200	159893	12730	704974
1983.25	0	4191	93921	81522	461498	48102	25307	115890	6781	837212
1983.5	0	16568	73051	58181	103554	9566	8632	20406	6582	296541
1983.75	0	21466	28246	22887	69662	33141	21401	27463	1986	226254
1984	0	0	31449	55602	85936	384437	38257	54862	87545	738087
1984.25	0	48384	92519	121907	85844	292035	90854	51595	98861	881999
1984.5	0	12845	64013	76175	22974	151269	4392	14552	28781	375001
1984.75	0	5277	26299	31296	9439	62148	1804	5978	11825	154067
1985	0	0	7584	7954	37116	22047	96842	7845	29712	209099
1985.25	0	4893	28409	51024	46143	40837	173435	19186	22233	386159
1985.5	0	17960	16757	1549	8677	2737	6921	1704	103	56409
1985.75	0	17960	16757	1549	8677	2737	6921	1704	103	56409
1986	0	0	192031	55680	19214	31665	54166	82055	12162	446974
1986.25	0	0	646145	29745	49347	34813	31707	44813	6772	843343
1986.5	0	0	9900	896	1605	2292	1572	3270	230	19766
1986.75	0	0	8284	750	1343	1918	1316	2737	193	16539
1987	0	1022	20406	100632	6885	5716	6634	4521	2717	148533
1987.25	0	1080	5704	291756	25178	15795	36855	26859	30288	433516
1987.5	0	1574	6035	19177	2588	1445	4640	5017	4122	44599
1987.75	0	1236	4738	15056	2032	1135	3643	3939	3236	35016
1988	0	0	48289	4308	144633	23976	14066	13944	8960	258176
1988.25	0	0	147033	25806	330103	28363	12739	11178	1136	556358
1988.5	0	116	10157	2291	4929	2081	1700	1008	441	22722
1988.75	0	0	61832	7132	7387	1764	378	3596	1856	83946

USA	1	2	3	4	5	6	7	8	9+	1+
1989	0	0	2201	41207	16655	31959	4421	1681	3324	101448
1989.25	0	0	3969	55949	45374	78904	11828	11085	3778	210887
1989.5	0	5045	879	3355	885	1749	328	0	0	12240
1989.75	0	16247	2832	10804	2851	5634	1055	0	0	39423
1990	0	0	21638	24050	63273	8600	10297	8270	4402	140528
1990.25	0	0	147357	41544	173169	45336	30998	5205	3473	447081
1990.5	0	281	11432	2380	2232	0	0	0	0	16325
1990.75	0	354	14388	2996	2809	0	0	0	0	20547
1991	0	2876	6474	55557	9228	21952	10668	5318	629	112704
1991.25	0	8312	18710	160553	26668	63438	30829	15369	1819	325699
1991.5	0	342	770	6608	1098	2611	1269	633	75	13405
1991.75	0	482	1084	9300	1545	3675	1786	890	105	18867
1992	0	0	5259	7916	118881	24898	19881	1509	1242	179586
1992.25	0	0	64638	55992	286396	48555	82220	20628	1921	560350
1992.5	0	64	3357	878	15821	866	686	0	0	21672
1992.75	0	19	1001	262	4719	258	205	0	0	6464
1993	0	24	981	1773	643	7624	330	2986	2394	16755
1993.25	0	759	21696	30408	14753	70903	24102	6754	2494	171868
1993.5	0	22	637	893	433	2081	708	198	73	5045
1993.75	0	36	1037	1453	705	3388	1152	323	119	8214
1994	0	15	358	128	77	60	107	21	27	793
1994.25	0	54	1362	559	372	308	547	108	145	3455
1994.5	0	290	2903	952	314	1188	1220	417	0	7284
1994.75	0	161	1443	410	120	433	418	138	0	3123
1995	0	32	559	942	232	217	109	234	194	2519
1995.25	0	69	1212	2084	520	492	248	531	442	5598
1995.5	0	41	192	66	7	9	10	6	0	331
1995.75	0	35	205	224	37	57	63	44	3	668
1996	0	7	323	936	1127	312	183	157	418	3463
1996.25	0	26	872	1840	1706	443	254	218	581	5940
1996.5	0	154	980	870	349	47	37	16	21	2474
1996.75	0	104	850	918	387	55	44	18	28	2404

Table B3. Catch at age by quarter of haddock discarded by the USA commercial fishery in 5Zj,m.

USA Discards	1	2	3	4	5	6	7	8	9+	1+
1974		263299								263299
1974.25		366210								366210
1974.5		245301								245301
1974.75		121189								121189
1977		690001								690001
1977.25		1525120								1525120
1977.5		1184351								1184351
1977.75		719528								719528
1978			397333							397333
1978.25			799667							799667
1978.5										0
1978.75										0
1980		3461913								3461913
1980.25		2778873								2778873
1980.5		1134360								1134360
1980.75		600633								600633
1994	12	189	874	463	401	314	550	68	122	2993
1994.25	64	981	4528	2396	2077	1625	2850	354	628	15503
1994.5	496	26069	20087	5065	1675	10287	11085	13215	1145	89124
1994.75	54	2861	2204	556	184	1129	1217	1450	126	9781
1995	66	1239	3292	1545	205	83	34	64	25	6553
1995.25	147	2775	7375	3462	459	186	76	143	56	14679
1995.5	40	99	112	24	2	1	3	0	0	281
1995.75	100	241	273	59	6	3	8	1	0	691
1996	24	291	1199	1878	1363	289	70	52	249	5415
1996.25	38	454	1873	2934	2130	451	110	81	388	8459
1996.5	164	618	1425	927	385	30	28	5	23	3605
1996.75	170	638	1472	957	397	31	29	6	23	3723

Table B4. Catch at age by quarter of haddock caught by the foreign small mesh fishery in 5Zj,m.

Small Mesh	1	2	3	4	5	6	7	8	9+	1+
1969	0	0	0	0	0	0	0	0	0	0
1969.25	0	320	2400	720	2200	18000	4360	1160	2000	31160
1969.5	0	62	5290	2661	3187	29670	10271	1640	1949	54730
1969.75	0	18	1550	779	933	8690	3009	480	571	16030
1970	24	0	0	0	0	0	0	0	0	24
1970.25	216	240	40	640	920	920	3920	1960	1720	10576
1970.5	8461	402	31	588	526	1114	2846	990	866	15824
1970.75	1899	118	9	172	154	326	834	290	254	4056
1971	0	292	63	0	30	31	24	205	57	703
1971.25	0	48468	10457	0	4930	5209	4016	34075	9543	116697
1971.5	0	1852	410	75	1343	137	572	4339	1703	10431
1971.75	0	4108	910	165	2977	303	1268	9621	3777	23129
1972	6114	571	4800	886	286	343	1029	229	9857	24114
1972.25	2446	229	1920	354	114	137	411	91	3943	9646
1972.5	13840	0	1520	240	0	240	200	80	3600	19720
1972.75	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0
1973.25	792080	159360	0	0	0	0	0	0	0	951440
1973.5	39511	118	0	0	0	0	0	0	0	39629
1973.75	27249	82	0	0	0	0	0	0	0	27331
1974	170	9939	2158	0	218	0	24	97	315	12921
1974.25	110	6461	1402	0	142	0	16	63	205	8399
1974.5	16640	9520	2840	0	120	0	0	0	2080	31200
1974.75	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0
1975.25	200	320	1040	200	0	0	0	0	0	1760
1975.5	167	133	1333	200	0	0	0	0	0	1833
1975.75	33	27	267	40	0	0	0	0	0	367
1976	10920	160	360	480	240	0	0	0	0	12160
1976.25	0	0	0	0	0	0	0	0	0	0
1976.5	0	0	0	0	0	0	0	0	0	0
1976.75	3160	0	0	0	0	0	0	0	0	3160

Table B5. Catch at age by quarter of haddock caught by the foreign groundfish fleets in 5Zj,m.

Foreign	1	2	3	4	5	6	7	8	9+	1+
1969	0	0	32741	5415	8572	88811	26787	3612	7735	173672
1969.25	0	140	6900	1162	2013	13734	3623	346	1529	29447
1969.5	0	126	12161	2070	1249	16119	4997	602	994	38318
1969.75	0	0	2972	996	643	8106	2244	105	1050	16116
1970	0	614	0	12361	4017	2779	43615	12396	13196	88978
1970.25	0	10	23	630	231	215	1763	705	304	3881
1970.5	0	2275	26	3646	1983	1214	11857	2762	1346	25109
1970.75	1022	617	0	792	421	1185	7650	2242	342	14271
1971	0	5213	3602	1847	12239	5686	7145	56500	32888	125119
1971.25	0	268	192	29	136	117	149	353	240	1484
1971.5	0	43218	3254	0	3198	1732	0	9008	3067	63476
1971.75	0	22144	1931	71	3145	1103	817	6818	2618	38647
1972	0	0	30948	4976	2080	18644	1611	4548	71435	134242
1972.25	0	0	245	32	13	52	47	1	205	596
1972.5	18481	0	11251	2926	568	936	320	231	8450	43163
1972.75	2585	0	1574	409	80	131	45	32	1182	6038
1973	0	18094	0	3348	1276	275	800	678	7675	32146
1973.25	0	0	0	0	0	0	0	0	0	0
1973.5	4987	34233	0	7636	535	68	741	103	1407	49711
1973.75	2854	19593	0	4371	306	39	424	59	805	28451
1974	0	67423	44505	0	698	1036	0	2899	10337	126897
1974.25	0	44888	12127	0	4484	0	0	3058	4246	68801
1974.5	0	145000	12162	0	532	0	0	734	650	159079
1974.75	0	5332	476	0	20	0	0	30	26	5885
1975	0	0	7773	544	34	220	28	25	334	8958
1975.25	0	96	2021	563	16	116	1	6	84	2903
1975.5	0	187	571	39	0	0	0	0	0	798
1975.75	0	686	2095	143	0	2	0	0	0	2926
1976	0	167	399	2461	325	0	19	0	149	3520
1976.25	18	228	243	1380	203	0	37	0	13	2121
1976.5	349	371	351	1058	208	0	29	0	27	2393
1976.75	228	277	288	1164	208	0	32	0	22	2220

Table B6. Catch at age by quarter of haddock caught by all fisheries in 5Zj,m.

Total	1	2	3	4	5	6	7	8	9+	1+
1969	0	0	260918	43152	68312	707756	213472	28786	61644	1384039
1969.25	0	13906	671135	113304	197296	1349209	355531	34733	150230	2885344
1969.5	0	4347	418550	73012	45634	577419	180061	22087	35731	1356841
1969.75	0	18	90119	30474	20090	250295	69906	3601	31868	496372
1970	24	2765	0	55670	18089	12514	196424	55828	59432	400746
1970.25	216	2948	6222	172176	63687	59355	483829	193851	84438	1066721
1970.5	8461	67338	808	107844	58880	36831	351682	82243	40476	754562
1970.75	16177	8730	9	11237	6038	16871	107677	31603	5034	203375
1971	0	20631	14117	7204	47780	22214	27900	220638	128368	488853
1971.25	0	258055	160956	22529	110927	96300	120787	310017	197567	1277139
1971.5	0	656257	49684	75	49761	26367	572	140735	48137	971587
1971.75	0	247181	22110	940	37494	12414	10231	84464	32518	447352
1972	6114	571	85112	13799	5683	48724	5210	12031	195232	372476
1972.25	2446	229	145275	19180	7887	30909	27682	870	124394	358872
1972.5	186174	0	106434	27529	5301	8971	3184	2232	82392	422217
1972.75	64021	0	38975	10138	1969	3243	1109	799	29271	149525
1973	0	115066	0	21292	8118	1750	5089	4309	48804	204427
1973.25	792080	532107	6269	96938	12136	5852	8917	937	70011	1525247
1973.5	166667	872962	0	194706	13639	1734	18901	2628	35881	1307119
1973.75	56694	202203	0	45088	3158	402	4377	609	8309	320839
1974	170	448006	117519	0	2027	2685	24	7611	27109	605151
1974.25	110	631250	71259	0	25969	0	16	17679	24662	770945
1974.5	16640	707272	40788	0	1781	0	0	2290	4110	772881
1974.75	0	318502	17600	0	741	0	0	1124	977	338943
1975	0	0	183303	12829	792	5197	655	595	7879	211249
1975.25	200	23674	491392	136697	3770	28197	318	1454	20314	706015
1975.5	167	176496	539240	37000	0	409	0	0	0	753312
1975.75	33	69941	213634	14642	0	162	0	0	0	298412
1976	10920	9972	23814	145021	19331	0	1139	0	8724	218921
1976.25	6692	82971	88460	502564	73814	0	13372	0	4610	772482
1976.5	48080	51112	48275	145528	28610	0	3955	0	3756	329316
1976.75	7162	4867	5060	20419	3650	0	559	0	392	42111
1977	0	708441	32728	37343	142789	70074	0	2642	3847	997865
1977.25	0	2417304	16675	79358	104134	64029	0	10623	9824	2701948
1977.5	0	3519768	13545	49864	43230	21347	0	1297	653	3649705
1977.75	0	1190258	974	11119	12771	6130	0	93	47	1221392
1978	0	0	1636041	32304	44205	113895	14749	2819	4780	1848791
1978.25	0	13693	2327355	24960	84363	116674	29189	7410	3466	2607110
1978.5	197	48878	1186680	22991	10994	19992	9281	0	462	1299475

Total	1	2	3	4	5	6	7	8	9+	1+
1978.75	1286	222418	4680517	80984	29773	51242	26470	0	332	5093022
1979	0	0	12911	1072261	42798	70949	54131	11985	3690	1268724
1979.25	0	0	76224	1489132	166797	104309	119509	10727	4931	1971629
1979.5	0	8979	79265	1250361	141928	23809	40695	20434	4316	1569787
1979.75	0	6344	30854	438721	10335	1608	544	0	1087	489494
1980	0	3600812	0	82087	906444	58313	54549	24182	899	4727286
1980.25	0	5431584	314775	111526	1000698	81582	73078	16193	4374	7033809
1980.5	2011	5905834	18512	71894	342459	34863	932	7270	4436	6388210
1980.75	603	2622364	8344	33951	157894	16553	475	3155	2161	2845501
1981	0	102403	2055918	176735	104807	400808	46882	9048	3795	2900395
1981.25	0	35941	1716893	46250	232153	610222	44567	24012	0	2710037
1981.5	0	393022	2205232	129209	120655	171011	21426	0	2630	3043185
1981.75	0	129122	708650	40559	36426	52383	5699	0	798	973637
1982	0	66363	220851	398257	15519	102588	232404	18044	26715	1080742
1982.25	0	69510	318361	1234064	66237	187461	237196	27433	31400	2171661
1982.5	0	351961	398122	797740	92343	23591	106271	9986	7175	1787189
1982.75	0	224684	110454	369193	26699	63450	147043	6505	0	948028
1983	0	3542	34193	102918	373051	58910	18671	164312	12848	768445
1983.25	0	20254	225234	175512	823809	78004	40646	157896	7750	1529103
1983.5	0	58739	324512	227754	325029	28580	17354	43707	11654	1037330
1983.75	0	57101	64079	39750	107094	41900	27070	36153	2118	375266
1984	0	17	31995	57724	89240	394237	42313	57025	95047	767597
1984.25	0	57152	110066	149287	109770	365913	119603	66475	139083	1117349
1984.5	0	13994	79874	100908	52728	288706	17115	33536	59572	646433
1984.75	0	5331	26799	33570	12749	70702	6575	8162	20510	184397
1985	3	1911	9109	9484	39046	23548	100607	8985	32762	225455
1985.25	175	72362	71674	82978	79287	59636	203214	26944	42942	639211
1985.5	2	1487772	212233	61514	48461	28222	45573	11344	27533	1922653
1985.75	0	500541	81252	21727	22456	11754	21468	5448	10658	675304
1986	68	191	222679	58855	24000	35057	56743	85079	14603	497274
1986.25	3539	4310	1491384	91578	76218	56183	42277	54353	9279	1829120
1986.5	2078	32279	796575	18706	33821	24735	13889	26231	13088	961403
1986.75	54	846	46574	3938	7764	6408	4754	7017	3645	81000
1987	0	37807	23660	147333	11400	7442	8151	7171	7916	250880
1987.25	0	955635	45561	752071	35588	19338	44935	32471	48237	1933837
1987.5	0	940916	49120	550286	42210	25522	23257	22079	43657	1697046
1987.75	0	56061	8390	65151	6965	3505	5487	6515	8467	160541
1988	50	634	88216	7876	186780	29526	15123	15393	23334	366932
1988.25	19	37243	1074115	58300	527090	48057	16406	19080	40674	1820983
1988.5	3783	12495	886293	45210	142981	27708	4104	7048	28546	1158168
1988.75	135	442	96533	9200	20165	3708	667	4075	5661	140586

Total	1	2	3	4	5	6	7	8	9+	1+
1989	0	2858	2720	74201	24111	55258	5473	1965	10302	176889
1989.25	0	819103	34384	338338	60281	143031	19465	12683	17832	1445116
1989.5	0	165319	19405	234480	29831	104869	3865	5641	15932	579343
1989.75	0	165513	21253	87391	15138	17043	1700	161	451	308649
1990	0	293	52622	24936	78367	9347	15901	8990	5735	196191
1990.25	0	3478	514691	52056	352121	54183	97437	13743	19284	1106991
1990.5	935	742	641269	45124	264099	2641	39974	19376	13885	1028045
1990.75	650	2209	56056	3815	48115	2230	9998	0	2697	125771
1991	0	4454	6474	109760	9228	61920	13680	31640	10432	247589
1991.25	1524	192753	60496	908246	39918	157589	46481	55008	21913	1483928
1991.5	1188	171162	13922	753364	24582	127710	5183	50884	21105	1169099
1991.75	2895	72722	8224	269281	14708	41778	6891	7934	7119	431552
1992	0	21681	27351	16433	228566	26625	41350	1509	12726	376242
1992.25	0	80917	147089	87779	695754	55000	162346	20628	44782	1294296
1992.5	405	43033	84483	17244	382644	7172	82873	601	23168	641623
1992.75	6095	84629	51915	5767	138555	258	28437	2815	9110	327581
1993	0	7808	59617	89348	28667	221438	3729	75190	42589	528388
1993.25	0	11571	85447	94059	38231	216012	26162	37695	17927	527104
1993.5	0	64297	120499	63280	12737	146466	2523	26790	11073	447665
1993.75	6591	162842	77511	32435	5688	50959	1312	13355	2420	353115
1994	12	204	1232	591	478	374	657	89	149	3786
1994.25	64	14579	87001	30461	16395	7525	48372	1520	11039	216957
1994.5	909	159664	451992	89855	22822	25021	55596	25329	25166	856353
1994.75	54	66622	196720	27007	14539	15282	20823	2034	2993	346074
1995	178	1657	5134	2928	485	344	143	349	228	11445
1995.25	147	12489	178906	156156	25069	19032	324	23121	5808	421051
1995.5	40	32144	225658	188573	15274	4390	807	21005	6903	494794
1995.75	1275	14084	115669	66094	12183	1435	1504	6660	2623	221528
1996	24	298	1522	2814	2490	601	253	209	667	8878
1996.25	69	3137	137776	259630	128962	16516	6532	299	22319	575241
1996.5	164	14674	222232	433465	185527	20772	5636	2833	34598	919902
1996.75	257	8892	106834	167100	109616	23511	5476	24	14705	436415

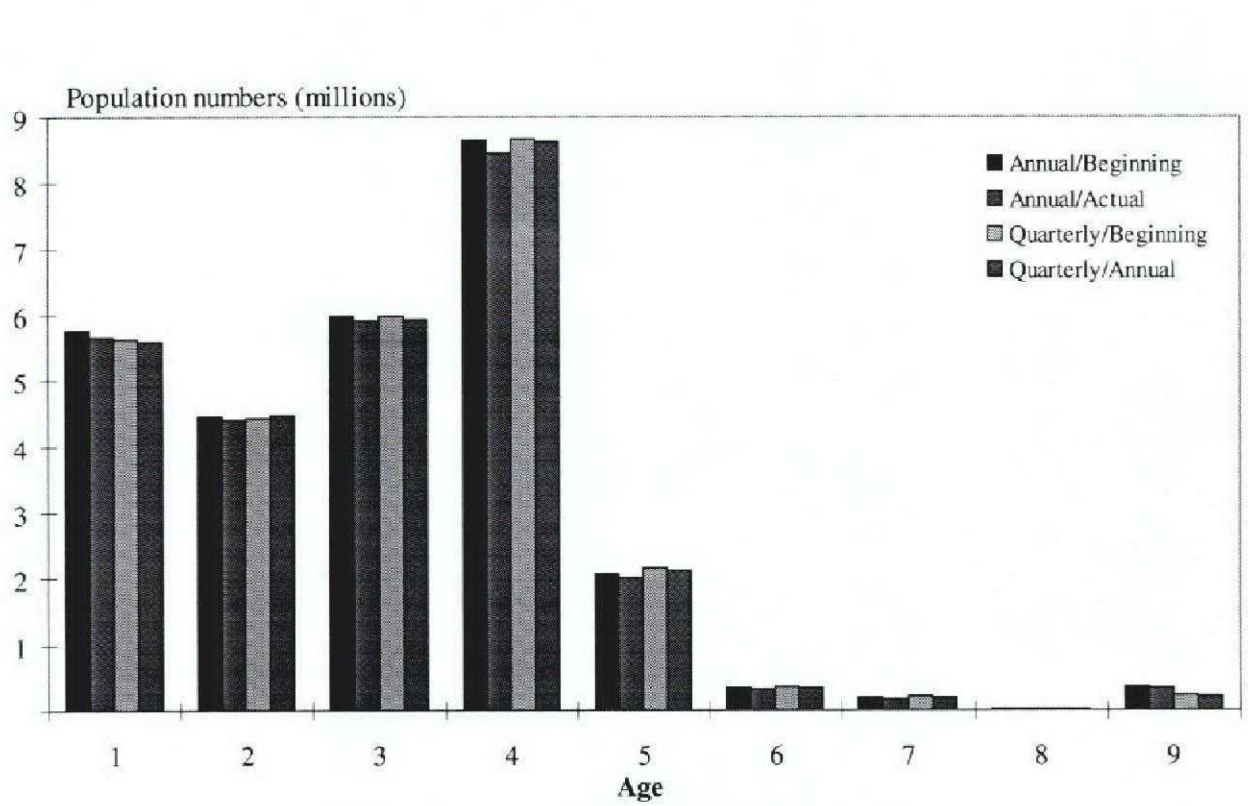


Fig. B1. Comparison of cohort size estimates at the beginning of 1996 for 5Zjm haddock from population analysis using annual or quarterly catch at age and indices set to beginning of year or at actual time of survey.

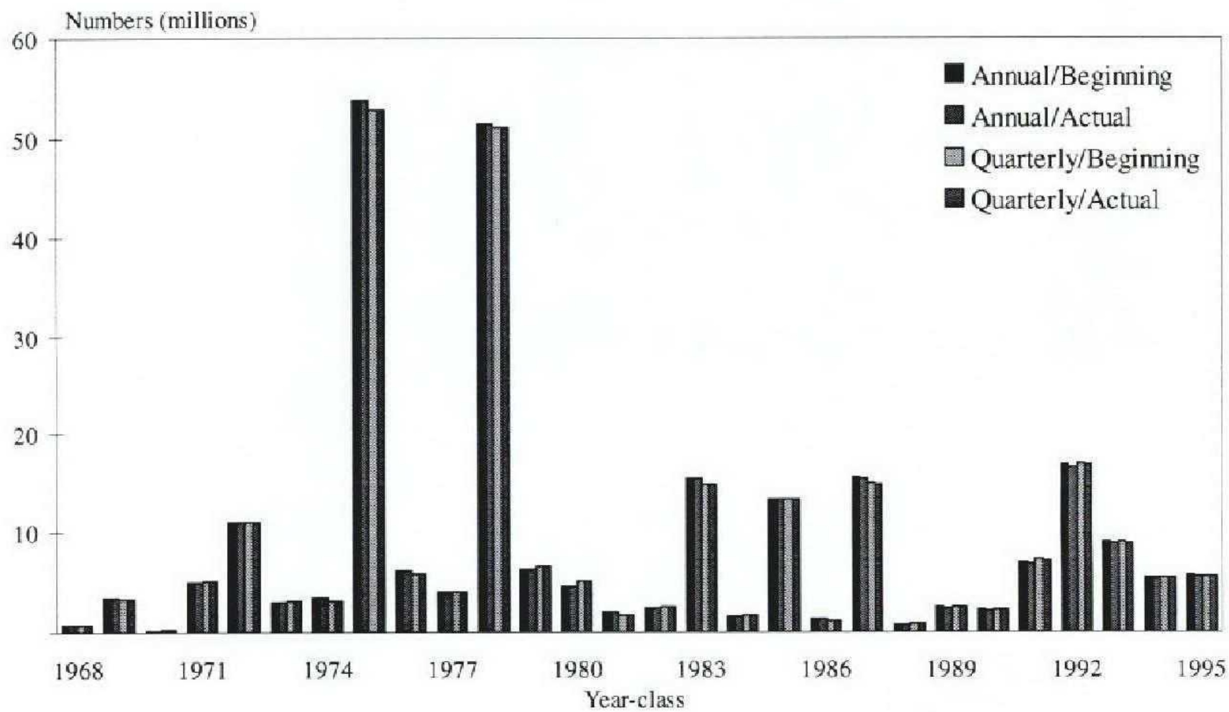


Fig. B2. Year-class size estimates of 5Zjm haddock from population analysis using annual or quarterly catch at age and indices set to beginning of year or at actual time of survey.

Annex C. Consistency of USA survey catchability coefficients.

For indices to be useful indicators of trends in abundance, it is necessary that they are related to absolute population abundance in a consistent manner over the entire time series. It is commonly assumed that abundance indices are proportional to population abundance and the constant relating the two is referred to as the catchability (q). Many factors other than population abundance may affect the catchability of a fishing operation, including gear performance and spatial and temporal changes in fish distribution. Research surveys operations are conducted in a fashion to control all these factors which may influence catchability so that survey indices will reflect changes in population abundance. For example, surveys are conducted at the same time of year using a consistent statistical sampling design. Generally the gear and fishing practices are kept constant but occasionally, changes have had to be made. In these instances, controlled experiments have been conducted to derive conversion coefficients which would allow the observations made before and after the change to be directly comparable.

In 1985, it was necessary to change the trawl doors used on the USA bottom trawl surveys from a BMV door to a polyvalent door. Between 1984 and 1991 experiments were conducted to obtain data to evaluate the impact of the door change on survey catchability. A total of 345 paired observations were collected giving 109 useable non-zero observations for haddock. A conversion coefficient of 1.49 was derived for the BMV door to make the catch results by number comparable to those obtained from the polyvalent door. The respective conversion coefficient for catch results by weight was 1.51, suggesting that the length composition of the catches were similar for the two doors.

An analysis was undertaken to determine if application of the derived conversion coefficient resulted in a survey abundance index which was consistent with VPA results. The effect of the door conversion factors on survey catchability can be easily examined but the vessel conversion factors are more difficult to explore as the two vessels are used irregularly throughout the surveys, therefore the vessel conversion coefficient for *Delaware II* relative to the *Albatross IV* of 0.82 was used in all analyses. Further, the door conversion was studied because it introduces a more consequential change. From 1963 to 1984 the USA spring and fall surveys used a BMV type door (Table 10).

Method

The frequency distributions of residuals obtained from two separate ADAPT calibrations which varied by whether or not the door conversion was applied to the NMFS surveys were examined. The formulation described in the assessment methods section was used with catch at age data to 1995 and survey data through to the DFO spring 1996 survey.

The statistical properties of the annual ln q's for the NMFS surveys were also investigated. They were calculated using a single population abundance at age estimate obtained from a calibration using the same data and formulation as described in the previous paragraph with the door and vessel conversion factors applied to the NMFS surveys. Annual ln q's were calculated as follows,

$$\ln q_{s,a,t} = \ln I_{s,a,t} - \ln N_{a,t}$$

where,

$N_{a,t}$ = population numbers,

and,

$I_{s,a,t}$ = abundance index

for s = NMFS spring survey, ages $a = 1, 2 \ldots 8$, time $t = 1969.29, 1970.29 \ldots 1993.29$
s = NMFS fall survey, ages $a = 0, 1 \ldots 5$, time $t = 1969.69, 1970.69 \ldots 1993.69$

The same population numbers (N) were then used to calculate ln q's for the indices when the door conversion was not applied. The survey ln q's for the final two years, 1994 and 1995 were not used in the comparisons as the population for those years were considered to be too dependent on the calibration. The annual ln q's for the years before 1985, with and without the door conversion factor applied and those for 1985 and the years following were then compared using box plots for the three sets of data. A 3-way ANOVA designed to check for a difference between the 1969-84 and the 1985-93 data for the two sets of ln q's, i.e., door and vessel converted and vessel only converted indices was performed. Season and age were also included as factors.

The impact of the door conversion factor was investigated by comparing the final year population numbers obtained from three ADAPT calibrations which differed by whether or not the door conversion factors for the NMFS surveys were applied and by the time span of data used, i.e. 1969 to 1996 versus 1985 to 1996, which involved the use of the polyvalent door only. The ADAPT formulation described in the assessment methods section was used. The Canadian spring survey data and vessel conversion factors were employed in all three calibrations.

Results

The frequency pattern of residuals obtained from the VPA calibration using door adjusted survey data show that the pre-1985 residuals had a preponderance of positive values while the post-1984 residuals had a preponderance of negative values, indicating an inconsistency in the catchability coefficients (Fig. C1). The sum of the residuals for the years before 1985 and the sum of those after and including 1985 show that they did not center around zero. When conversion factors were not used, the sum of the residuals for the same two time periods are closer to zero and the distributions were also less skewed. The mean square residuals for the calibration using converted versus unconverted indices were not appreciably different.

The average ln q's by age for the 1969 to 1984 period with the door conversion applied were compared to those for the same period without the door conversion applied and for the 1985 to

1993 period which involved only a vessel conversion (Fig. C2). The mean (dashed line) is useful for data which are well behaved but the median (solid line) is more robust and therefore may be a better descriptor for this data which contains many outliers, especially in the fall survey. The means and medians for the spring survey are generally very similar and there are fewer outliers than in the fall data. The spring mean and median annual ln q's for the more recent period are generally nearer to the 1969-84 data when no door conversion factor is applied than when the conversion factor is used. The same trend is seen for the fall survey for ages 1 and 2 but for ages 3, 4 and 5 the door converted data for the 1969-84 period is more similar to the 1985-93 data. The age 0 data are inconclusive and are also the most variable, having the widest 10 to 90 percentile spread.

A 3-way ANOVA confirmed a difference between ln q's for the 1969-84 and 1985-93 periods when the door conversion was applied. The null hypothesis was that the mean ln q was equal for the two time periods. The results of a two tailed test showed that when the door conversion was applied, the observed difference in ln q's would have a low probability of occurrence by chance ($0.05 > P > 0.02$, $F=5.696$ with 1 and 312 degrees of freedom). When no door conversion was applied, the observed difference in ln q's would have a high probability of occurrence by chance ($.90<P < 0.95$, $F= 0.430$ with 1 and 312 degrees of freedom).

A 24 to 26% increase in ages 1 to 4 population numbers was observed when door conversion factors were not used to do a calibration (Fig. C3). An even larger increase was seen for older ages but they make up a much smaller portion of the population. The highest population numbers are obtained when a short series, i.e., 1985 to 1995, (with vessel conversion) is used. An increase of 30 to 39% for ages 1 to 4 from the numbers obtained with the full converted survey series was observed. When compared with the full, door and vessel converted series calibration, total numbers increased by 26 and 34 percent when the full, vessel only converted series and the vessel converted short series, respectively, were used.

These preliminary investigations suggest that application of the experimentally derived conversion coefficients may be resulting in abundance indices which are inconsistent with results from VPA. The cause of this inconsistency may originate with data issues in either the catch used for the VPA or the research survey abundance indices. It is recommended that survey indices adjusted by the the door conversion coefficients continue to be employed but that further analysis be conducted giving consideration to other factors which may influence the comparability, including:

- examine the time series carefully for annual patterns and outlier effects
- conduct a similar analysis using results from the assessment of the 5Z management unit
- consider the potential impact of the use of a Yankee 41 net for the spring survey during 1973-81
- review the information on mis-reporting of catch and evaluate the degree of mis-reporting needed to result in the degree of observed inconsistency
- review the performance characteristics of the two doors and consider the expected implications for haddock
- other species, particularly cod, should be similarly evaluated for comparative purposes.

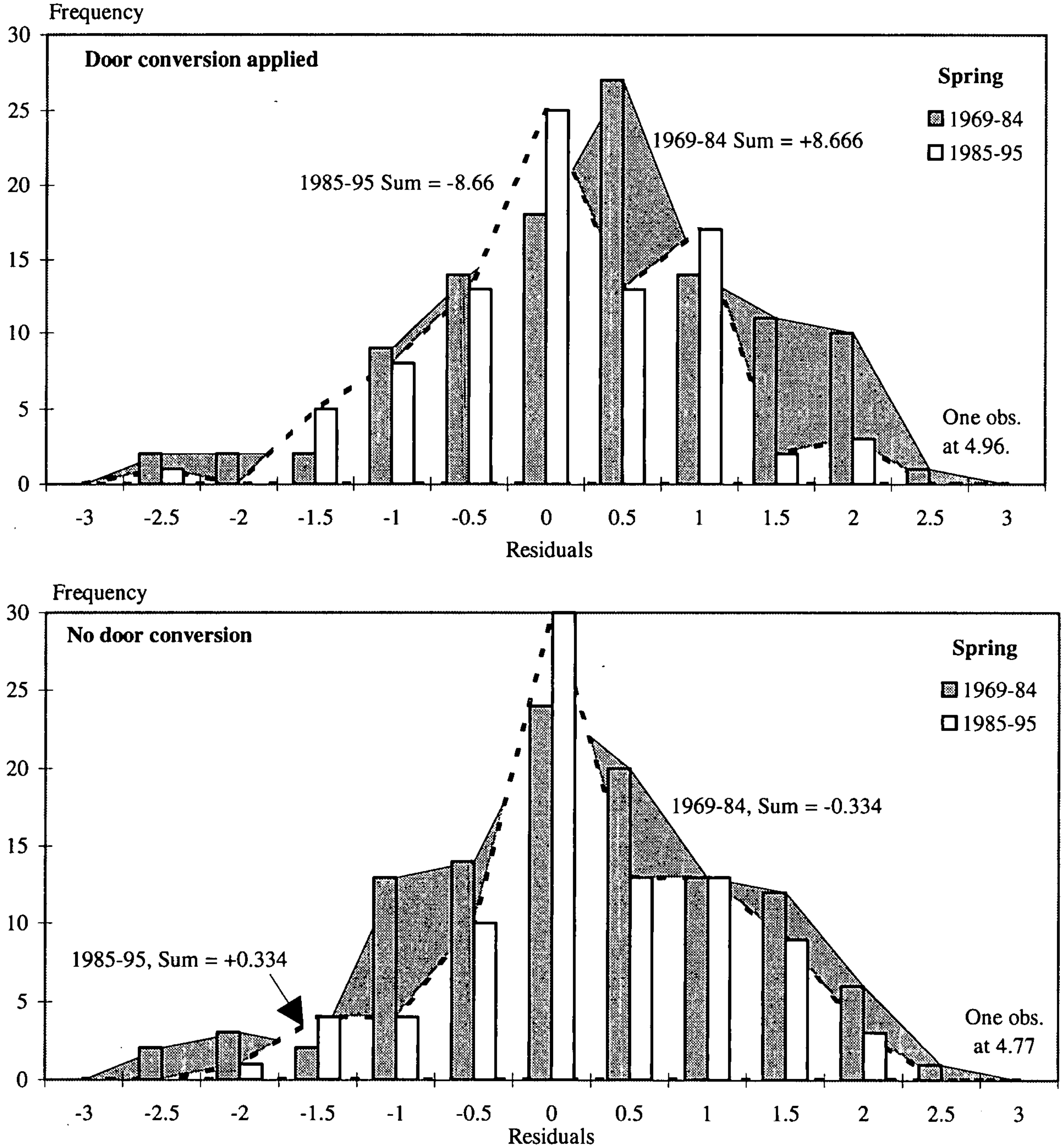
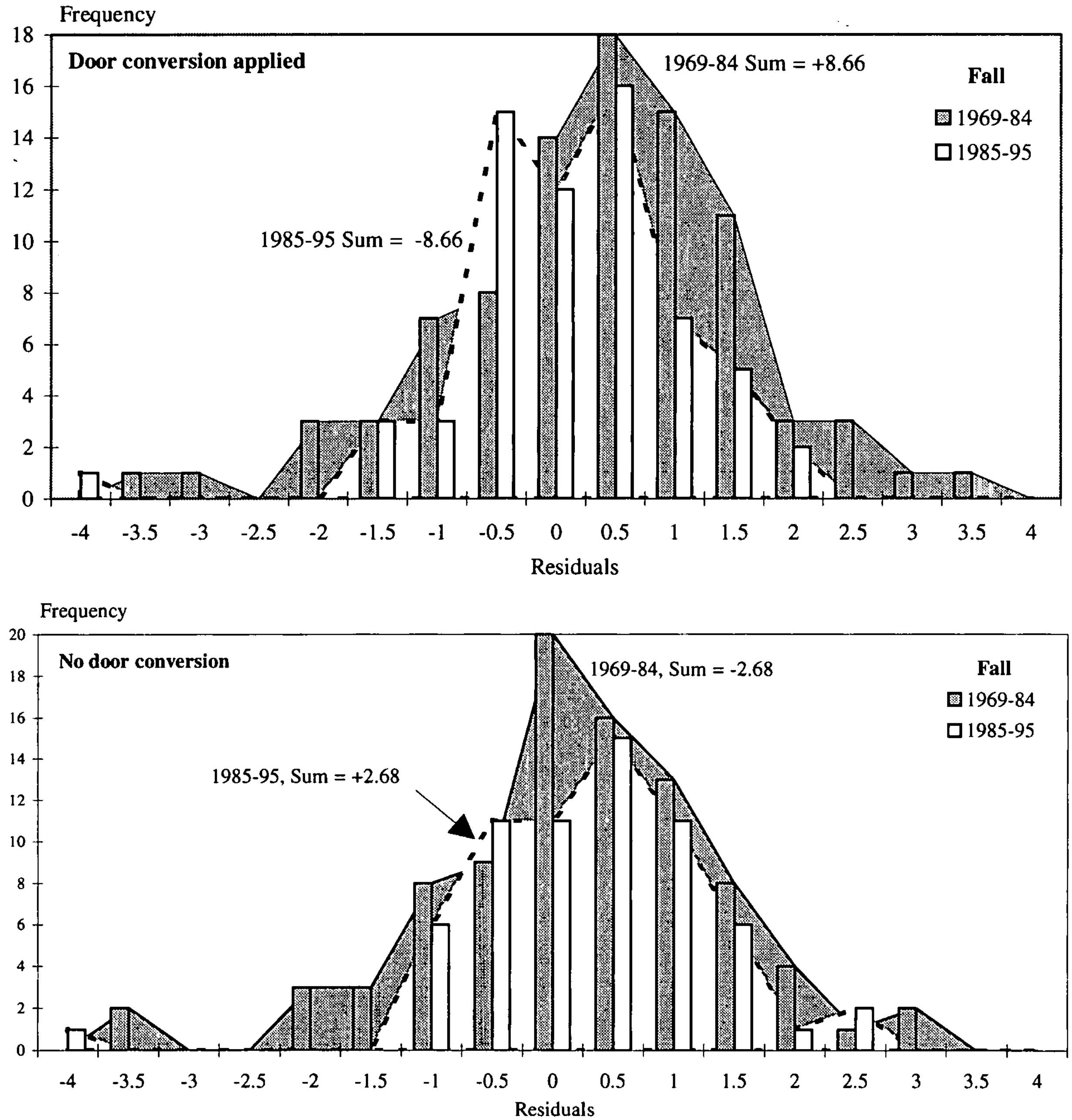


Fig. C1a. Spring. Comparison of frequency distributions of residuals for the periods 1969-84, when a BMV door was used, and 1985-95, when a polyvalent door was used, for the NMFS spring and fall surveys from two separate ADAPT calibrations for 5Zjm haddock which varied by whether or not the door conversion was applied to the NMFS surveys. Each distribution is represented by a bar and an area plot.



C1b. Fall. Comparison of frequency distributions of residuals for the periods 1969-84, when a BMV door was used, and 1985-95, when a polyvalent door was used, for the NMFS spring and fall surveys from two separate ADAPT calibrations for 5Zjm haddock which varied by whether or not the door conversion was applied to the NMFS surveys. Each distribution is represented by a bar and an area plot.

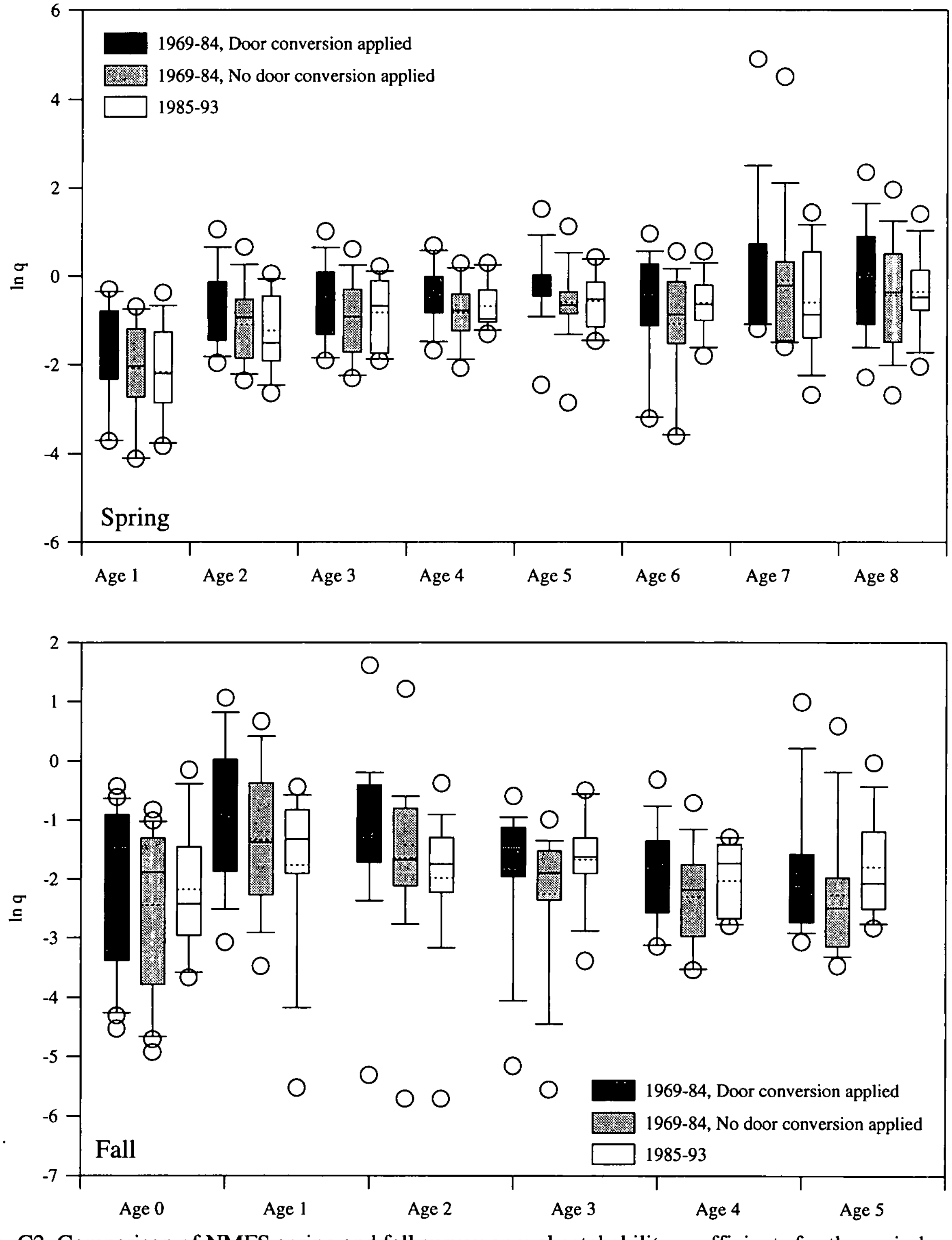


Fig. C2. Comparison of NMFS spring and fall survey annual catchability coefficients for the periods 1969-84, when a BMV door was used, with and without door conversion factors applied to the NMFS spring and fall surveys, and for 1985-93, when a polyvalent door was used. All catchability coefficients were calculated from the same 5Zjm haddock population resulting from an ADAPT formulation which had the door conversions applied to the NMFS surveys.

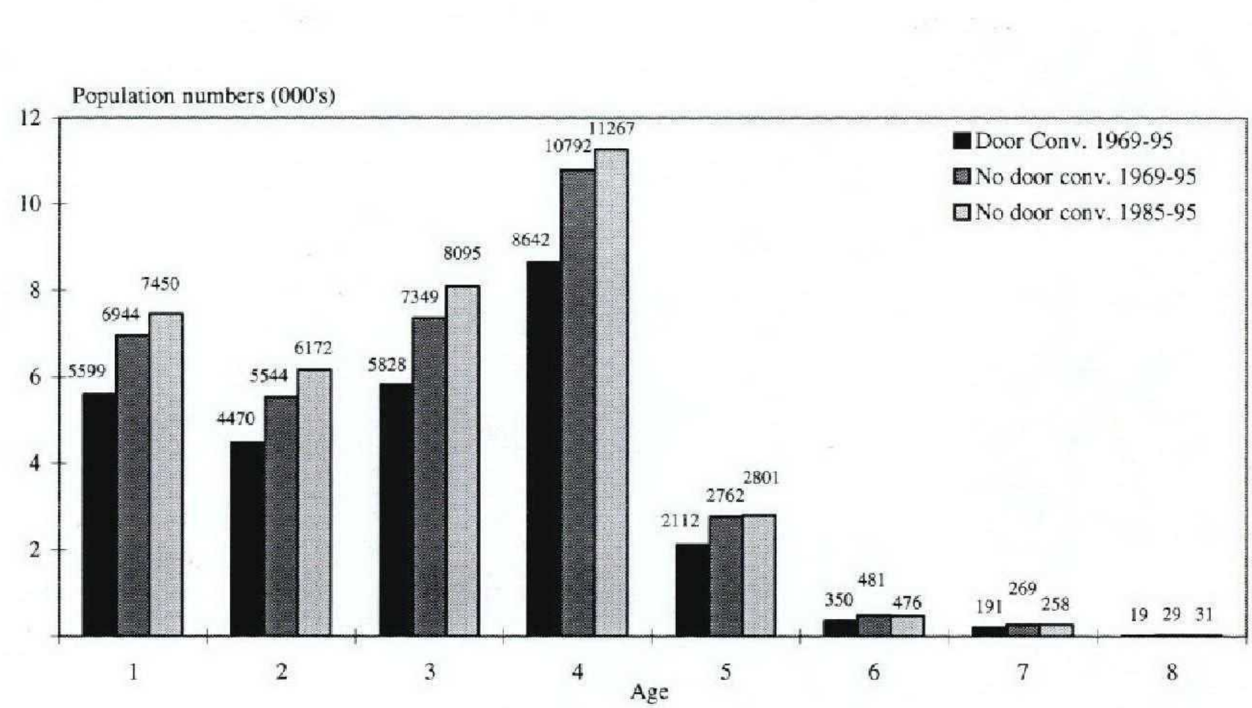


Fig. C3. Differences in 5Zjm haddock 1996 cohort size estimates from three population analyses which varied by the number of years of data used and, for the 1969-96 data set, whether or not the door conversion was applied to the NMFS surveys.