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Population Status of Eastern Georges Bank Cod (Unit Areas 5Zj,m) for 1978-2004.

État du stock de morue de l'est du banc Georges (zones-unités 5Zj,m) pour la période 1978-2004.

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Abstract

An analytical assessment of the Georges Bank cod stock in 5Zj,m was completed using updated catch-at-age for ages 1-10 and research survey indices for ages 2-8. A benchmark ADAPT formulation, based on TRAC recommendations, was used to characterize the population. Results of the assessment provided statistically significant parameter estimates for the 2003 beginning-of-year population at ages 2 through 10**.** Bias and precision for the estimates were within acceptable limits. The adult biomass (3+) increased from the low of 8,700t in 1995 to about 18,500t at the beginning of 2001, primarily due to survival and growth of the 1995, 1996, and 1998 year-classes. Since 2001, adult biomass has declined to 16,000t at the beginning of 2002 and 13,300t at the beginning of 2003. Exploitation rate on ages 4-6 decreased from more than 50% in the mid-1990's to about the $F_{0.1}$ level (F=0.18, 15% exploitation rate) in 1995 but has since been slightly higher, ranging between 16%-28%. A change in partial recruitment to the fishery has occurred since 1994 with reduced catchability on ages 5+. This change is due to the bycatch nature of the Canadian fishery and to management measures that reduced spatial and temporal access to the resource for both the Canadian and USA fisheries. Recruitment in recent years has been poor, with the 1996 and 1998 year-classes above the recent average**.** With an expected 2,800t total catch in 2003, projections for 2004 indicate a yield of about 1,300 t at $F_{0.1}$ and stable stock biomass between 2003 and 2005. The adult stock biomass remains below a threshold of 25,000 t, above which chances of good recruitment are improved.

With the current poor recruitment and exploitation rates near the present levels, improvement in stock status is not expected in the near term.

Résumé

Nous avons effectué une évaluation analytique du stock de morue du banc Georges dans 5Zj,m à partir de données à jour de captures par âge des poissons de 1 à 10 ans et d’indices de relevés de recherche pour les poissons de 2 à 8 ans. Nous avons caractérisé la population en appliquant une procédure ADAPT de référence fondée sur les recommandations du Transboundary Resources Assessment Committee (TRAC). L’évaluation a donné des estimations statistiquement significatives de paramètres de la population de morues âgées de 2 à 10 ans au début de l’année 2003**.** Le biais et la précision des estimations se situaient dans les limites acceptables. La biomasse des adultes (3+) est passée de son niveau le plus bas, soit 8 700 t, en 1995 à environ 18 500 t au début de 2001, surtout en raison de la survie et de la croissance des classes d’âge 1995, 1996 et 1998. Depuis 2001, la biomasse des adultes a diminué; elle se chiffrait à 16 000 t au début de 2002 et à 13 300 t au début de 2003. Le taux d’exploitation des morues de 4 à 6 ans a baissé, passant de plus de 50 % au milieu des années 1990 à une valeur environ égale au niveau de référence $F_{0.1}$ (F = 0,18; taux d’exploitation de 15 %) en 1995, puis il a légèrement augmenté et varie entre 16 et 28 %. Étant donné la capturabilité réduite des morues de 5 ans et plus, le recrutement partiel a changé depuis 1994, ce qui s’explique par le fait qu’il s’agit d’une pêche accessoire au Canada et par les mesures de

gestion qui ont réduit l’accès à la ressource, tant sur le plan spatial que temporel, pour les pêcheurs canadiens et étasuniens. Ces dernières années, le recrutement a été faible, mais les classes d’âge 1996 et 1998 sont plus fortes que la moyenne récente**.** Compte tenu des captures prévues pour 2003 (2 800 t), les prévisions pour 2004 indiquent que la production sera d’environ 1 300 t pour une exploitation à $F_{0.1}$ et que la biomasse du stock restera stable de 2003 à 2005. La biomasse des adultes du stock se maintient sous le seuil de 25 000 t, au-delà duquel les chances d’obtenir un bon recrutement augmentent.

Les taux d’exploitation et le faible recrutement actuels ne laissent pas entrevoir une amélioration de l’état du stock à court terme.

Introduction

This report incorporates commercial catch data and research survey results for the 1978-2003 time period to estimate the stock status of cod in NAFO unit areas 5Zj and 5Zm (5Zj,m) (Figure 1). Definition of this management unit was based on analysis of tagging results and commercial and survey catch distribution (Hunt, 1990). Hunt and Hatt (2002) and DFO(2002) last reported the status of cod in this management unit.

A benchmark review of the model used for the assessement of cod in 5Zj,m was conducted in February, 2002 (TRAC, 2002a) and a new ADAPT model formulation was recommended. This new model differed from the previously used model in that some RV survey indices were excluded and population sizes at age 10 for 1997-2001 were estimated rather than assumed equal to a value derived from averaging fishing mortalities.

The Fishery

Canadian landings of cod from unit areas 5Zj,m of Georges Bank peaked at about 18,000 t in 1982 and have declined from about 14,000 t in 1990 to 1,100 t in 1995, reflecting the lower TAC (Table 1, Figure 2). The 2002 fishery opened in June and resulted in a 1,400t catch. Landings by gear sector in the Canadian fishery (Figure 2) shows a consistent pattern in recent years.

Between 1978-1984, USA landings increased from 5,500t to 10,500t then declined and remained stable at about 6,000t t during 1985-1993 (Table 2). Closed Area II was implemented in December 1994 and US cod landings during 1994-2000 ranged from between 560t to 1,230t and averaged about 800t. USA landings of cod from areas 5Zj,m in both 2001 and 2002 were about 1,400t, the highest since 1993. Almost 100 percent of USA catches in 5Zj,m were taken by otter trawl gear.

Combined USA and Canada landings during 1978-2002 are shown in Table 2 and Figure 3. Landings were 2,700t in 2002, a 24% decrease from 2001 and were the lowest since 1994. Canadian catches decreased by 39% while USA landings remained stable. USA landings accounted for about 50% of the 2002 total compared to the 1997-2001 average of about 30%.

Length composition from samples of landings and catches obtained by commercial port samples and at-sea Observer sampling was used to estimate catch at length and age composition in the Canadian fishery. A summary of the number of length and age samples used to estimate catch-at-age is shown in Table 3 and Figure 4a. The fishery was adequately sampled and about 19,000 length observations and 1,200 age determinations were available to construct the catch-at-age for 2002 (Table 4). Comparison of length distributions between the at-sea and on-shore samples showed some substantial differences (Figure 4b).

For illustrative purposes, comparison of July 2002 longline catch at length derived from on-shore and at-sea samples and with survey estimates of population numbers at length was completed (Figure 5). In general, catches observed at-sea had a greater representation of cod between 40 and 60 cm compared to catches sampled on-shore and the at-sea length distribution was similar to the population length frequency derived from the February research vessel survey. This may be an indication of discarding at-sea to avoid quota overruns. Estimates of age composition of fish sampled at-sea suggest that ages 2-4 would have accounted for most of the possible discards. Further work is required to assess the extent of discarding that may have occurred in the fishery and to incorporate these estimates in the catch at age.

Starting in 2000, quarterly weight-length relationships derived from at-sea Observer sampling from 1995-2000 were applied to estimate the catch-at-age. Landings were regulated by 100% dockside monitoring. Mobile gear catches by tonnage class group were derived to account for potential differences between large offshore trawlers and tonnage classes 2 and 3 trawlers in areas fished and size composition.

Precision estimates of intra-reader age determinations by the Canadian age reader were completed and results were acceptable with a CV of 1.80 and overall agreement of about 87% (Table 5a). A Canada/USA otolith exchange was completed and resulted in an overall agreement of about 78 percent with a CV of 6.8 (Table 5b). A comparison of differences between the Canadian and US 2002 otolith exchange took place in Woods Hole, Mass, US, during the 2003 TRAC meeting. Thirteen otoliths were examined and discussed. Most of the otoliths were from the US spring survey sample (Cruise 02-04, Code 200202, April 2002). This sample was prepared differently for aging by both readers – sectioned by the Canadian reader and baked and broken by the US reader. Results were agreement on five of the Canadian ages and three of the US, three undecided and three agreed to at a different age. Only half of the differences were discussed because of time restrictions.

With a decrease in disagreement and a bias developing, it was agreed at the TRAC 2003 proceedings that an aging workshop would be held in the fall of 2003 for cod and haddock with L. Van Eeckhaute coordinating.

Catch-at-age for the reported USA landings in 1994-2002 was estimated from USA length and age samples. For 1997-2002, USA length samples from 5Ze landings were considered to be representative of 5Zj,m landings and were included to supplement the 5Zj,m length frequencies. USA age samples for landings in 5Zj,m were limited and were, therefore, supplemented with Canadian age samples (Table 3).

Total removals-at-age and percent-at-age are given in Table 6 and in Figure 6. Average fishery weight-at-age and average beginning-of-year weights are given in Table 7. Fishery weight at length was used for estimating catch at age. Calculations of the population biomass were made using weights-at-age obtained from Canadian spring survey data (Hunt and Johnson, 1999). A length/weight relationship derived from 1986-2003 surveys was used to calculate mean weight from mean length in each survey year. The data collected during surveys most adequately represents a sample of the entire population, while fishery data represents that portion of the population available to commercial gear, that is, the larger fish of the partially recruited ages.

Comparisons between observed catch-at-age and projected catch-at-age from the 2002 assessment are shown in Figure 7, and shows good correspondence. In 2002, the 1998 year-class accounted for almost 48% of the catch in numbers, a higher proportion than the projected level of 35%. Canadian (Fig. 8a) and USA (Fig.8b) catch-at-length and age contributions for 2002 are shown in Figure 8 and indicate considerable overlap in length for adjacent age groups. However, both inter- and intra-reader age comparisons show an acceptable level of precision and no evidence of bias over the age range (Table 5a and 5b). Comparison of the 2002 percent catch at age (Canada + USA) with the short term and long term average is shown in Figure 9 and shows an increase in the contribution of ages 5+ in 2002 over the long-term average.

DFO survey weight-at-age shows a declining trend in recent years (Table 7, Figure 10). Values from the 2002 and 2003 surveys were the lowest observed for some agegroups and use of these values will have an impact on the determination of population biomass.

Indices of Abundance

Research Surveys

Hunt (1990) describes the approach used to estimate mean catch per tow specific to the 5Zj,m area for Canadian and USA surveys. Only sets within the 5Zj,m area were used, with stratum areas adjusted to conform to the 5Zj,m boundary. Vessel and gear conversion factors, reported by Serchuk *et al*. 1994, were used to adjust results of the USA surveys conducted by the RV *Delaware II* to RV *Albatross IV* equivalents and to account for a change in trawl doors in 1985. The impact of vessel conversion factors was reported by Hunt and Buzeta (1996). The Canadian survey was initiated in 1986, while the USA autumn survey started in 1963 and the USA spring survey began in 1968.

The USA spring survey has used two different bottom trawls over the 1978-2003 time period. The Yankee #41 trawl was used between 1978 and 1981, and the Yankee #36 trawl has been used since 1982. No conversion factors are available to account for potential differences in catchability between trawls and therefore the two series were considered as separate indices in the ADAPT model.

Catch in numbers and weight for the 2001-2003 DFO surveys show a decrease from that observed in 2000 (Table 8). The highest catch rates occurred in the Canadian zone in the 5Zj area along the northern edge. The 2003 catch distribution pattern (shown as box symbols in Figure 11a) was similar to the average (shown as density contours in Figure 11a), however DFO stratum 5Z2 (Figure 1b) accounts for most of the survey biomass. A substantial reduction in the contribution of DFO stratum 5Z2 (NE part of the Bank in the Canadian zone) between 2002 and 2003 is apparent (Figure 12). Single large sets of over 2t of cod had a strong influence on the average catch per tow in both 2001 and 2002 but were not evident in 2003.

Total catch in numbers for the 2003 NEFSC spring survey indicates an increase over 2001 and 2002, primarily due to the 1998 and 1999 year class (Table 8). The 2003 catch distribution is fairly dispersed with larger catches occurring in NEFSC strata 16 (Fig 11b and Fig.1c). The highest percent of total biomass of cod in the 5Zj,m strata occurred in the eastern part of stratum 16 (Fig.12b). Total catch in numbers for the 2002 NEFSC autumn survey indicates an increase from that observed during 2000 and 2001 for all age groups (Table 8). One very large tow of 6.78t contributed to the increase in the index. The 2002 autumn catch distribution is primarily along the Northern Edge (Fig. 11c) and similar to the average (1997-2001) density. Historically, the highest biomass in the autumn occurs in both strata 21 and 16, however, in 2002, very little of the biomass was found in stratum 21 (Fig. 12c.)

Catch per tow indices from each of the surveys are given in Table 8 and Figure 13.

The research vessel surveys were assigned a decimal year value (DFO=0.16, NMFS spring 0.29, NMFS fall 0.69) to correspond to the season in which the survey was conducted. This eliminated the requirement to lag the NMFS fall survey as an index of beginning of year abundance for use in the ADAPT formulation.

The three survey indices for ages 3+ biomass, adjusted by the estimated average catchability (Q's) at age from recent ADAPT formulations (Gavaris, 1988) are shown in Figure 13 (the 1982 NMFS spring survey is not shown due to scaling). In general, all three surveys appear to provide a consistent index. The DFO surveys show a decline between 1990 and 1995, a substantial increase in 1996, a decline in 1997 and 1998, followed by an increase in 1999 and 2000 and a decrease to lowest observed values in 2003. The NMFS fall survey catch per tow remained at a low and stable level between 1994 and 2001 but increased to an anomalously high level in 2002. A single large tow in the NMFS fall 2002 survey accounted for about 60% of the increase. The NMFS spring survey increased slightly between 2001 and 2003.

Estimates of recruitment at age two from the surveys are shown in Figure 14 as population numbers derived from catch per tow, adjusted by catchability factors. The index of recruitment of the 1996 year-class is similar to the 1990 year-class. Overall, recruitment remains well below the average with some indication from the NMFS fall 2002 that the 2000 year-class may be an improvement over previous year-classes.

Commercial Fishery Catch Rates

The mobile gear catch rate was used as an index of abundance in the 1995 DFO evaluation of cod in 5Zj,m (Hunt and Buzeta, 1995). However, the reduced TAC and bycatch limitations imposed since 1995 and the change from a directed to a bycatch fishery preclude use of catch rates as an indicator of abundance. Effort information for the longline fleet was not collected in 1994 and therefore catch rates for this fleet sector in 1994 are not available.

A summary of catch, effort and catch per day for the mobile, longline and gillnet fleets for 1990-2002 is given in Table 9. No standardization was applied to account for possible tonnage class differences and only trips landing more than 500kg of cod were included. Estimated total effort (number of fishing days) is calculated from the catch per day and reported catch to account for missing effort data for some trips. The number of active vessels and total effort in 1995 were less than 50% of the 1990-94 average for all three fleet sectors.

The number of Canadian vessels, by gear sector, with cod landings of greater than 500kg per trip for the 1990-2002 time period are shown in Figure 15. Overall, the number of vessels participating in the fishery declined between 1990 and 1995 with an increase in again 1996. Most of this increase was due to the addition of about 20 tonnage class one longline vessels in 1996. The number of vessels has remained relatively stable since 1996.

Landings per day fished declined for all three gear sectors but has remained relatively constant between 1998 and 2002 (Figure 16). Generally, catch rates are higher for the fixed gear sector compared to the mobile gear sector.

Fishers continue to report difficulty in avoiding areas of cod abundance. Substantial changes to fishing practices have been required to ensure that cod allocations are not overrun in advance of taking haddock allocations.

Landings of cod taken by the USA fishery in 5Zj,m are almost exclusively caught by otter trawl, primarily during the 2nd calendar quarter (O'Brien and Munroe 2001). Since 1994, the majority of vessels fish near the northwest corner of Closed Area II, and since 2000, vessels are also fishing near the southwest corner of Closed Area II. A preliminary measure of fishery performance of otter trawl gear was estimated by summing catch and effort for vessels in this area during 1990-2002. The data were not standardized for any variable, i.e. tonnage class, season, depth. Fishery performance (t/day fished) indicates a declining trend from 1990 to 1995 and then a generally increasing trend to 2002 (Fig.16b). This estimate is not a true indicator of abundance but more an indicator of localized aggregations and is influenced by the movement of cod across the western boundary of the closed area.

Longline Research Survey

A longline research survey of the Georges Bank area was initiated in 1995 using a box design with one set in each selected box. A detailed description of methods, results and comparison of the annual results with Sequential Population Analysis (SPA) population estimates is reported in Johnston and Hunt (1999) and by Hunt and Hatt (2001). Preliminary results for 1996-2003 standardised catch in weight and numbers are shown in Figure 17. A general increase in catch rates is evident from 1999 to 2002 followed by a decline between 2002 and 2003. A further analysis of the survey results was completed in an attempt to reduce inter-annual varaiblity associated with changes in set coverage. Annual catches for each sampled location were standardized to the 1996-2002 mean for the same location and an overall mean determined (Figure 17).

Utility of the survey as an indicator of changes in stock abundance was considered at the benchmark review (TRAC, 2002a). It was concluded that the trend from the survey showed consistency with population trends but that the uncertainties associated with conformity to the experimental design and the limited spatial coverage of the survey precluded using the longline index within the ADAPT formulation. The survey may provide some supplemental information if it continues to be conducted in the future but it is considered to have limited analytical merit.

Partial Recruitment to the Fishery

Investigation of partial recruitment was completed in the benchmark review (TRAC, 2002a) and it was concluded that a change in partial recruitment associated with fishing patterns and seasons had occurred (Hunt and Hatt, 2002).

Spawning Stock Biomass (SSB) Calculation

Spawning stock biomass (SSB) was estimated by applying the proportion mature at age and beginning of year mean weight at age to the population abundance estimate derived from ADAPT (Hunt and Hatt, 2002).

Further evaluation of changes in the age at first maturity is required including the examination of the effects of small sample size on maturity ogives and the consistency of maturity assignments. For the purpose of describing trends in adult stock biomass, the biomass associated with ages 3+ is considered to be more representative and less influenced by inter-annual variations in mature individuals.

ESTIMATION OF STOCK PARAMETERS

The adaptive framework (Gavaris 1988) was used to calibrate the Sequential Population Analysis with the three research survey age-specific indices of abundance. The integrated formulation used the following data:

$C_{a,y}$ = catch
a=1 to 10, y=1978 to 2002

$I_{1,a,y}$ = USA fall survey
a=1 to 6 y=1978.69 to 2002.69
$I_{2,a,y}$ = USA spring survey (Yankee #41 trawl)
a=1 to 8, y=1978.29 to 1981.29

$I_{3,a,y}$ = USA spring survey (Yankee #36 trawl)
a=1 to 8, y=1982.29 to 2003.29 (includes the current year results)

$I_{4,a,y}$= Canadian spring survey
a=2 to 7, y=1986.16 to 2003.16

$\theta_{a,t'} = \ln \text{population abundance}$ for ages *a* = 2, 3 ... 10 at time $t' =$ 2003
$\kappa_{s,a} = \ln \text{calibration constants}$ for each abundance index source *s*, and ages, *a*.

A solution for the parameters was obtained by minimizing the sum of squared differences between the natural logarithm observed abundance indices and the natural logarithm population abundance adjusted for catchability by the calibration constants. The objective function for minimization was defined as

$$\underset{s,a,t}{\Psi}\left(\hat{\theta},\hat{\kappa}\right)=\sum_{s,a,t}\left(\psi_{s,a,t}\left(\hat{\theta},\hat{\kappa}\right)\right)^2=\sum_{s,a,t}\left(\ln I_{s,a,t}-\left(\hat{\kappa}_{s,a}+\ln N_{a,t}\left(\hat{\theta}\right)\right)\right)^2$$

For convenience, the population abundance $N_{a,t}\left(\hat{\theta}\right)$ is abbreviated by $N_{a,t}$. At time t', the population abundance was obtained directly from the parameter estimates, $N_{a,t'} = e^{\hat{\theta}_{a,t'}}$. For all other times, the population abundance was computed using the virtual population analysis algorithm, which incorporates the common exponential decay model

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

Partitioning of the USA spring survey was introduced in 1998 to account for a change in the survey trawl in 1982. Experimentally derived conversion factors between the two trawl types for cod are not available and further investigation of trawl gear and vessel effects may be required.

The survey indices were compared to beginning of year population abundance. Natural mortality was assumed constant and equal to 0.2 for all age groups. The fishing mortality rate on age 10 for 1998-2002 was estimated from the SPA model. The fishing mortality rate on age 10 for 1978-1997 was calculated as the weighed average for ages 8 to 9 in the same year. Errors in the catch-at-age were assumed negligible relative to those for the abundance index. The errors for the log transformed abundance index were assumed independent and identically distributed.

ADAPT was used to solve for the parameters using the techniques described by Gavaris (1988) and Hunt and Johnson (1999). Parameter estimates and associated precision were derived using a bootstrap statistical technique.

Initial trial ADAPT formulations which included age zero and one in 2003 did not result in statistically significant estimates at these ages and therefore they were set to an arbitrary low value of 1.5 million.

Assessment Results

Parameter estimates, bias adjustment and standard error derived from the above ADAPT formulation are given in Table 10. Population parameter estimates for 2002 have a relative error of 34% to 57% for ages 2 to 10. In general, catchabilities for survey indices show a flat topped selection at ages 4 and older. Catchabilities were highest for the DFO spring survey, followed by the NMFS spring surveys and the NMFS fall survey.

There appear to be some year effects in the residuals for survey indices (Figure 18), particularily for the NMFS fall 2003 survey. However, residuals by age for all three surveys appear to be reasonably well balanced and without trend within cohorts. The relatively high number of positive residuals for NMFS surveys prior to 1985 may be a function of trawl door conversion factors. As noted above, preliminary analysis of the impact of trawl door conversion has been completed but further work is required before alternative conversion factors can be recommended.

The decline in adult stock biomass (ages 3+) between 1990 and 1995 was substantial, and the biomass was the lowest observed in 1995 at 8,700 t (Figure 19, Table 11). However, the biomass shows a gradual increase from 1995 to about 18,500 t in 2001. A decrease in biomass occurred between 2001 and 2003 and is estimated to be about 13,300 t at the beginning of 2003. Much of this decrease is associated with the low weight-at-age from recent DFO surveys. About 30% of the 2003 biomass is comprised of ages 8-10 and biomass remains well below the long term average of over 30,000 t.

Given the dome-shaped partial recruitment pattern described above, fishing mortality on ages 4-6 is considered to be representative of average exploitation rate. Exploitation (Table 11) increased rapidly between 1989 and 1991 and was over three times the $F_{0.1}$ = 0.18 level in 1991-93. The decline that began in 1994 is consistent with reduced effort. Fishing mortality in 1995 was near the $F_{0.1}$ level. The rate of exploitation for the stock has been over 30% for most of the time series, above 50% in 1991-93, close to the $F_{0.1}$ level of about 15% in 1995, but between 16%-28% in recent years (Figure 20).

The reduced exploitation starting in 1995 has resulted in improved survival of the 1992 and 1995 year-classes and increased the relative contribution of ages 5 and older (Figure 21). The higher mean weight-at-age and survival associated with these older fish has generated most of the increased stock biomass but reflects growth rather than recruitment.

Recruitment since the 1990 year-class has been below the time series average (6.3 million age 1 fish). The 1996 and 1998 year-classes show some improvement to the recent average recruitment. Subsequent year-classes show very poor recruitment prospects (Figure 19 and Table 11).

Retrospective Analysis

Retrospective analysis of F and population biomass indicates that F mid-1990's to be is under-estimated and abundance over-estimated relative to current estimates (Figure 22). A reverse trend to under-estimate initial year-class size is evident for abundance at age one and is most pronounced for the 1999 year-class. The retrospective pattern seen in this assessment is similar to that seen in the 2002 assessment results (Hunt and Hatt, 2001) .

Yield Per Recruit Analysis

Hunt and Johnson (1999) reported on a yield per recruit analysis using average mean weight-at-ages 1-15 and partial recruitment reflecting the recent 1995-98 trend in the fishery. They reported an $F_{0.1}$ fishing mortality of 0.199, however recent bi-lateral discussions with the USA recommended a value of F_{ref} of 0.18 and this was used as a reference level.

Prognosis

Catch projections were completed using the bias-adjusted beginning of year population abundance for 2003 derived from ADAPT. Partial recruitment was derived from the 2000-2002 fishing mortality matrix (Table 11), to reflect changes in PR associated with both gear and season. Mean (2000-2002 fishery) and beginning of year (2001-2003 RV survey) weights-at-age were used to reflect the recent weights-at-age. Recruitment for 2003 and 2004 age one was set to 1.5 million (Table 12).

Yield projection at F_{ref} for 2003-2004 with an expected catch in 2003 of 2,800 t indicates a **combined** Canada/USA 2004 yield of about 1,300 t. Details of the projection are given in Table 12 and Figure 23 and 24. There is about a 20% relative error associated with the projected catch. The 1998 year-class at age 5 is expected to account for about 40% of the catch biomass in 2003 and about 30% in 2004.

Adult biomass levels and subsequent **recruitment** abundance-at-age 1 are compared in Figure 25 for the 1978-2002 time period. Recruits appear to have a positive correlation with biomass and the probability of good recruitment increases at higher biomass levels. The projected 2003 adult biomass of 13,300 t is well below the stock size (>25,000t) at which improved recruitment would be expected to occur. Rebuilding to increase the adult biomass would enhance the prospects for the future. The relationship between recruits and adult biomass (Figure 26) shows a decline since 1996 indicating poorer survivorship.

Gains in fishable biomass may be partitioned into those associated with somatic growth of cod which have previously recruited to the fishery and those associated with new recruitment to the fishery (Rivard 1980). Over the long term, about 60-90% of the total stock production (Figure 27) has been derived from growth and the rest has come from recruitment. In recent years, due to weak recruitment, the amount due to growth has increased and is now over 90% of the total.

Yields from the fishery have exceeded surplus production in some years (Figure 28), particularily in the early 1990’s. Low productivity since 2001 and current catches have resulted in yield greater than production (growth overfishing).

With the current poor recruitment and exploitation rates near the present levels, improvement in stock status is not expected in the near term.

Cod and haddock are often caught together in the Canadian groundfish fisheries. However, their catchabilities to the fisheries differ and they are not necessarily caught in proportion to their relative abundance. Exploitation of haddock at $F_{0.1}$ levels with current fishing practices may compromise the achievement of rebuilding objectives for this cod stock. Anecdotal information from the 2001 and 2002 fisheries and prosecution of suspected violators suggest an increasing probability of cod discards and catch mis-reporting. There is a potential for this practice to continue in the 2003 fishery if the allowable cod catch is lowered while the haddock catch increases.

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Table 1. Nominal landings(t) of cod by year, gear and month for Canada in unit areas 5Zj,m for 1986-2002. (see Hunt and Hatt (2000) for 1978-1985 landings detail).

YEAR	GEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
1986	Gillnet						43.6	81.9	75.1	28.7				229.3
	Longline		58.1	81.0	12.0	24.2	146.4	127.2	635.1	619.0	408.6	12.1		2123.6
	Misc	0.5	2.0	8.6	15.3	10.3	3.1	0.3	0.8	0.2	0.5	0.3		41.7
	Mobile	14.4	8.8		15.1	6.1	2364.2	3137.6	476.8	49.2	10.8	4.4	21.7	6109.2
1986	Total	14.9	68.9	89.6	42.5	40.5	2557.3	3346.9	1187.8	697.1	419.9	16.8	21.7	8503.8
1987	Gillnet						109.3	248.5	308.5	38.2				704.6
	Longline		6.2	112.0	68.1	8.2	314.9	672.8	1110.2	796.5	310.0	12.5	32.7	3444.0
	Misc	4.7	10.9	14.9	16.6	9.2	10.8	6.3	3.7	1.1	1.5	6.3	1.9	87.9
	Mobile	18.7	0.5	3.3			2484.9	3940.8	889.5	145.0	2.1	78.3	44.3	7607.3
1987	Total	23.3	17.7	130.2	84.7	17.4	2919.9	4868.3	2311.9	980.8	313.6	97.1	78.9	11843.8
1988	Gillnet						180.1	224.4	140.6	49.7	20.9			615.8
	Longline	53.9	86.3	68.0	205.2	27.2	1277.5	1773.5	487.4	455.3	121.3	28.2	1.4	4585.1
	Misc	2.3	9.0	11.7	10.5	16.4	10.3	6.7	1.7		0.5	1.9	2.1	72.9
	Mobile	23.0	520.0	56.5		12.7	3146.9	3138.6	416.2	17.5	98.5	28.9	8.5	7467.4
1988	Total	79.2	615.3	136.2	215.7	56.2	4614.8	5143.2	1046.0	522.5	241.3	58.9	11.9	12741.2
1989	Gillnet						131.4	358.9	440.2	174.5	9.2			1114.2
	Longline	40.6	202.2	244.5	78.8	248.1	938.4	1130.0	1360.0	346.2	64.7			4653.5
	Misc	7.1	6.9	9.0	21.2	33.0	16.6	5.3	1.4	0.0	2.6	2.7		105.8
	Mobile	4.7	139.8	7.2		2.3	1587.8	86.5	70.0	1.7	87.2	32.7	1.6	2021.5
1989	Total	52.3	348.9	260.7	99.9	283.3	2674.2	1580.8	1871.6	522.5	163.7	35.4	1.6	7895.0
1990	Gillnet						113.5	343.9	309.3	142.7				909.3
	Longline	125.3	150.1	259.7		129.4	1196.4	1523.4	1154.4	642.6	244.1	13.0		5438.4
	Misc	6.2	12.6	19.2	19.0	9.9	22.0	1.6	1.2	1.3	0.7	0.5	1.5	95.8
	Mobile					1.3	3189.1	1755.4	1551.1	946.0	461.0	15.8	1.1	7920.8
1990	Total	131.5	162.6	278.9	19.0	140.6	4521.0	3624.3	3016.0	1732.6	705.8	29.4	2.6	14364.3
1991	Gillnet					17.2	433.8	749.3	355.4	164.4	20.5			1740.6
	Longline	49.3	334.9	190.3	230.0	201.9	630.1	1063.9	952.4	742.3	367.8	113.4	46.9	4923.1
	Misc	7.7	7.8	7.4	25.2	14.6	19.8	24.5	19.7	7.8	0.7	8.8	0.3	144.3
	Mobile	348.3	33.1	22.2	0.6		3456.0	1492.5	671.3	314.1	295.4	14.7	5.7	6653.8
1991	Total	405.2	375.9	219.9	255.8	233.6	4539.6	3330.2	1998.8	1228.6	684.4	136.8	52.9	13461.8
1992	Gillnet					0.7	293.6	350.1	341.9	202.8	25.7	2.1		1216.8
	Longline	114.2	339.6	476.7	280.4	240.7	931.3	747.5	653.6	522.5	338.7	106.2		4751.3
	Misc	9.4	13.4	19.2	21.4	22.8	10.4	6.1	4.8	2.3	3.0	0.6	0.4	114.2
	Mobile	266.2	328.8		0.6	3.9	2834.9	972.2	286.9	213.7	541.5	132.2	9.4	5590.4
1992	Total	389.8	681.8	495.9	302.4	268.2	4070.2	2076.0	1287.2	941.3	908.9	241.1	9.9	11672.6
1993	Gillnet						286.5	367.4	260.9	212.1	47.4			1174.3
	Longline	4.2	30.4	166.0	80.4	148.1	422.0	514.4	461.9	261.1	122.3	119.8	63.0	2393.6
	Misc	8.6	4.1	10.3	13.5	17.4	4.5	4.9	1.0	0.3	0.7	1.5		66.9
	Mobile	823.8	997.5	77.6	380.3		1204.3	590.5	162.5	123.4	237.3	177.8	113.8	4888.8
1993	Total	836.7	1032.0	253.9	474.2	165.5	1917.3	1477.2	886.3	596.8	407.6	299.2	176.8	8523.6
1994	Gillnet					0.1	133.4	539.3	243.0	96.9	18.5			1031.2
	Longline					0.1	409.1	481.2	868.8	492.3	4.6	30.3		2286.5
	Misc	7.0	6.6	10.1	14.3	8.6	7.0	3.6	1.6	0.7	1.6	3.4	1.0	65.5
	Mobile	2.0					777.1	410.2	115.3	127.5	263.3	116.7	82.3	1894.4
1994	Total	9.0	6.6	10.1	14.3	8.8	1326.6	1434.4	1228.8	717.3	288.0	150.4	83.4	5277.6

Table 1. Canadian landings, continued.

YEAR	GEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
1995	Gillnet						17.3	39.4		69.7				126.4
	Longline						116.3	162.7	122.5	97.6	19.9	20.3	6.7	545.9
	Misc	1.6	3.7	4.3	4.6	4.4	4.6	7.7	2.9	0.6	0.1	0.0		34.6
	Mobile	1.0					100.2	62.1	56.9	82.3	25.3	41.1	24.4	393.4
1995	Total	2.6	3.7	4.3	4.6	4.4	238.4	271.9	182.3	250.2	45.3	61.4	31.2	1100.4
1996	Gillnet						25.8	137.5	81.3					244.5
	Longline						28.8	389.0	290.3	91.0	136.9	65.5	21.4	1023.0
	Mobile	2.2					217.2	96.3	99.9	57.8	42.2	40.0	103.2	658.8
1996	Total	2.2					271.7	622.8	471.5	148.8	179.1	105.5	124.6	1926.3
1997	Gillnet						132.6	132.8	107.4	50.6	46.9			470.3
	Longline						176.6	431.8	384.8	254.8	132.0	14.7	21.2	1415.9
	Mobile						360.4	165.9	210.4	134.9	55.9	52.0	53.0	1032.5
1997	Total						669.6	730.6	702.6	440.3	234.8	66.7	74.2	2918.7
1998	Gillnet						75.7	89.6	62.8	25.1	46.4			299.6
	Longline						74.0	344.5	220.8	196.7	87.3	21.2	18.2	962.8
	Mobile						177.9	70.5	138.3	94.6	98.6	38.6	26.5	645.1
1998	Total						327.7	504.6	422.0	316.4	232.3	59.8	44.7	1907.4
1999	Gillnet						58.5	100.0	48.2	14.7	36.0	6.5	5.8	269.6
	Longline						94.7	288.1	243.7	152.4	106.7	26.5	17.2	929.4
	Mobile	3.2					226.1	156.0	46.8	71.6	58.6	37.7	19.4	619.5
1999	Total	3.2					379.3	544.2	338.7	238.7	201.3	70.8	42.3	1818.5
2000	Gillnet						55.1	76.2	28.3	23.6	40.7	9.4	4.4	237.7
	Longline						40.7	190.8	177.2	221.6	137.5	15.3	16.4	799.4
	Mobile	0.0					101.5	140.3	81.6	73.0	69.5	38.3	30.4	534.5
2000	Total	0.0					197.3	407.3	287.1	318.1	247.7	62.9	51.2	1571.1
2001	Gillnet						36.7	75.3	47.8	60.1	42.7	21.0		283.6
	Longline						62.4	211.6	273.3	282.4	229.3	61.7	16.2	1136.9
	Mobile						159.6	84.3	58.2	103.5	133.5	110.7	72.3	722.1
	Discards[1]				38.8				39.3				8.6	86.7
2001	Total				38.8		258.7	371.2	418.6	446.0	405.5	193.4	97.1	2229.3
2002	Gillnet						3.1	45.4	51.1	23.3	0.5	8.8	7.3	139.6
	Longline						1.6	150.6	198.6	161.9	126.9	30.9	29.9	700.3
	Mobile						38.2	87.0	33.5	77.6	62.2	55.3	85.5	439.4
	Discards[1]				28.9				34.9				11.0	74.7
2002	Total	11.3			28.9		44.3	283.0	318.1	262.8	189.7	95.0	133.7	1354.0

[1]estimated from directed scallop fishery catch rates (see Stone and Legault (2003) for details); not included in catch at age

Table 2. Summary of total landings (t) by Canada and the USA in unit areas 5Zj,m for 1978-2002. Canadian values for 1986-1998 revised from previous reports.

YEAR	CANADA	REVISED	USA	TOTAL	REVISED
1978	8778		5502	14280	
1979	5978		6408	12386	
1980	8063		6418	14481	
1981	8499		8094	16593	
1982	17824		8565	26389	
1983	12130		8572	20702	
1984	5763		10551	16314	
1985	10443		6641	17084	
1986	8504	(8411)	5696	14200	(14107)
1987	11844	(11845)	4792	16636	(16637)
1988	12741	(12932)	7645	20386	(20577)
1989	7895	(8001)	6182	14077	(14183)
1990	14364	(14310)	6378	20742	(20688)
1991	13462	(13455)	6777	20239	(20232)
1992	11673	(11712)	5080	16753	(16792)
1993	8524	(8519)	4019	12543	(12538)
1994	5278	(5277)	1229	6507	(6505)
1995	1100		665	1765	
1996	1926	(1885)	773	2699	(2658)
1997	2919	(2898)	557	3476	(3455)
1998	1907	(1874)	795	2702	(2669)
1999	1818		1150	2968	
2000	1572		662	2234	
2001	2229		1361	3590	(3498)
2002	1354		1379	2733	

Table 3. Canadian and USA 5Zj,m commercial landings samples for 1978-2002. At-sea observer samples are included in Canadian length samples since 1994. USA length samples are for 5Zj,m only for 1978-1995, and for 5Z for 1996-2002 and USA 5Zj,m age samples were supplemented with DFO 5Zj,m age samples for 1996-2002.

	USA			Canada		
	Samples	Lengths	Ages(total)	Samples	Lengths	Ages
1978	29	2047	385	29	7684	1308
79	21	1833	402	13	3991	656
1980	16	1258	286	10	2784	536
81	21	1615	456	17	4147	842
82	45	4111	778	17	4756	858
83	40	3775	903	15	3822	604
84	44	3891	1130	7	1889	385
85	23	2076	597	18	7644	1062
86	27	2145	644	19	5745	888
87	23	1865	525	33	9477	1288
88	37	3229	797	43	11709	1984
89	19	1572	251	32	8716	1561
1990	28	1989	287	40	9901	2012
91	23	1894	397	45	10873	1782
92	25	2048	445	48	10878	1906
93	29	2215	440	51	12158	2146
94	13	1323	260	104	25845	1268
95	-	-	-	36	11598	548
96	3	284	74(953)	129	26663	879
97	80	6638	55(1299	118	31882	1244
98	82	7076	46(1766)	139	26549	1720
99	70	6045	250(1168)	84	24954	918
2000	156	12219	41(1551)	107	20782	1436
2001	108	8389	351(2423)	108	18190	1509
2002	86	6306	378(1642)	91	18974	1264

Table 4. Summary of 2002 Canadian commercial and Observer samples used to estimate catch-at-age. USA catch-at-age for 1994-2002 was provided by the USA, and based on commercial landings samples prorated by market category supplemented with Canadian age samples.

GEAR	MONTH	Landings (T) MONTH	#LEN	#AGES	Landings (T) QUARTER
OTB+Misc	Jan				
	Feb				
	Mar				0
	Apr				
	May				
	Jun	38	913	89	38
	Jul	87	886	124	
	Aug	33	200	37	
	Sep	78	1230	173	198
	Oct	62	754	79	
	Nov	55	1843	232	
	Dec+Jan/03	86	1205	42	203
Total Canadian		439	7031	776	439
Total USA		1379	6306	378	
Total					
Longline	Jan				
	Feb				
	Mar				
	Apr				
	May				
	Jun	2			2
	Jul	151	2067	54	
	Aug	199	4493	128	
	Sep	161	941	49	511
	Oct	127	996	191	
	Nov	31	297		
	Dec	30	166		188
Total		701	8960	422	701
Gillnet	Jan				
	Feb				
	Mar				
	Apr				
	May				
	Jun	3	447		3
	Jul	45	760		
	Aug	51	1324		
	Sep	23	313	35	119
	Oct	1	139	31	
	Nov	9			
	Dec	7			17
Total		139	2983	66	139
Age Keys	Q1				
	Q2	43	1360	89	
	Q3	829	12214	600	
	Q4	407	5400	575	
Total Canada		**1279**	**18974**	**1264**	**1279**
Total Canada + USA		**2659**	**6306**	**1642**	

Table 5a. Results of intra-reader ageing agreements.

Results of intra-reader aging comparisons

Canadian samples include: NED2002002(31); NED2001003(31); 20010338(41); random qtr2(32); 20020727(45); random qtr3(32); 20010948(36); random qtr4(34).

1st Age			2nd Age - BH						
BH	2	3	4	5	6	7	8	9	Total
2	3								3
3	1	53	4						58
4		4	47	1					52
5			3	49	2				54
6				5	25	2			32
7						15	2		17
8						2	18	5	25
Total									241

	DIFF	
-1	0	+1
15	210	16

CV=1.80

87% Agreement

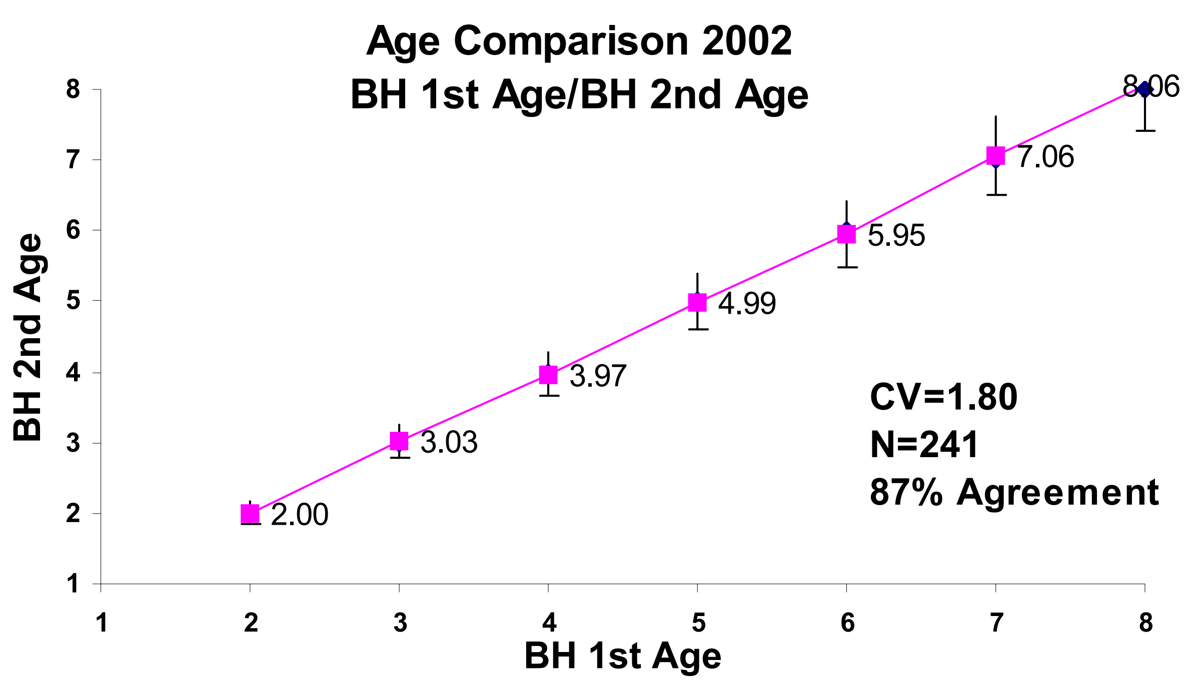


Table 5b. Results of inter-reader aging comparisons.

Canadian exchange samples: NED2002002 RV Feb. Survey (20); Observer sample - Oct. 2001 (10); Commercial sample - July 2001 (30)
US exchange sample: Cruise 02-04 Code 200202 Spring Survey (50)

1st Age	2nd Age (CAN							
US	1	2	3	4	5	6	7	Total
1	2							2
2		1	1					2
3			16	2	1			19
4			2	23	7			32
5				3	20	3	1	27
6				1	1	17		19
7						2	4	6
Total	2	1	19	29	29	22	5	107

78% Agreement

DIFF		
-1	0	1
9	83	15

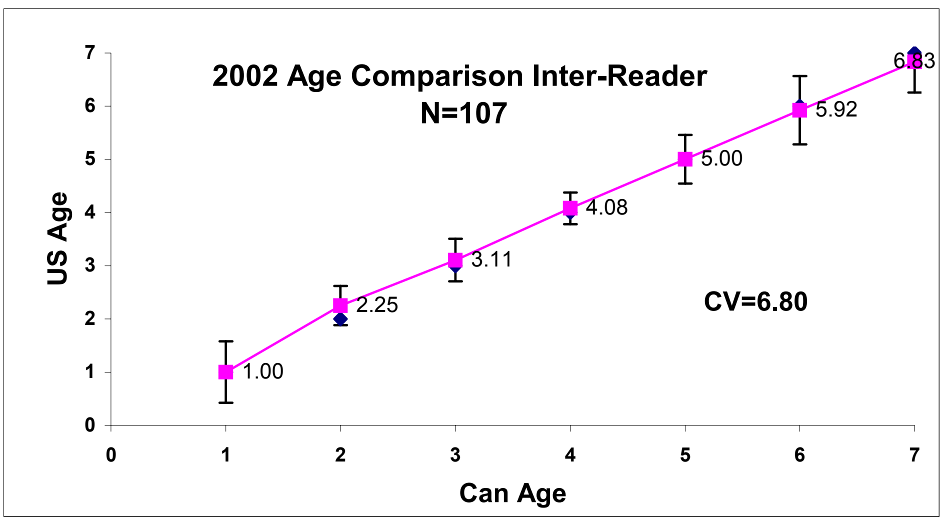


Table 6. Landings-at-age (000's) and percent at age for combined Canada and USA fishery.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1978	0	2	121	3588	1076	307	110	83	21	12	4	5323
1979	0	10	814	399	1774	545	149	22	45	4	3	3765
1980	0	1	987	1495	265	916	345	109	20	33	5	4177
1981	0	19	603	1443	1249	155	595	169	65	36	18	4352
1982	0	6	2682	1686	1429	1066	189	345	157	37	12	7609
1983	0	40	1319	3416	1474	466	283	31	71	39	6	7145
1984	0	10	269	911	1346	511	290	230	31	72	26	3697
1985	0	12	2792	1221	631	941	224	96	100	14	27	6058
1986	0	28	328	2202	516	306	403	58	39	26	4	3911
1987	0	14	3666	865	1099	144	121	167	37	24	8	6144
1988	0	10	317	3619	640	853	143	101	142	40	19	5884
1989	0	1	734	647	1823	192	312	56	25	51	12	3852
1990	0	7	680	3204	965	1198	116	122	10	14	23	6339
1991	0	11	626	783	1940	953	790	93	56	18	7	5278
1992	0	86	2353	1248	431	906	249	232	25	27	2	5559
1993	0	4	414	1968	809	215	332	110	93	23	17	3986
1994	0	2	182	486	751	246	41	59	26	20	1	1814
1995	0	0	56	235	120	89	14	4	3	2	0	523
1996	0	1	39	235	392	76	48	11	3	2	0	806
1997	0	3	108	156	288	293	71	32	10	4	1	966
1998	0	0	82	275	137	139	116	18	11	3	0	783
1999	0	2	46	422	271	80	44	41	9	1	3	920
2000	0	0	46	110	323	124	32	19	12	2	0	669
2001	0	2	17	412	195	360	93	27	16	4	0	1125
2002	0	0	8	114	363	94	139	23	7	4	1	754
1978	0%	0%	2%	67%	20%	6%	2%	2%	0%	0%	0%	
1979	0%	0%	22%	11%	47%	14%	4%	1%	1%	0%	0%	
1980	0%	0%	24%	36%	6%	22%	8%	3%	0%	1%	0%	
1981	0%	0%	14%	33%	29%	4%	14%	4%	1%	1%	0%	
1982	0%	0%	35%	22%	19%	14%	2%	5%	2%	0%	0%	
1983	0%	1%	18%	48%	21%	7%	4%	0%	1%	1%	0%	
1984	0%	0%	7%	25%	36%	14%	8%	6%	1%	2%	1%	
1985	0%	0%	46%	20%	10%	16%	4%	2%	2%	0%	0%	
1986	0%	1%	8%	56%	13%	8%	10%	1%	1%	1%	0%	
1987	0%	0%	60%	14%	18%	2%	2%	3%	1%	0%	0%	
1988	0%	0%	5%	62%	11%	14%	2%	2%	2%	1%	0%	
1989	0%	0%	19%	17%	47%	5%	8%	1%	1%	1%	0%	
1990	0%	0%	11%	51%	15%	19%	2%	2%	0%	0%	0%	
1991	0%	0%	12%	15%	37%	18%	15%	2%	1%	0%	0%	
1992	0%	2%	42%	22%	8%	16%	4%	4%	0%	0%	0%	
1993	0%	0%	10%	49%	20%	5%	8%	3%	2%	1%	0%	
1994	0%	0%	10%	27%	41%	14%	2%	3%	1%	1%	0%	
1995	0%	0%	11%	45%	23%	17%	3%	1%	1%	0%	0%	
1996	0%	0%	5%	29%	49%	9%	6%	1%	0%	0%	0%	
1997	0%	0%	11%	16%	30%	30%	7%	3%	1%	0%	0%	
1998	0%	0%	10%	35%	18%	18%	15%	2%	1%	0%	0%	
1999	0%	0%	5%	46%	29%	9%	5%	4%	1%	0%	0%	
2000	0%	0%	7%	17%	48%	18%	5%	3%	2%	0%	0%	
2001	0%	0%	1%	37%	17%	32%	8%	2%	1%	0%	0%	
2002	0%	0%	1%	15%	48%	12%	18%	3%	1%	0%	0%	
Average 1978-1990	0%	0%	21%	35%	23%	11%	5%	2%	1%	1%	0%	
Average 1991-2002	0%	0%	11%	29%	31%	17%	8%	3%	1%	0%	0%	

Table 7. Weight-at-age (kg) derived from fishery (mid-year) and from 1987-2003 DFO surveys (beginning of year) for 5Zj,m cod.

Midyear	0	1	2	3	4	5	6	7	8	9	10
1978	0.05	0.707	1.310	2.461	3.469	4.336	5.787	7.374	8.492	11.785	13.624
1979	0.05	0.889	1.494	2.149	4.211	4.888	7.178	9.183	10.313	11.699	14.064
1980	0.05	0.836	1.460	2.468	3.668	5.647	6.676	8.390	9.089	8.432	14.351
1981	0.05	0.882	1.495	2.358	3.415	5.213	7.222	8.565	9.888	14.170	13.574
1982	0.05	0.765	1.402	2.664	3.834	5.352	6.511	9.363	9.897	12.503	13.680
1983	0.05	0.971	1.490	2.377	3.309	4.637	6.393	7.964	10.286	11.227	12.209
1984	0.05	1.053	1.635	2.451	3.619	5.083	6.582	8.909	10.104	11.303	13.792
1985	0.05	0.907	1.418	2.086	3.887	5.087	6.412	8.097	10.236	11.418	12.724
1986	0.05	0.929	1.475	2.447	3.660	5.603	7.191	8.915	9.955	12.687	8.913
1987	0.05	0.726	1.481	2.495	4.187	5.810	7.726	8.949	10.013	11.414	13.928
1988	0.05	0.786	1.520	2.359	3.511	5.401	6.647	8.776	9.987	11.143	13.166
1989	0.05	0.809	1.617	2.269	3.772	5.396	6.694	8.222	10.718	11.665	14.143
1990	0.05	0.831	1.560	2.462	3.522	4.892	6.333	8.456	10.648	12.580	14.043
1991	0.05	1.114	1.627	2.548	3.420	4.769	5.891	7.410	10.520	9.686	14.521
1992	0.05	1.148	1.542	2.464	3.843	4.704	6.156	7.509	9.846	12.059	14.521
1993	0.05	0.883	1.571	2.308	3.079	4.496	5.729	7.075	8.884	9.699	10.858
1994	0.05	0.906	1.457	2.409	3.830	4.804	7.092	7.862	8.934	9.698	10.374
1995	0.05	0.900	1.489	2.507	3.723	5.224	6.522	11.055	10.118	10.383	14.521
1996	0.05	1.034	1.538	2.358	3.337	5.237	6.358	6.916	8.455	12.883	10.514
1997	0.05	0.978	1.498	2.232	3.339	4.254	5.797	8.048	8.330	11.870	14.521
1998	0.05	0.629	1.483	2.373	3.193	4.270	5.827	6.990	8.298	12.684	11.815
1999	0.05	0.796	1.554	2.286	3.527	4.164	6.310	6.775	8.043	12.153	13.536
2000	0.05	0.866	1.458	2.128	3.075	4.230	4.923	6.200	7.344	8.267	12.974
2001	0.05	0.880	1.488	2.334	2.998	4.053	5.122	5.081	8.019	9.224	14.812
2002	0.050	0.551	1.419	2.266	3.076	4.301	5.065	6.746	8.278	8.822	8.458
1978-2002	0.050	0.871	1.499	2.370	3.540	4.874	6.326	7.953	9.388	11.178	12.945
2000-2002	0.050	0.766	1.455	2.243	3.050	4.195	5.037	6.009	7.880	8.771	12.082

Beginning	0	1	2	3	4	5	6	7	8	9	10
1978	0.05	0.120	0.780	1.617	2.671	4.038	5.838	7.051	8.947	13.194	14.579
1979	0.05	0.120	0.780	1.617	2.671	4.038	5.838	7.051	8.947	13.194	14.579
1980	0.05	0.120	0.780	1.617	2.671	4.038	5.838	7.051	8.947	13.194	14.579
1981	0.05	0.120	0.780	1.617	2.671	4.038	5.838	7.051	8.947	13.194	14.579
1982	0.05	0.120	0.780	1.617	2.671	4.038	5.838	7.051	8.947	13.194	14.579
1983	0.05	0.120	0.780	1.617	2.671	4.038	5.838	7.051	8.947	13.194	14.579
1984	0.05	0.120	0.780	1.617	2.671	4.038	5.838	7.051	8.947	13.194	14.579
1985	0.05	0.120	0.780	1.617	2.671	4.038	5.838	7.051	8.947	13.194	14.579
1986	0.05	0.121	0.806	1.700	2.783	4.202	6.217	7.311	9.307	13.864	14.579
1987	0.05	0.151	0.843	1.690	2.838	5.800	8.426	8.154	7.464	13.569	15.657
1988	0.05	0.126	0.894	1.883	3.002	4.519	6.952	9.028	9.850	13.569	15.657
1989	0.05	0.153	0.805	1.669	2.868	4.226	6.588	7.634	8.099	13.635	14.579
1990	0.05	0.204	0.787	1.896	3.075	4.581	6.336	8.307	9.491	14.919	16.104
1991	0.05	0.086	0.870	1.923	3.181	4.266	5.099	7.308	9.616	13.732	15.765
1992	0.05	0.140	0.813	1.972	3.102	4.376	6.195	7.105	8.585	17.232	14.579
1993	0.05	0.081	0.936	1.884	3.087	4.791	6.024	6.969	7.581	12.021	12.825
1994	0.05	0.076	0.655	1.439	2.865	4.340	7.591	8.091	11.428	16.162	14.579
1995	0.05	0.146	0.798	1.567	2.225	3.535	5.132	6.204	7.275	14.856	17.550
1996	0.05	0.052	0.729	1.647	2.699	4.124	6.250	5.662	11.000	14.090	15.553
1997	0.05	0.100	0.725	1.762	2.352	3.434	6.564	7.529	10.996	13.680	16.935
1998	0.05	0.102	0.620	1.349	2.461	3.312	4.811	5.931	8.386	9.896	11.509
1999	0.05	0.151	0.999	1.414	2.425	3.317	4.848	7.116	11.222	13.319	14.579
2000	0.05	0.118	0.905	1.608	2.423	3.276	4.854	6.189	7.984	14.441	14.630
2001	0.05	0.120	0.735	1.500	2.596	3.901	5.311	7.191	7.512	10.847	10.923
2002	0.05	0.120	0.423	1.175	2.306	3.592	4.412	5.952	8.436	10.001	11.842
2003	0.05	0.120	0.695[1]	1.032	1.787	3.090	3.480	5.237	6.807	7.662	14.579
1986-2003	0.050	0.120	0.780	1.617	2.671	4.038	5.838	7.051	8.947	13.194	14.579
2001-2003	0.050	0.120	0.618	1.236	2.230	3.528	4.401	6.127	7.585	9.503	12.448

[1] DFO 2003 spring (null) replaced with NMFS spring 2003

Table 8. DFO and NEFSC survey indices of abundance (catch per standard tow in numbers).

Spring DFO		1	2	3	4	5	6	7	8	Sum
1986		1.78	8.19	7.41	0.77	1.6	1.03	0.51	0.08	21.37
1987		0.12	4.31	1.55	1.81	0.39	0.21	0.44	0.21	9.04
1988		0.36	1.08	12.85	1.36	2.02	0.23	0.19	0.43	18.52
1989		0.84	5.22	1.84	4.11	0.62	0.8	0.1	0.2	13.73
1990		0.25	1.91	8.36	4.7	10.6	1.29	2.63	0.35	30.09
1991		2.83	2.43	3.4	3.93	2.06	2.87	0.36	0.6	18.48
1992		0.11	4.93	2.94	0.99	1.55	1.09	0.72	0.22	12.55
1993		0.07	0.85	4.15	1.5	0.89	1.82	0.66	0.64	10.58
1994		0.03	1.51	1.66	3.1	1.15	0.44	0.88	0.2	8.97
1995		0.08	0.45	2.99	1.82	1.25	0.45	0.11	0.16	7.31
1996		0.22	0.49	4.2	10.44	3.45	2.49	1.07	0.26	22.62
1997		0.07	0.9	1.37	3.19	3.04	0.52	0.12	0.08	9.29
1998		0.01	1.42	2.04	0.79	0.77	0.58	0.14	0.07	5.82
1999		0.01	0.38	3.12	2.63	1.08	0.76	0.46	0.02	8.46
2000		0	1.02	3.12	11.96	5.19	2.48	1.23	0.76	25.76
2001		0.01	0.09	1.93	1.25	3.35	1.55	0.8	0.54	9.52
2002		0	0.28	1.15	5.05	1.67	3.09	1.1	0.45	12.79
2003		0	0.02	0.48	1.23	2.09	0.47	0.53	0.17	4.99
Fall NMFS										
1978		2.64	0.26	5.1	0.73	0.11	0.27			9.11
1979		2.96	2.93	0.21	2.71	0.44	0.11			9.36
1980		1.43	0.76	1.21	0.05	0.35	0.44			4.24
1981		4.24	2.19	1.69	0.48	0.02	0.35			8.97
1982		1.05	1.29	0.08	0.12	0	0.02			2.56
1983		0.12	0.42	0.89	0.05	0.03	0			1.51
1984		2.84	0.14	1.03	1.68	0.05	0.03			5.77
1985		0.39	1.8	0.3	0.03	0	0.05			2.57
1986		5.2	0.11	0.35	0	0	0			5.66
1987		0.24	1.53	0.23	0.19	0	0			2.19
1988		1.02	0.33	2.13	0.25	0.44	0			4.17
1989		0.72	1.68	0.28	0.77	0.1	0.44			3.99
1990		0.72	0.79	1.49	0.21	0.37	0.1			3.68
1991		0.36	0.13	0.16	0.02	0.06	0.37			1.10
1992		0.37	1.31	0.28	0	0.07	0.06			2.09
1993		0.14	0.19	0.28	0.03	0	0.07			0.71
1994		0.14	0.54	0.39	0.28	0.14	0			1.49
1995		0.05	0.22	0.54	0.12	0.05	0.14			1.12
1996		0.56	0.15	0.56	0.41	0.1	0.05			1.83
1997		0.29	0.7	0.32	0.1	0.15	0.1			1.66
1998		0.32	1.29	0.9	0.12	0.2	0.15			2.98
1999		0.03	0.03	0.45	0.22	0.06	0.2			0.99
2000		0.1	0.37	0.12	0.16	0.08	0.06			0.89
2001		0.13	0.34	0.36	0.07	0.09	0.09			1.08
2002		0.26	1.24	2.29	3.43	0.35	0.22			7.79
Spring NMFS	Yankee 41									
1978		0.27	0	5.1	1.12	1.61	0.34	1.37	0.19	10.00
1979		0.69	2.65	0.22	2.57	1	0.34	0.17	0.22	7.86
1980		0.03	2.96	2.9	0.28	3.01	0.59	0.12	0.08	9.97
1981		1.7	1.57	2.43	1.73	0.07	0.6	0.31	0.12	8.53
Spring NMFS	Yankee 36									
1982		0.79	11.58	24.99	22.29	16.98	0	5.55	1.24	83.42
1983		0.69	3.63	6.33	1.36	1.06	0.66	0.28	0.11	14.12
1984		0.2	0.22	0.81	1.22	0.48	0.39	0.34	0	3.66
1985		0.08	3.67	1.15	1.92	2.75	0.6	0.35	0.45	10.97
1986		1.13	0.62	2.05	0.55	0.78	0.98	0.05	0.21	6.37
1987		0	2.17	0.46	0.98	0	0.34	0.28	0.06	4.29
1988		0.58	0.45	5.05	0.5	0.84	0.08	0.03	0.14	7.67
1989		0.21	1.55	0.47	2.39	0.46	0.54	0.07	0.06	5.75
1990		0.13	0.62	3.14	1.09	1.18	0.29	0.3	0.03	6.78
1991		1.31	1.12	0.92	1.63	0.83	0.69	0.08	0.03	6.61
1992		0.14	1.2	0.65	0.17	0.45	0.27	0.29	0.05	3.22
1993		0	0.83	2.32	0.47	0.08	0.33	0.08	0.08	4.19
1994		0.1	0.37	0.29	0.36	0.09	0.02	0.06	0	1.29
1995		0.09	0.52	1.64	0.88	1.63	0.35	0.47	0.06	5.64
1996		0.25	0.54	1.78	2.41	0.22	0.17	0.05	0	5.42
1997		0.1	0.37	0.11	0.73	0.93	0.1	0.23	0.1	2.67
1998		0	1.99	3.8	1.91	1.88	1.17	0.06	0.06	10.87
1999		0.04	0.24	1.24	1.14	0.66	0.31	0.18	0.06	3.87
2000		0	0.55	1.16	2.43	0.89	0.25	0.09	0.04	5.41
2001		0	0.12	1.6	0.17	0.63	0.2	0	0.02	2.74
2002		0.01	0.2	0.93	2.03	0.39	0.4	0.12	0	4.08
2003		0	0.29	0.78	1.59	1.69	0.16	0.16	0.01	4.68

Table 9. Summary of Canadian landings (t) and effort data (days) by gear sector for Georges Bank cod. Effort is the calculated value from total landings divided by average landings per day.

	Mobile	Gillnet	Longline		Mobile	Gillnet	Longline
1990 Total catch (t)	7920	909	5438	1997 Total catch (t)	1033	470	1416
Total with effort (t)	7285	534	1579	Total with effort (t)	1009	409	1152
Number of Boats	176	14	103	Number of boats	74	9	74
Percent with effort	92.0	58.7	29.0	Percent with effort	97.7	87.0	81.4
Effort (fish_days)	4168	367	2847	Effort (fish_days)	1187	189	874
Catch per day	1.9	2.48	1.91	Landings per day	0.87	2.49	1.62
1991 Total catch (t)	6653	1741	4923	1998 Total catch (t)	645	300	963
Total with effort (t)	6395	1084	1581	Total with effort (t)	626	299	861
Number of boats	188	26	118	Number of boats	71	9	64
Percent with effort	96.1	62.3	32.1	Percent with effort	97.1	99.7	89.4
Effort (fish_days)	3914	495	2647	Effort (fish_days)	1057	181	646
Landings per day	1.7	3.52	1.86	Landings per day	0.61	1.66	1.49
1992 Total catch (t)	5590	1217	4751	1999 Total catch (t)	620	270	929
Total with effort (t)	5583	684	1893	Total with effort (t)	607	264	912
Number of boats	138	19	130	Number of boats	69	7	60
Percent with effort	99.9	56.2	39.8	Percent with effort	97.9	97.8	98.2
Effort (fish_days)	2055	691	2699	Effort (fish_days)	939	179	596
Landings per day	2.72	1.76	1.76	Landings per day	0.66	1.51	1.56
1993 Total catch (t)	4889	1174	2394	2000 Total catch (t)	535	238	799
Total with effort (t)	4877	943	1179	Total with effort (t)	523	238	794
Number of boats	125	20	135	Number of boats	73	9	57
Percent with effort	99.8	80.3	49.2	Percent with effort	97.8	100.0	99.4
Effort (fish_days)	2385	788	2784	Effort (fish_days)	1092	184	605
Landings per day	2.05	1.49	0.86	Landings per day	0.49	1.29	1.32
1994 Total catch (t)	1894	1031	2287	2001 Total catch (t)	722	284	1137
Total with effort (t)	1886	79	73	Total with effort (t)	722	284	1137
Number of boats	95	21	78	Number of boats	75	7	77
Percent with effort	99.6	7.7	3.2	Percent with effort	100.0	100.0	100.0
Effort (fish_days)	1933			Effort (fish_days)	1604	132	836
Landings per day	0.98			Landings per day	0.45	2.15	1.36
1995 Total catch (t)	393	126	546	2002 Total catch (t)	439	140	700
Total with effort (t)	313	116	494	Total with effort (t)	439	140	700
Number of boats	64	11	49	Number of boats	71	6	65
Percent with effort	79.6	92.1	90.5	Percent with effort	100.0	100.0	100.0
Effort (fish_days)	634	221	575	Effort (fish_days)	2744	96	680
Landings per day	0.62	0.57	0.95	Landings per day	0.16	1.46	1.03
1996 Total catch (t)	659	245	1023				
Total with effort (t)	656	245	984				
Number of boats	76	10	102				
Percent with effort	99.5	100.0	96.2				
Effort (fish_days)	1080	111	890				
Landings per day	0.61	2.21	1.15				

Table 10. Statistical properties of estimates for population abundance and survey calibration constants from 1000 Bootstrap parameter estimates for 5Zj,m cod estimated from ADAPT.

Parameter	Estimate	Standard Error	Bias
Abundance [1998 10]	43.84	24.97	3.65
Abundance [1999 10]	93.34	39.36	6.09
Abundance [2000 10]	105.44	48.79	7.05
Abundance [2001 10]	66.99	31.06	3.79
Abundance [2002 10]	148.71	66.12	9.16
Abundance [2003 2]	453.14	241.38	55.79
Abundance [2003 3]	1126.34	426.13	89.77
Abundance [2003 4]	970.66	326.89	39.27
Abundance [2003 5]	1197.70	413.33	50.67
Abundance [2003 6]	309.25	104.93	17.50
Abundance [2003 7]	427.84	159.34	20.70
Abundance [2003 8]	254.81	90.47	12.98
Abundance [2003 9]	101.30	42.06	4.30
Abundance [2003 10]	107.96	44.53	4.53
DFO Age [2]	0.000336	0.000073	0.000010
DFO Age [3]	0.001155	0.000244	0.000019
DFO Age [4]	0.001742	0.000396	0.000037
DFO Age [5]	0.002358	0.000510	0.000044
DFO Age [6]	0.002386	0.000541	0.000088
DFO Age [7]	0.002325	0.000564	0.000090
NMFS Fall Age [1]	0.000112	0.000020	0.000002
NMFS Fall Age [2]	0.000154	0.000028	0.000001
NMFS Fall Age [3]	0.000238	0.000042	0.000004
NMFS Fall Age [4]	0.000156	0.000030	0.000001
NMFS Fall Age [5]	0.000185	0.000037	0.000003
NMFS Y41 Age [1]	0.000029	0.000015	0.000004
NMFS Y41 Age [2]	0.000314	0.000178	0.000038
NMFS Y41 Age [3]	0.000391	0.000195	0.000041
NMFS Y41 Age [4]	0.000434	0.000217	0.000041
NMFS Y41 Age [5]	0.000682	0.000376	0.000072
NMFS Y41 Age [6]	0.000771	0.000383	0.000083
NMFS Y41 Age [7]	0.001246	0.000582	0.000126
NMFS Y41 Age [8]	0.001599	0.000788	0.000138
NMFS Y36 Age [1]	0.000046	0.000010	0.000001
NMFS Y36 Age [2]	0.000239	0.000045	0.000004
NMFS Y36 Age [3]	0.000563	0.000107	0.000010
NMFS Y36 Age [4]	0.000794	0.000161	0.000013
NMFS Y36 Age [5]	0.000972	0.000189	0.000015
NMFS Y36 Age [6]	0.000775	0.000162	0.000015
NMFS Y36 Age [7]	0.000698	0.000138	0.000011
NMFS Y36 Age [8]	0.000636	0.000150	0.000013

Table 11. Population estimates for 5Zj,m cod derived from ADAPT.

Abundance (000's)	Age 0	1	2	3	4	5	6	7	8	9	10	1+	2+	3+
1978	11541	11051	2192	10494	3483	984	305	277	56	26	9	28869	17818	15626
1979	11229	9449	9046	1685	5376	1887	531	151	152	27	11	28304	18854	9809
1980	21128	9193	7727	6672	1021	2811	1055	301	104	84	19	28969	19776	12048
1981	7654	17298	7526	5437	4118	598	1480	555	148	67	39	37228	19930	12404
1982	5580	6266	14145	5618	3156	2251	350	679	303	63	23	32832	26566	12420
1983	16499	4568	5125	9168	3087	1307	892	119	249	108	19	24622	20053	14928
1984	5531	13509	3704	3011	4447	1212	653	476	69	140	53	27220	13712	10007
1985	25764	4529	11051	2790	1648	2433	535	275	185	29	50	23474	18946	7895
1986	8540	21094	3697	6539	1193	784	1150	238	139	62	11	34896	13802	10105
1987	16532	6992	17245	2731	3379	515	368	580	142	79	28	32032	25040	7795
1988	4862	13535	5712	10822	1460	1781	293	193	325	83	43	34204	20669	14957
1989	7037	3981	11073	4390	5616	623	697	112	68	140	32	26700	22719	11647
1990	10966	5761	3258	8403	3012	2963	339	292	42	33	69	24103	18342	15084
1991	3154	8978	4710	2056	4011	1601	1354	173	130	26	15	23039	14060	9350
1992	4338	2582	7341	3292	982	1553	464	406	59	56	5	16736	14153	6812
1993	2806	3551	2037	3900	1578	419	466	158	126	26	22	12261	8710	6673
1994	1814	2298	2904	1295	1439	570	151	89	32	21	1	8799	6501	3597
1995	3402	1486	1879	2214	625	508	247	87	21	3	0	7070	5585	3705
1996	5005	2786	1216	1488	1601	403	336	189	68	14	1	8102	5316	4100
1997	2023	4098	2280	960	1007	958	262	232	145	53	10	9996	5898	3618
1998	4912	1656	3353	1769	646	566	522	151	161	110	40	8932	7276	3924
1999	2330	4021	1356	2671	1201	405	338	322	107	122	87	10543	6522	5166
2000	1904	1908	3291	1068	1807	740	260	237	227	79	98	9616	7708	4417
2001	593	1559	1562	2653	775	1189	494	184	176	175	63	8766	7208	5646
2002	1832	485	1275	1264	1800	459	650	321	126	130	140	6511	6026	4751
2003	1500	1500	397	1037	931	1147	292	407	242	97	103	6050	4550	4153

Beginning of Year Biomass	0	1	2	3	4	5	6	7	8	9	10	1+	2 +	3 +
1978	577	1331	1709	16971	9303	3975	1780	1953	498	347	131	38000	36669	34959
1979	561	1138	7054	2726	14358	7618	3098	1065	1363	353	164	38936	37798	30744
1980	1056	1107	6026	10790	2728	11350	6162	2120	929	1113	270	42595	41487	35461
1981	383	2083	5869	8793	10999	2415	8640	3911	1329	885	572	45497	43413	37544
1982	279	755	11031	9085	8428	9090	2046	4789	2707	838	333	49102	48347	37316
1983	825	550	3997	14826	8244	5278	5205	837	2224	1422	277	42860	42310	38313
1984	277	1627	2889	4870	11876	4892	3811	3357	620	1844	779	36565	34938	32049
1985	1288	545	8618	4512	4401	9824	3124	1941	1651	383	729	35728	35183	26565
1986	427	2544	2979	11114	3321	3295	7146	1738	1297	861	161	34455	31911	28932
1987	827	1058	14529	4614	9591	2988	3103	4732	1061	1070	433	43179	42121	27592
1988	243	1710	5107	20379	4382	8050	2034	1742	3204	1129	679	48416	46706	41599
1989	352	608	8908	7328	16108	2634	4593	857	550	1904	466	43958	43350	34442
1990	548	1172	2565	15931	9260	13572	2145	2429	402	498	1107	49080	47908	45343
1991	158	773	4100	3954	12757	6828	6902	1264	1250	352	229	38411	37637	33538
1992	217	362	5969	6493	3047	6796	2874	2884	504	971	77	29977	29615	23646
1993	140	286	1906	7347	4871	2007	2810	1099	953	310	285	21875	21589	19683
1994	91	175	1903	1864	4122	2476	1147	718	364	339	17	13126	12951	11048
1995	170	217	1499	3468	1390	1797	1268	542	151	51	1	10384	10167	8667
1996	250	144	886	2452	4320	1664	2100	1072	744	202	22	13606	13462	12576
1997	101	409	1653	1692	2369	3290	1719	1747	1595	726	174	15373	14965	13312
1998	246	169	2080	2387	1589	1874	2509	894	1348	1087	463	14400	14230	12150
1999	117	608	1354	3777	2912	1344	1639	2293	1201	1621	1272	18021	17412	16058
2000	95	225	2978	1717	4377	2423	1260	1466	1814	1142	1439	18843	18617	15639
2001	30	188	1148	3979	2012	4637	2625	1320	1325	1902	690	19826	19638	18490
2002	92	58	539	1485	4152	1650	2869	1912	1062	1303	1652	16683	16624	16085
2003		181	276	1070	1664	3544	1015	2132	1646	743	1508	13781	13600	13324

Fishing Mortality	0	1	2	3	4	5	6	7	8	9	10	4-9F	4-9 Exp	**4-6F**	**4-6 Exp**
1978	0.000	0.000	0.063	0.469	0.413	0.418	0.502	0.398	0.532	0.653	0.571	0.421	31%	**0.420**	**31%**
1979	0.000	0.001	0.104	0.301	0.448	0.381	0.368	0.175	0.391	0.166	0.358	0.420	31%	**0.427**	**32%**
1980	0.000	0.000	0.151	0.282	0.335	0.442	0.443	0.505	0.238	0.565	0.385	0.423	31%	**0.420**	**31%**
1981	0.000	0.001	0.092	0.344	0.404	0.335	0.579	0.406	0.650	0.877	0.720	0.445	33%	**0.439**	**32%**
1982	0.000	0.001	0.234	0.399	0.681	0.726	0.883	0.805	0.832	1.005	0.862	0.729	47%	**0.711**	**47%**
1983	0.000	0.010	0.332	0.524	0.735	0.495	0.427	0.338	0.376	0.501	0.414	0.605	42%	**0.624**	**42%**
1984	0.000	0.001	0.083	0.403	0.403	0.617	0.663	0.748	0.670	0.828	0.776	0.499	36%	**0.471**	**34%**
1985	0.000	0.003	0.325	0.649	0.543	0.550	0.611	0.481	0.890	0.768	0.873	0.564	39%	**0.554**	**39%**
1986	0.000	0.001	0.103	0.460	0.640	0.556	0.483	0.314	0.370	0.609	0.443	0.538	38%	**0.561**	**39%**
1987	0.000	0.002	0.266	0.426	0.440	0.366	0.446	0.379	0.336	0.397	0.358	0.423	31%	**0.432**	**32%**
1988	0.000	0.001	0.063	0.456	0.651	0.738	0.758	0.844	0.645	0.755	0.668	0.707	46%	**0.704**	**46%**
1989	0.000	0.000	0.076	0.177	0.439	0.411	0.669	0.775	0.510	0.509	0.509	0.466	34%	**0.460**	**34%**
1990	0.000	0.001	0.260	0.540	0.432	0.583	0.472	0.611	0.301	0.632	0.447	0.509	36%	**0.505**	**36%**
1991	0.000	0.001	0.158	0.537	0.749	1.039	1.004	0.880	0.636	1.380	0.759	0.863	53%	**0.865**	**53%**
1992	0.000	0.037	0.432	0.533	0.644	1.003	0.879	0.972	0.623	0.729	0.675	0.872	53%	**0.866**	**53%**
1993	0.000	0.001	0.251	0.793	0.805	0.778	1.456	1.398	1.590	2.903	1.814	0.999	58%	**0.924**	**55%**
1994	0.000	0.001	0.071	0.521	0.818	0.600	0.300	1.228	2.010	5.788	0.000	0.807	51%	**0.724**	**47%**
1995	0.000	0.000	0.033	0.122	0.230	0.200	0.059	0.043	0.161	0.616	0.226	0.180	15%	**0.188**	**16%**
1996	0.000	0.000	0.036	0.187	0.306	0.221	0.154	0.058	0.032	0.124	0.048	0.247	20%	**0.269**	**22%**
1997	0.000	0.001	0.053	0.192	0.366	0.390	0.322	0.144	0.067	0.056	0.070	0.328	25%	**0.371**	**28%**
1998	0.000	0.000	0.027	0.184	0.256	0.298	0.257	0.122	0.064	0.025	0.006	0.232	19%	**0.270**	**22%**
1999	0.000	0.000	0.037	0.187	0.276	0.229	0.142	0.129	0.082	0.010	0.034	0.210	17%	**0.243**	**20%**
2000	0.000	0.000	0.015	0.117	0.212	0.193	0.133	0.083	0.048	0.018	0.002	0.177	15%	**0.200**	**16%**
2001	0.000	0.001	0.011	0.177	0.307	0.382	0.213	0.152	0.087	0.023	0.005	0.282	22%	**0.324**	**25%**
2002	0.000	0.000	0.006	0.096	0.230	0.232	0.240	0.075	0.044	0.025	0.008	0.203	17%	**0.232**	**19%**

Table 12. Projection results for the 2003, 2004 fishery and 2003-2005 population using bootstrap bias adjusted point estimates with a 2003=2002 yield of 2,800t and a fishing mortality in 2004 of F_{ref}=0.18.

Year						**Age**									
Projected Population Numbers															
	0	1	2	3	4	5	6	7	8	9	10				
2003	1500	1500	397	1037	931	1147	292	407	242	97	103				
2004	1500	1228	1228	321	729	569	691	190	295	184	77				
2005	1500	1228	1005	997	241	503	389	494	145	232	148				
Fishing Mortality															
2003	0.000	0.000	0.013	0.151	0.293	0.306	0.231	0.121	0.074	0.029	0.006				
2004	0.000	0.000	0.008	0.089	0.172	0.180	0.136	0.071	0.043	0.017	0.004				
,Natural Mortality															
2003	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20				
2004	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20				
Partial Recruitment to Fishery															
2003	0.00	0.00	0.04	0.49	0.96	1.00	0.75	0.40	0.24	0.09	0.02				
2004	0.00	0.00	0.04	0.49	0.96	1.00	0.75	0.40	0.24	0.09	0.02				
Beginning Weights															
2003	0.05	0.12	0.70	1.03	1.79	3.09	3.48	5.24	6.81	7.66	14.58				
2004	0.05	0.12	0.62	1.24	2.23	3.53	4.40	6.13	7.59	9.50	12.45				
2005	0.05	0.12	0.62	1.24	2.23	3.53	4.40	6.13	7.59	9.50	12.45				
Projected Population Biomass															
												0+	1+	2+	3+
2003	75	181	276	1070	1664	3544	1015	2132	1646	743	1508	13856	13781	13600	13324
2004	75	148	758	397	1626	2006	3042	1161	2240	1748	991	14193	14118	13970	13211
2005	75	148	621	1233	536	1773	1712	3027	1096	2200	1901	14322	14247	14100	13479
Projected Catch Numbers															
2003	0	0	5	132	216	276	55	42	16	2	1				
2004	0	0	9	25	105	85	80	12	11	3	0				
Midyear Weights															
2003	0.05	0.77	1.45	2.24	3.05	4.19	5.04	6.01	7.88	8.77	12.08				
2004	0.05	0.77	1.45	2.24	3.05	4.19	5.04	6.01	7.88	8.77	12.08				
Projected Catch Biomass															
2003	0	0	7	297	657	1157	276	254	123	22	7	2800	2800	2800	2793
2004	0	0	12	56	320	357	401	71	89	24	3	1335	1335	1335	1322

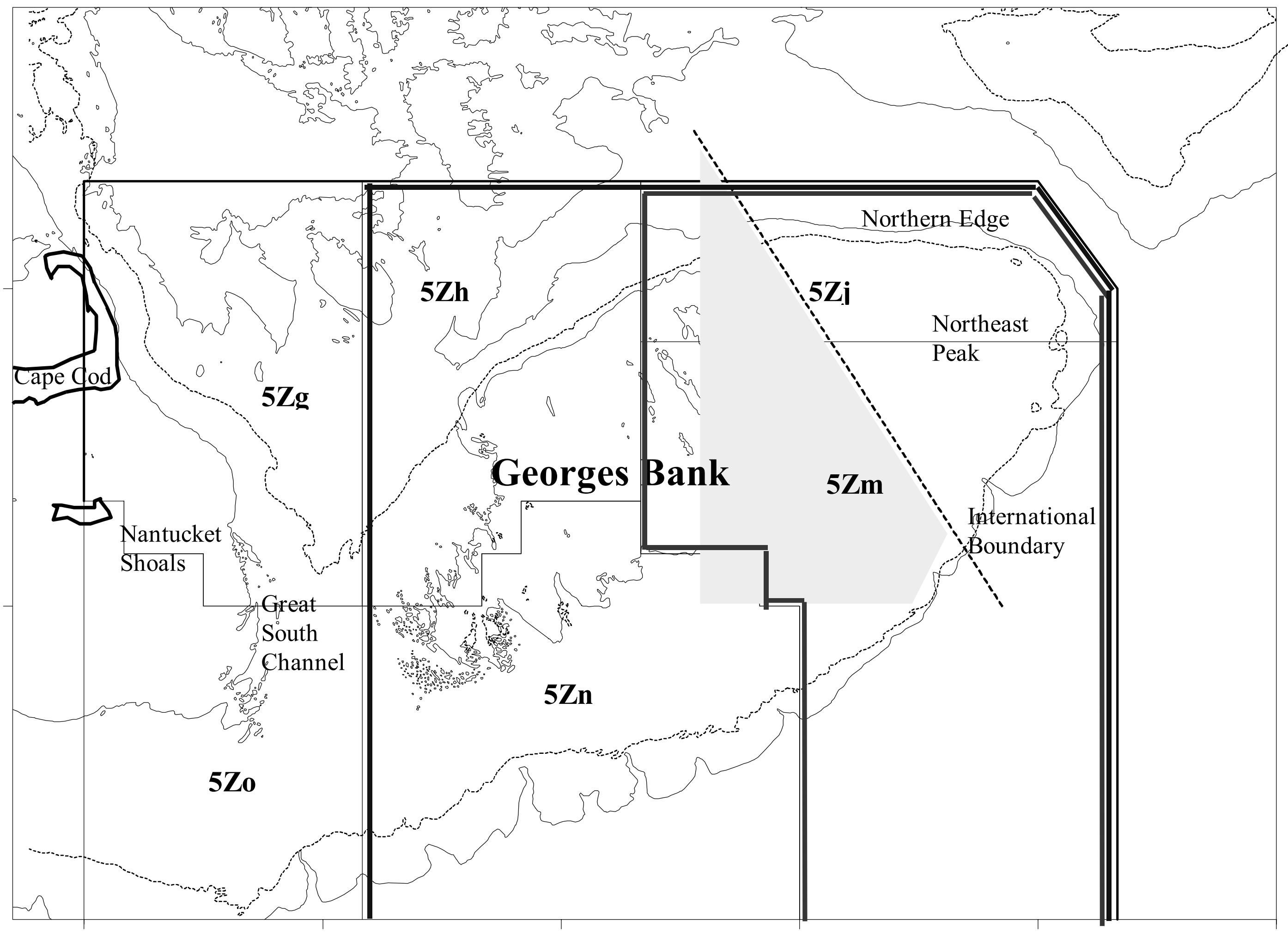


Figure 1a. Map of the Georges Bank area showing the 5Zj,m management unit. Shaded area indicates USA closed area II.

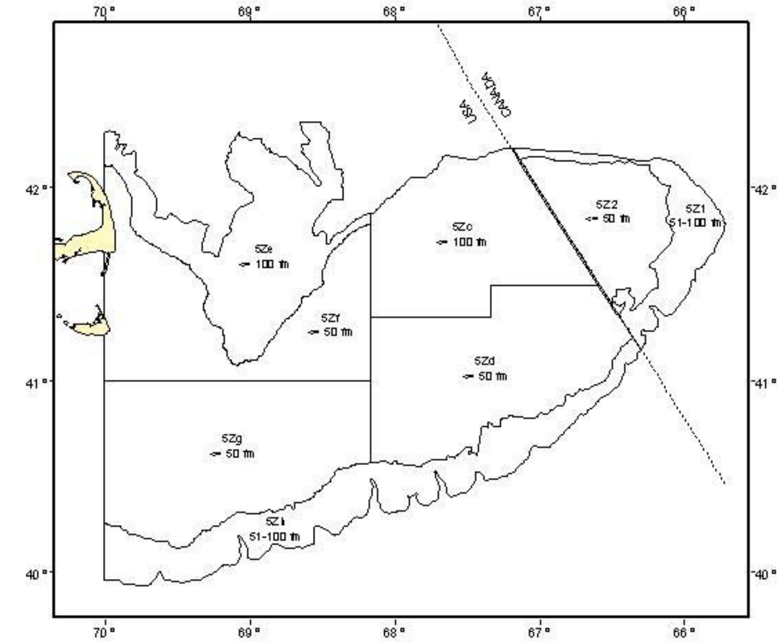


Figure 1b. DFO survey strata on Georges Bank.

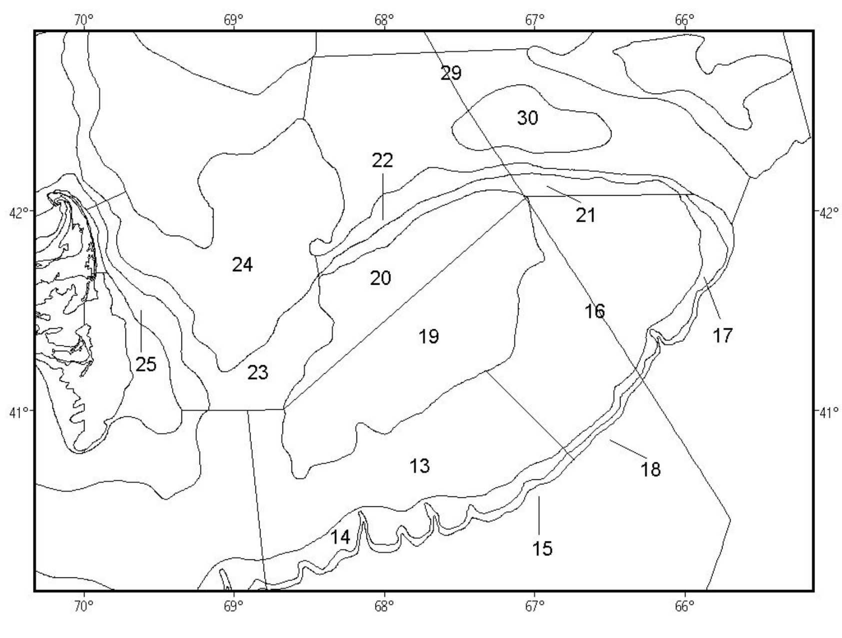


Figure 1c. NEFSC survey strata on Georges Bank.

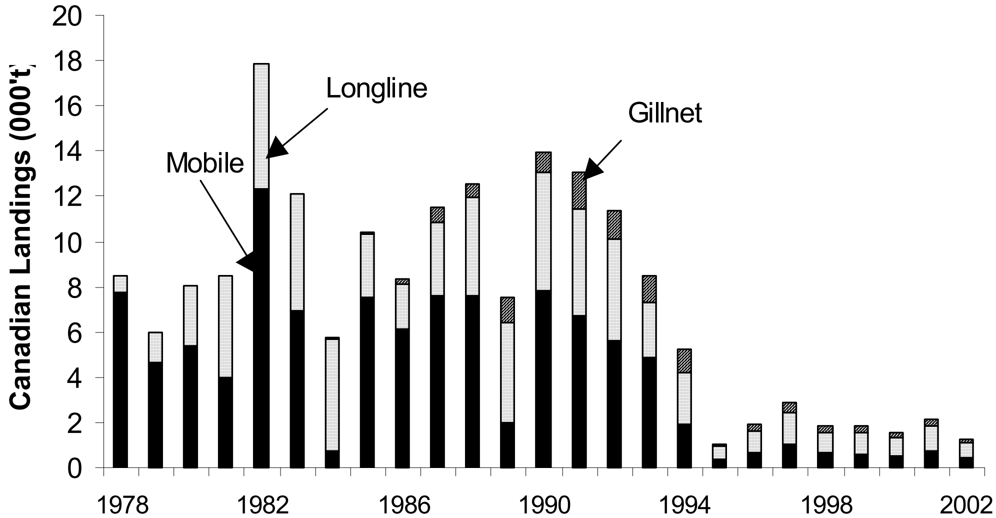


Figure 2. Landings of 5Zj,m cod by Canada gear sectors.

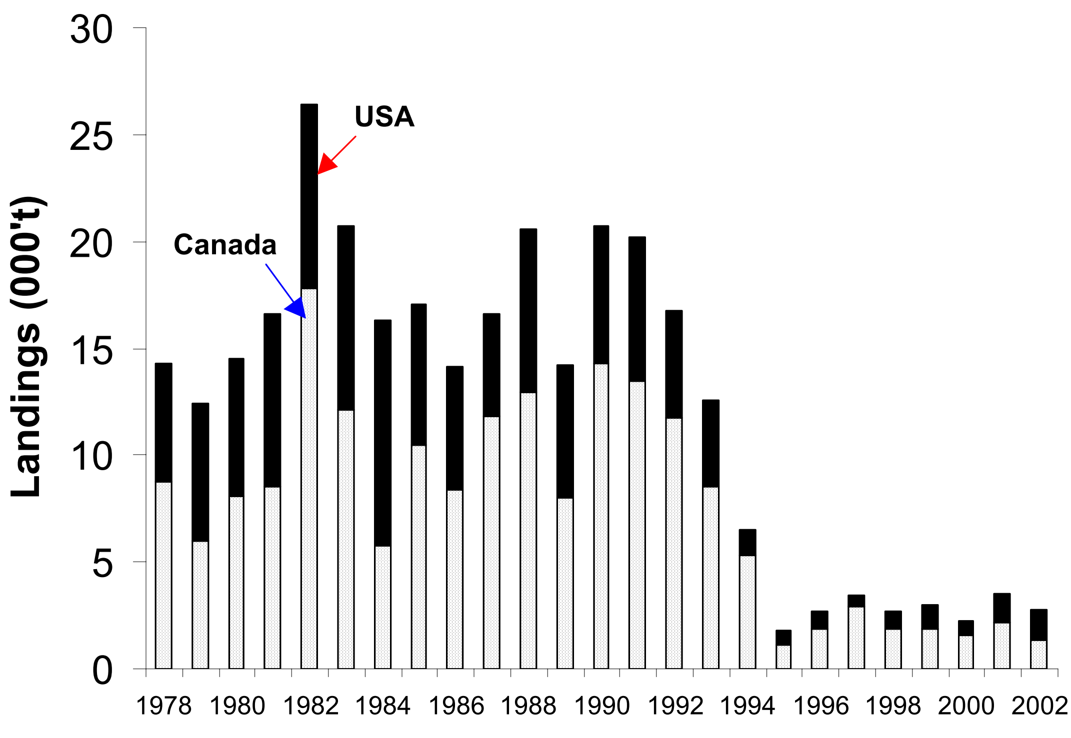
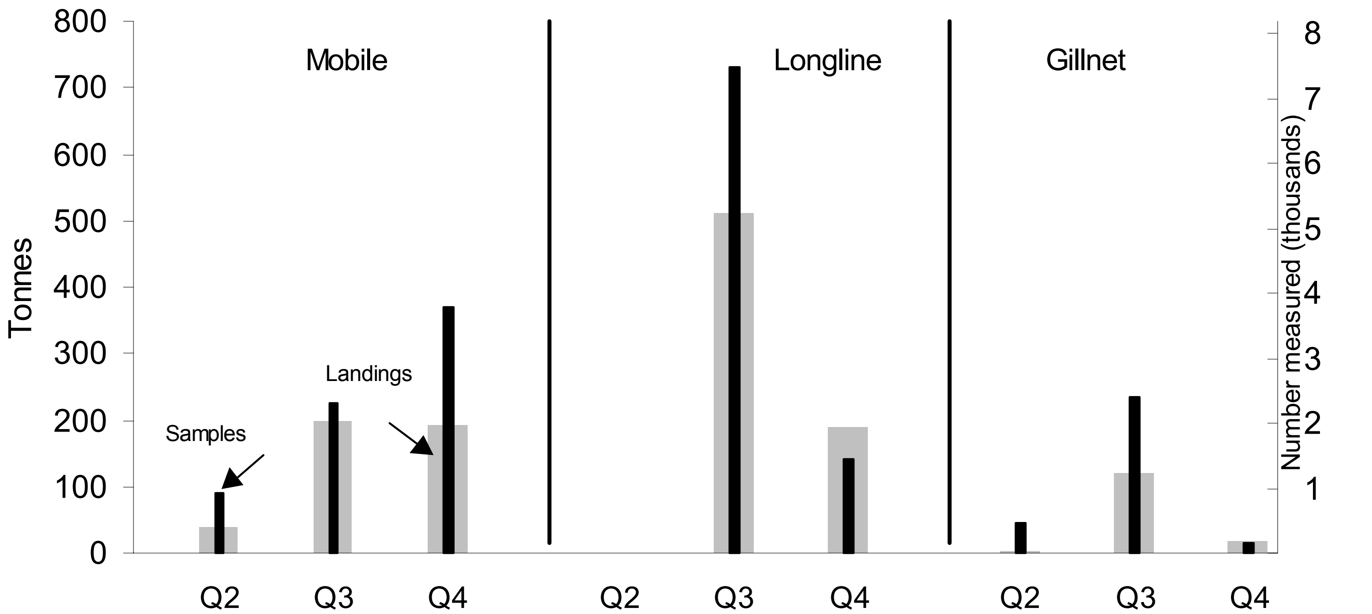


Figure 3. Landings of 5Zj,m cod by Canadian and USA fisheries.

Figure 4a. Summary of Canadian landings by gear sector and corresponding length samples used in determining catch at age.



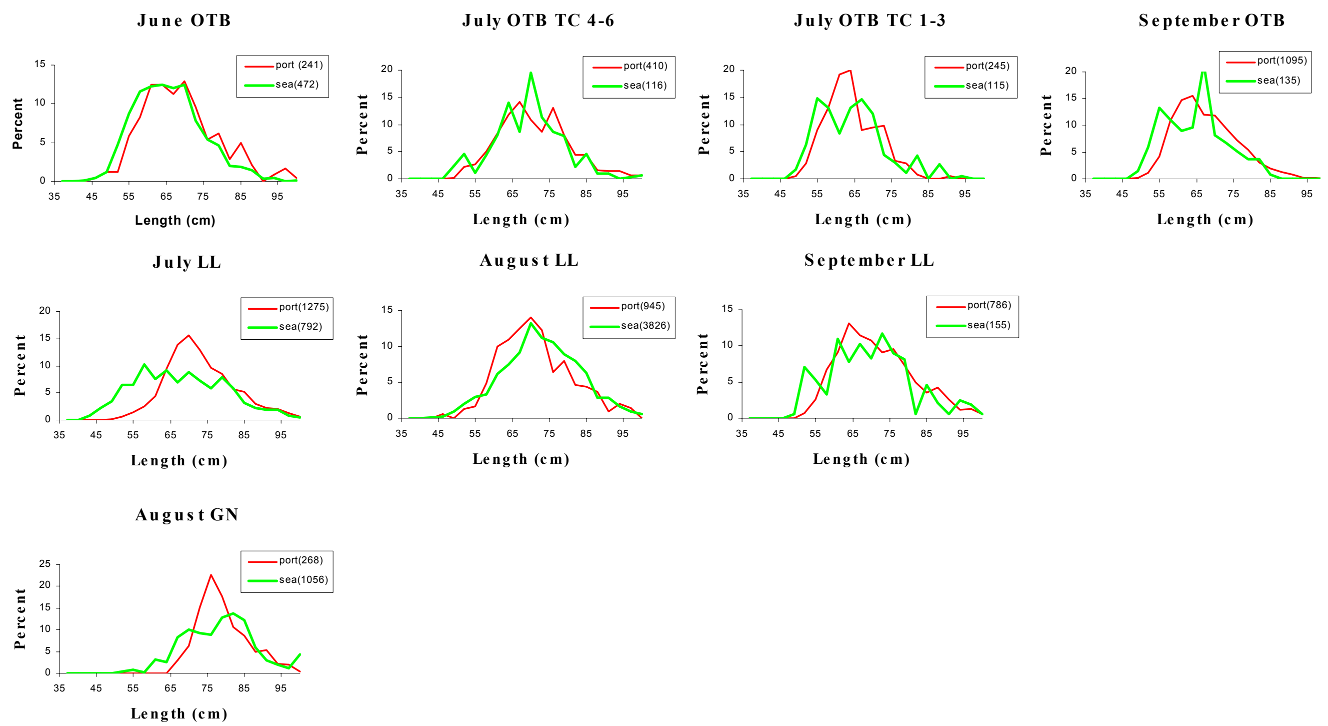


Figure 4b. Comparison of Canadian 2002 at-sea and on-shore length frequency distributions.

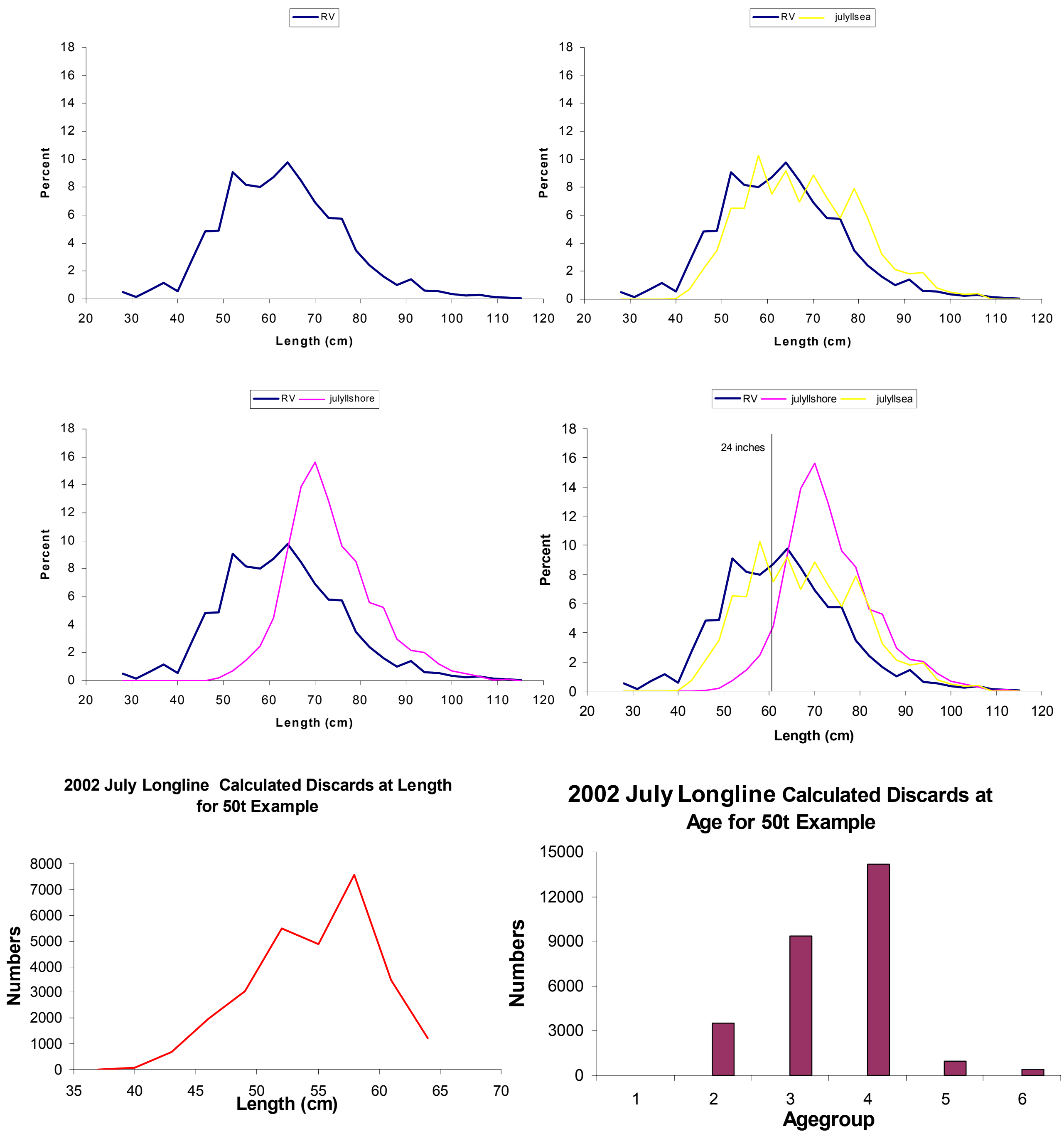


Figure 5. Illustrative example of discard calculation showing comparison of population length distribution from RV surveys with at-sea and landings samples; estimated discards at length and age for a 50 t example.

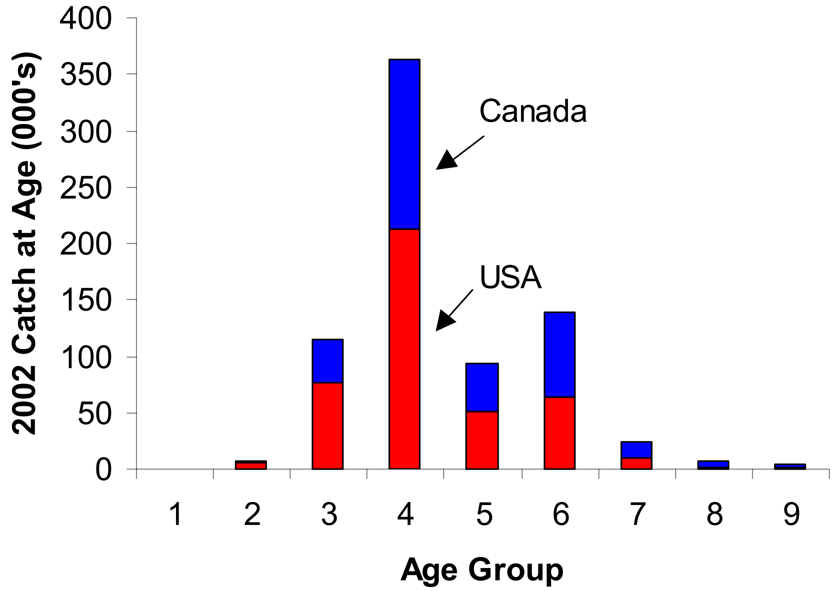


Figure 6. Catch at age in the 2002 combined Canadian and USA 5Zj,m cod fishery.

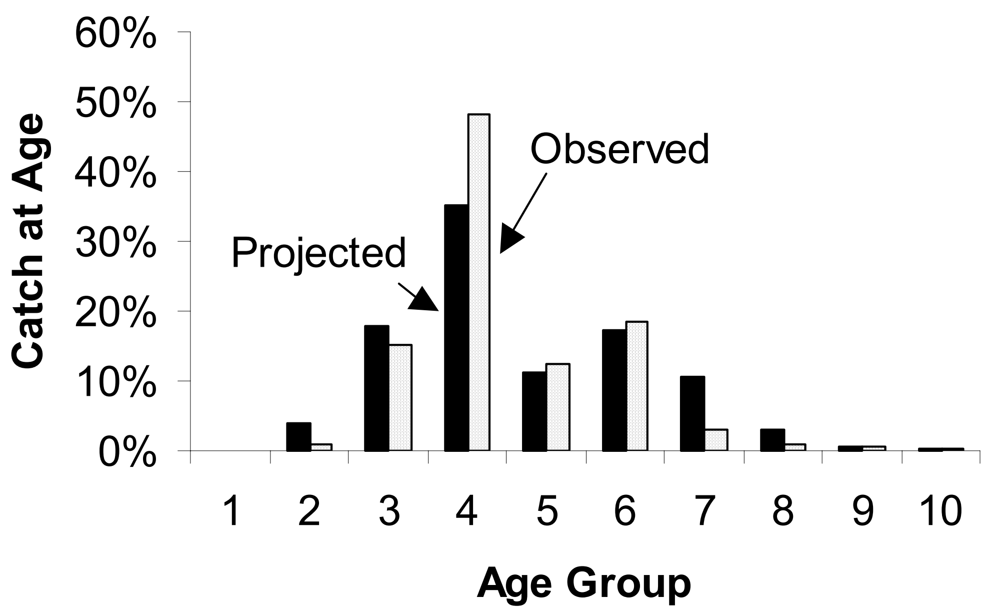


Figure 7. Observed and predicted percent catch at age for the 2002.

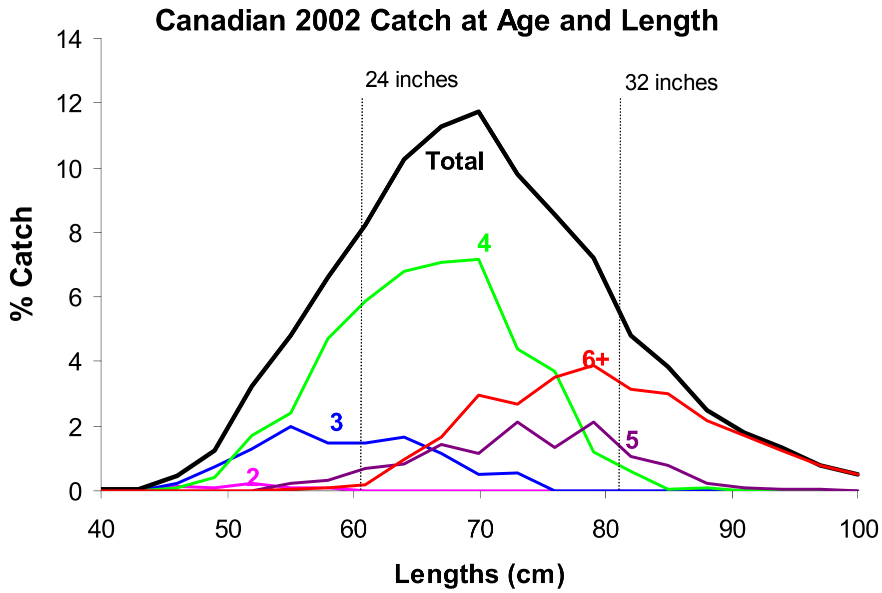


Figure 8a. Length composition by age group for the 2002 Canadian 5Zj,m cod fishery.

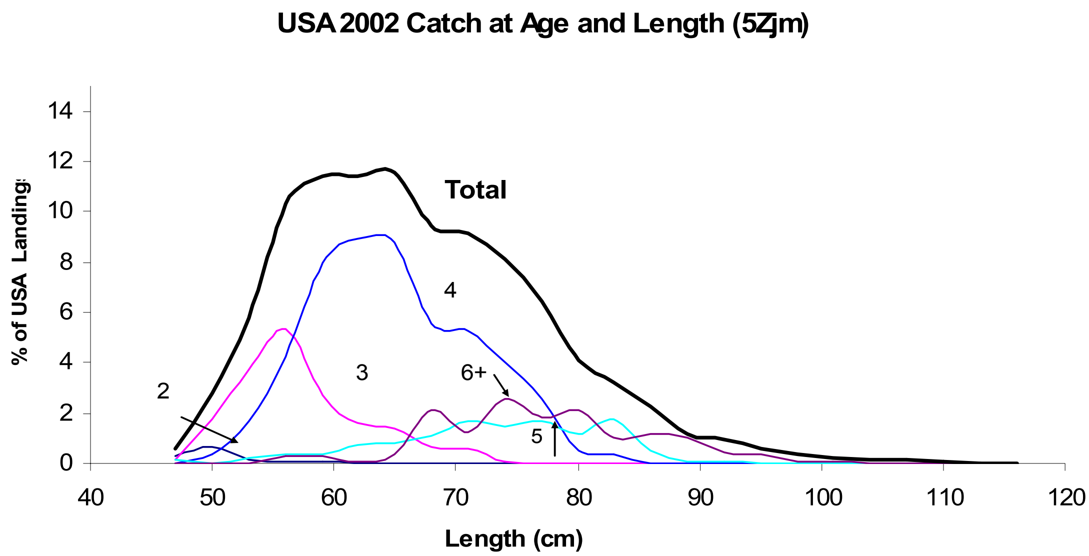


Figure 8b. Length composition by age group for the 2002 USA 5Zj,m cod fishery.

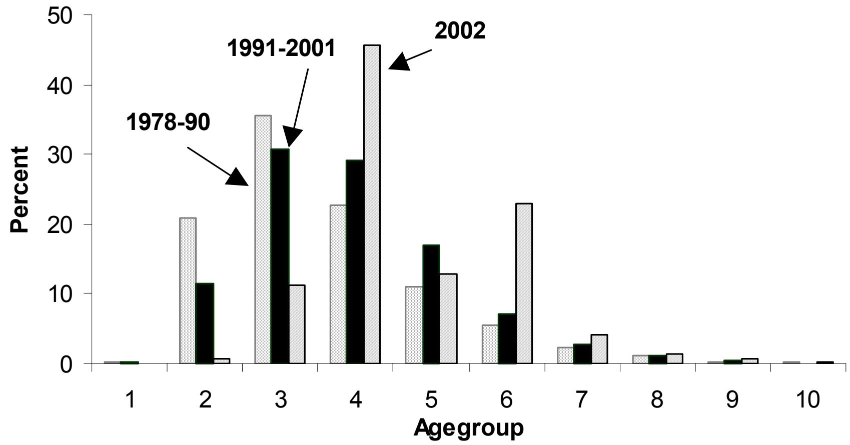


Figure 9. Comparison of the observed percent catch at age (Canada + USA) in 2002 with the percent catch at age from earlier time periods.

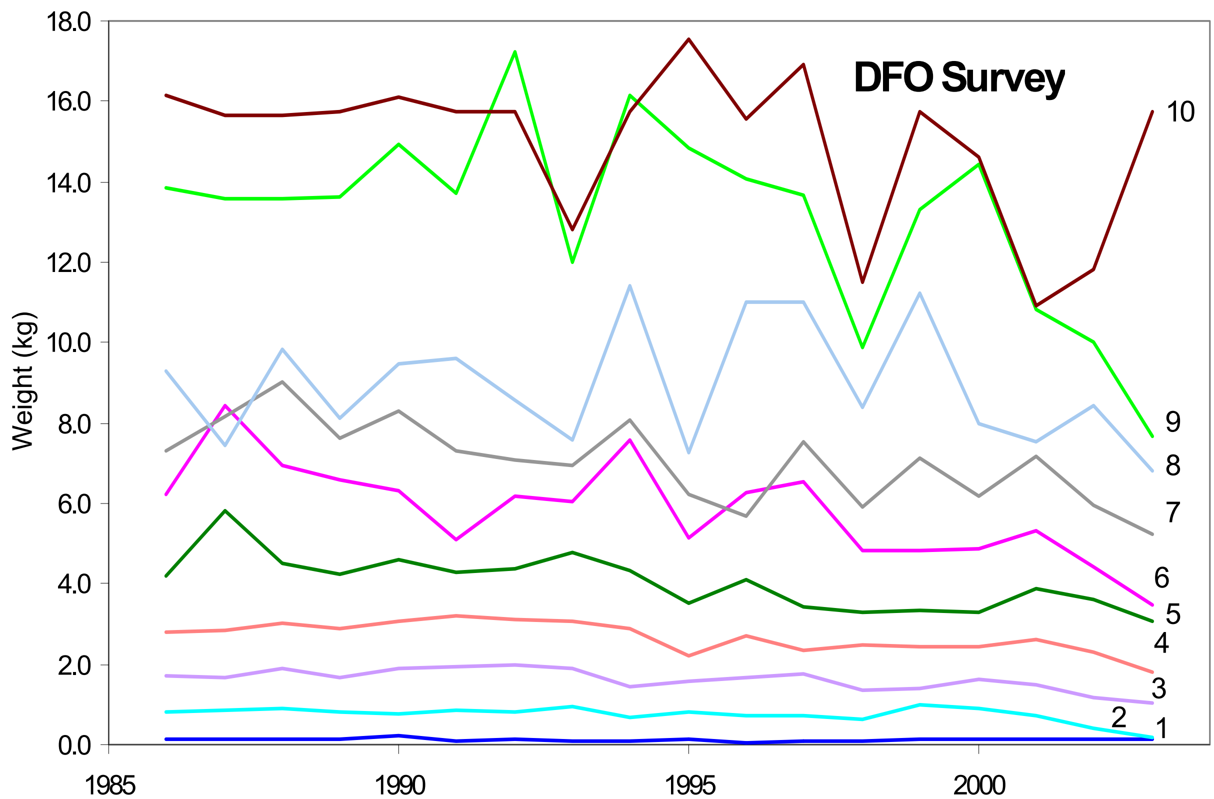


Figure 10. Beginning of year mean weight (kg) at age for cod derived from DFO research surveys.

Cod Distribution (kg/tow), 1998-2002 average density and 2003 catch per tow

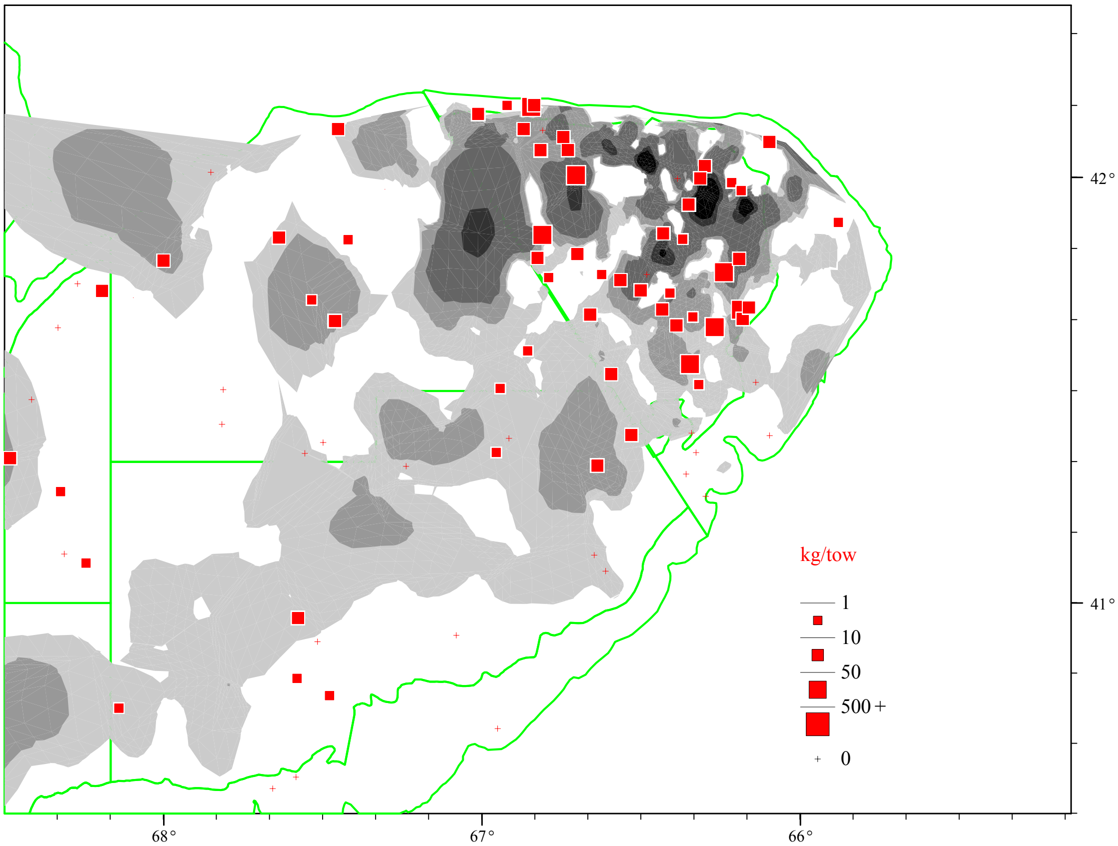


Figure 11a. Comparison of cod per standard tow (kg/tow) from the 2003 DFO research survey (box symbol) with average density gradient distribution for the 1998-2002 surveys.

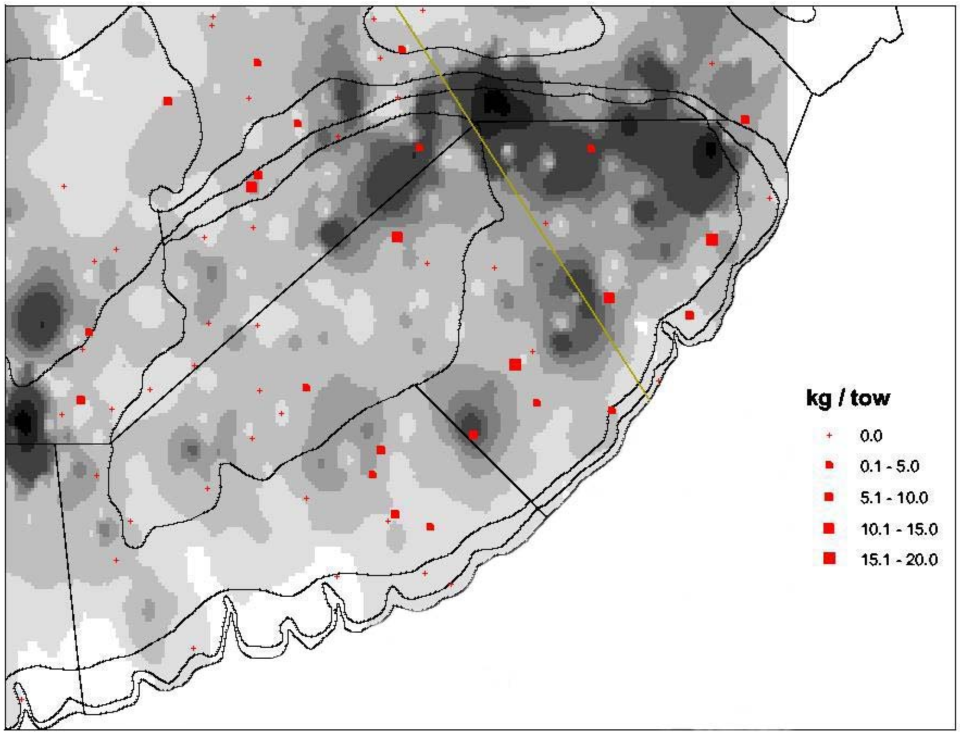


Figure 11b. Comparison of Atlantic cod per standard tow (kg/tow) from the 2003 NEFSC spring research survey (box symbol) with average density gradient distribution for the 1998-2002 NEFSC spring surveys.

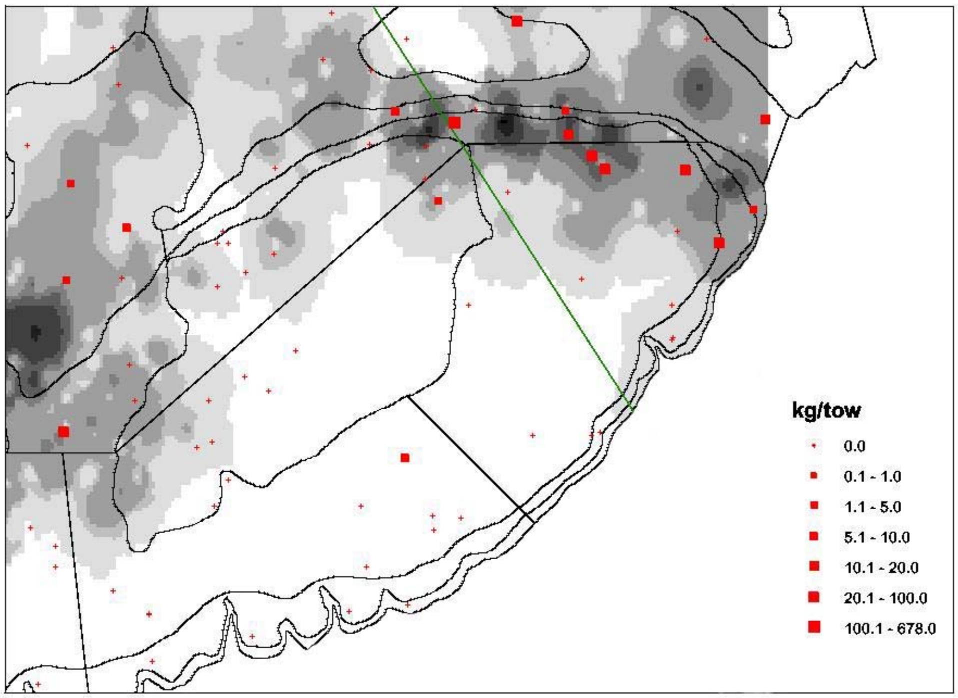


Figure 11c. Comparison of Atlantic cod per standard tow (kg/tow) from the 2002 NEFSC autumn research survey (box symbol) with average density gradient distribution for the 1997-2001 NEFSC autumn surveys.

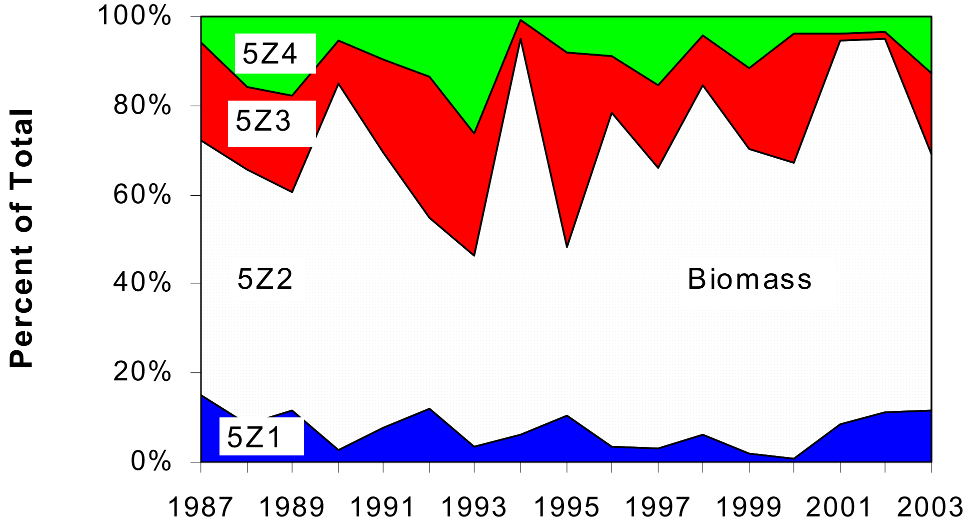


Figure 12a. DFO spring survey biomass index for 1987-2003 by stratum. Area labels refer to survey strata, where 5Z1 = 50-100fm and 5Z2 = <50fm in the Canadian zone and 5Z3 and 5Z4 are in the USA zone.

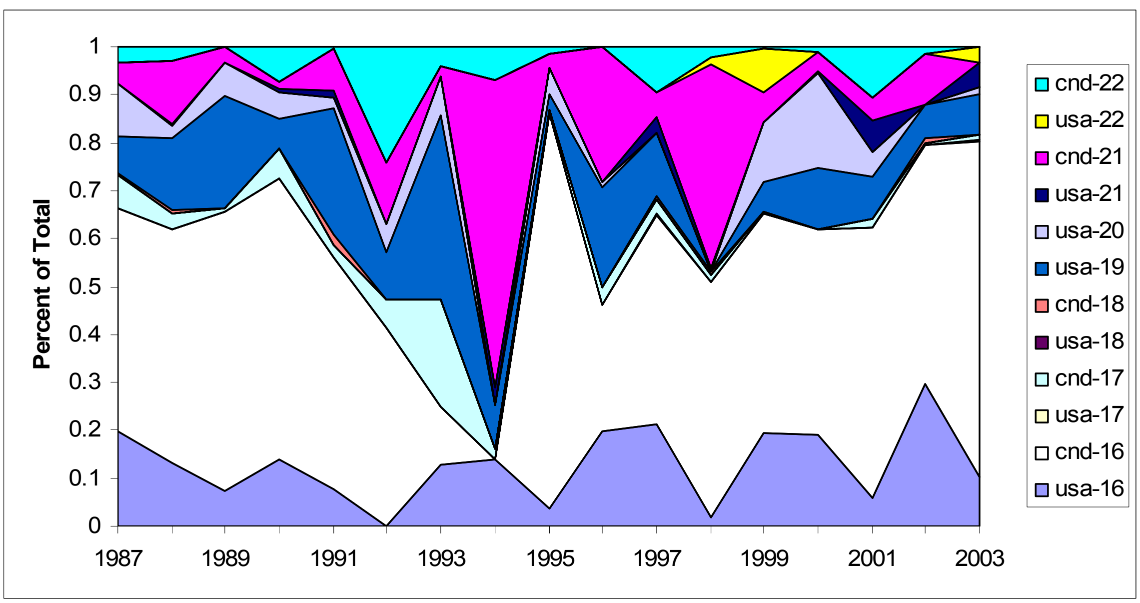


Figure 12b. NEFSC spring survey biomass index for 1987-2003 by stratum (strata 16-18, 21-22 are split by International Boundary) within area 5Zjm.

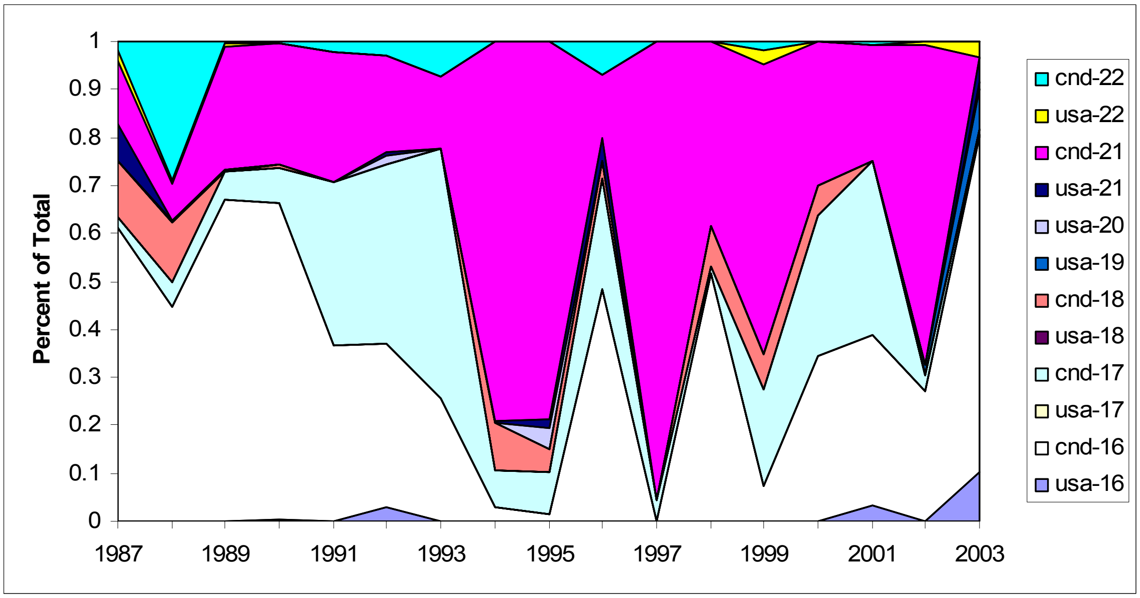


Figure 12c. NEFSC autumn survey biomass index for 1987-2002 by stratum (strata 16-18, 21-22 are split by International Boundary) within area 5Zjm.

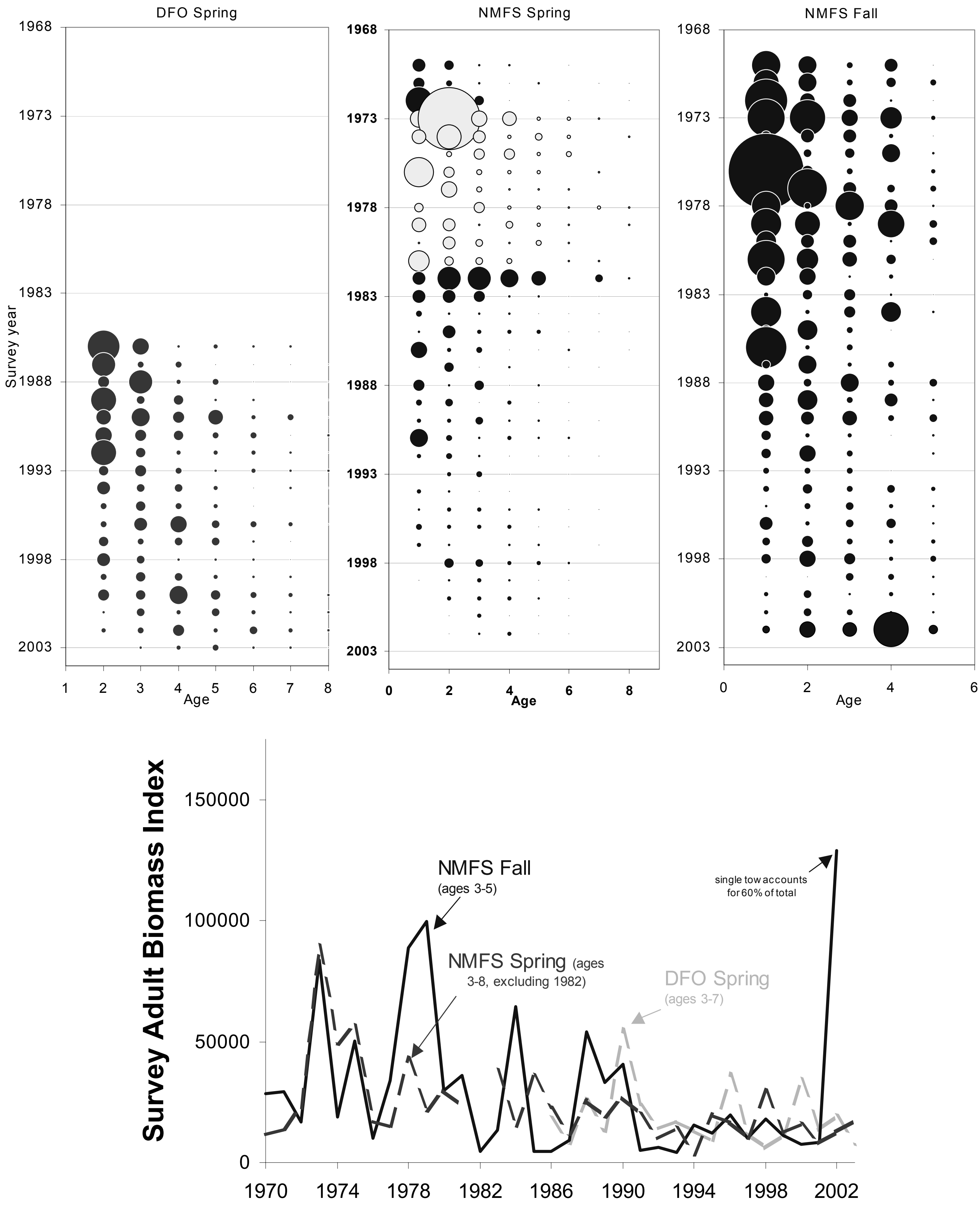


Figure 13. Estimates of adult biomass (t) indices, adjusted by estimated average catchability at age from ADAPT, for 5Zj,m cod from the DFO spring and NMFS spring and fall surveys in 5Zj,m.

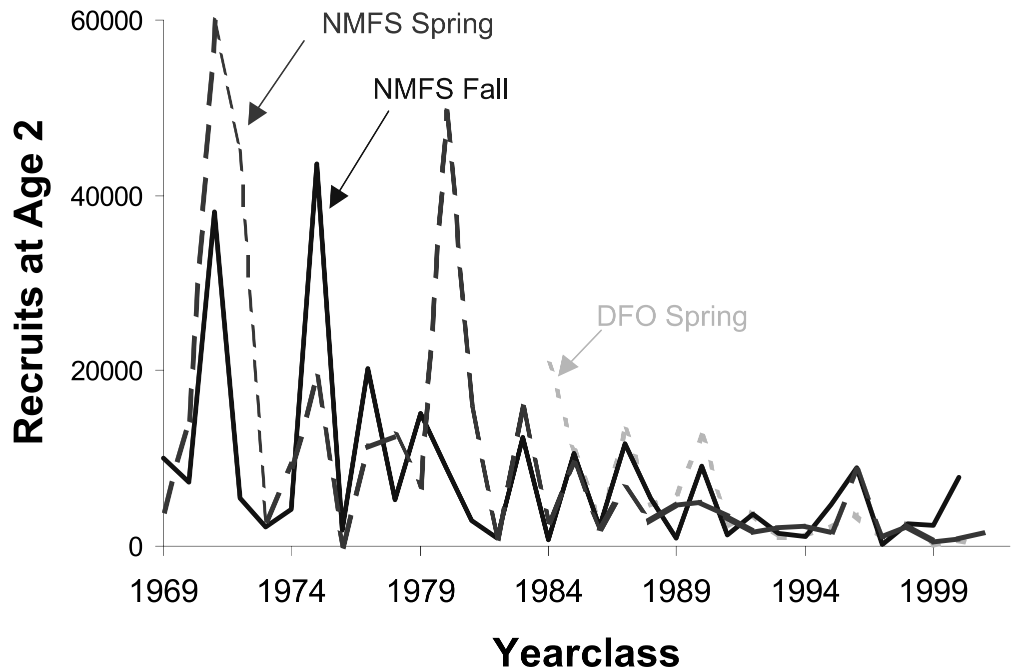


Figure 14. Estimates of recruitment indices at age 2 for 5Zj,m cod from the DFO spring and NMFS spring and fall surveys in 5Zj,m.

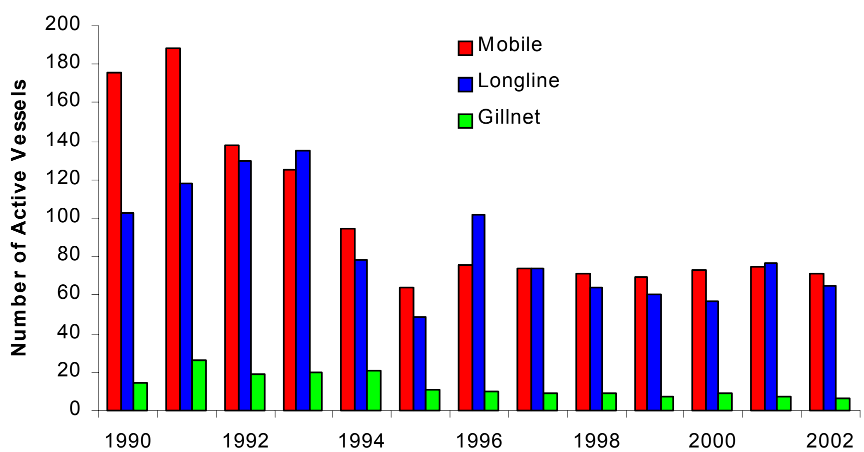


Figure 15. Number of Canadian fishing vessels by gear type.

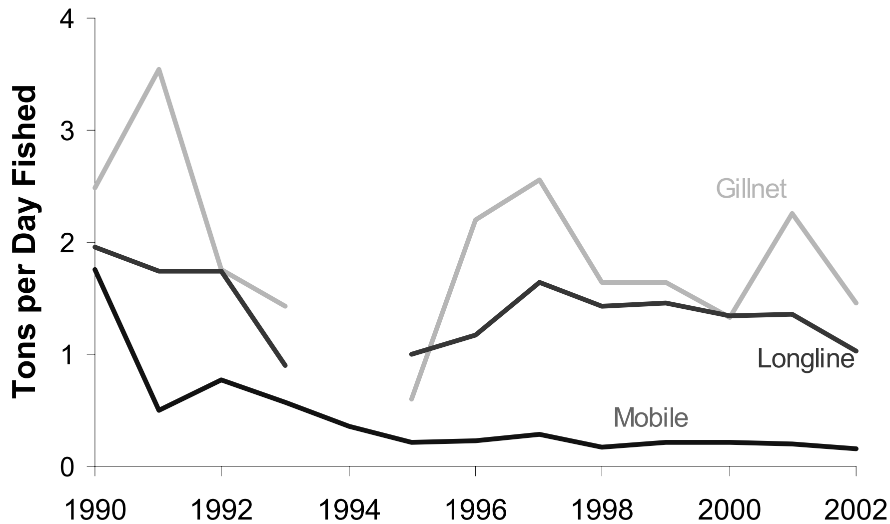


Figure 16a. Landings per day fished by gear type for trips with >500kg cod landings. Effort data for 1994 fixed gear was not available.

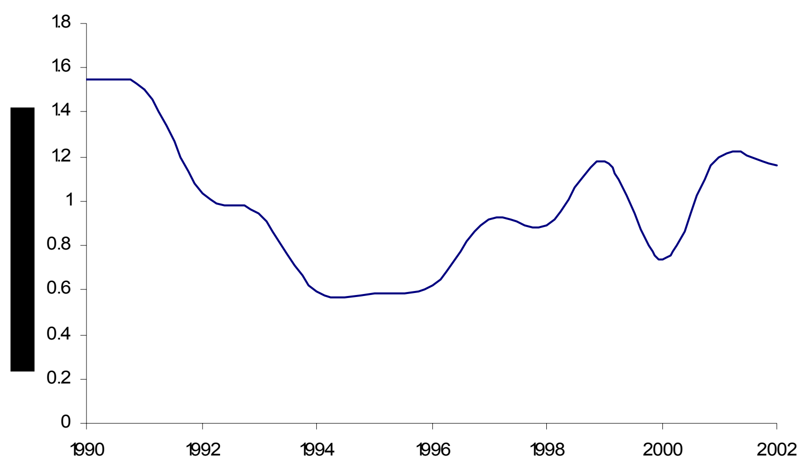


Figure 16b. Fishery performance(ton/day fished) of USA otter trawl gear for trips with >500 kg of cod landings during 1990-2002.

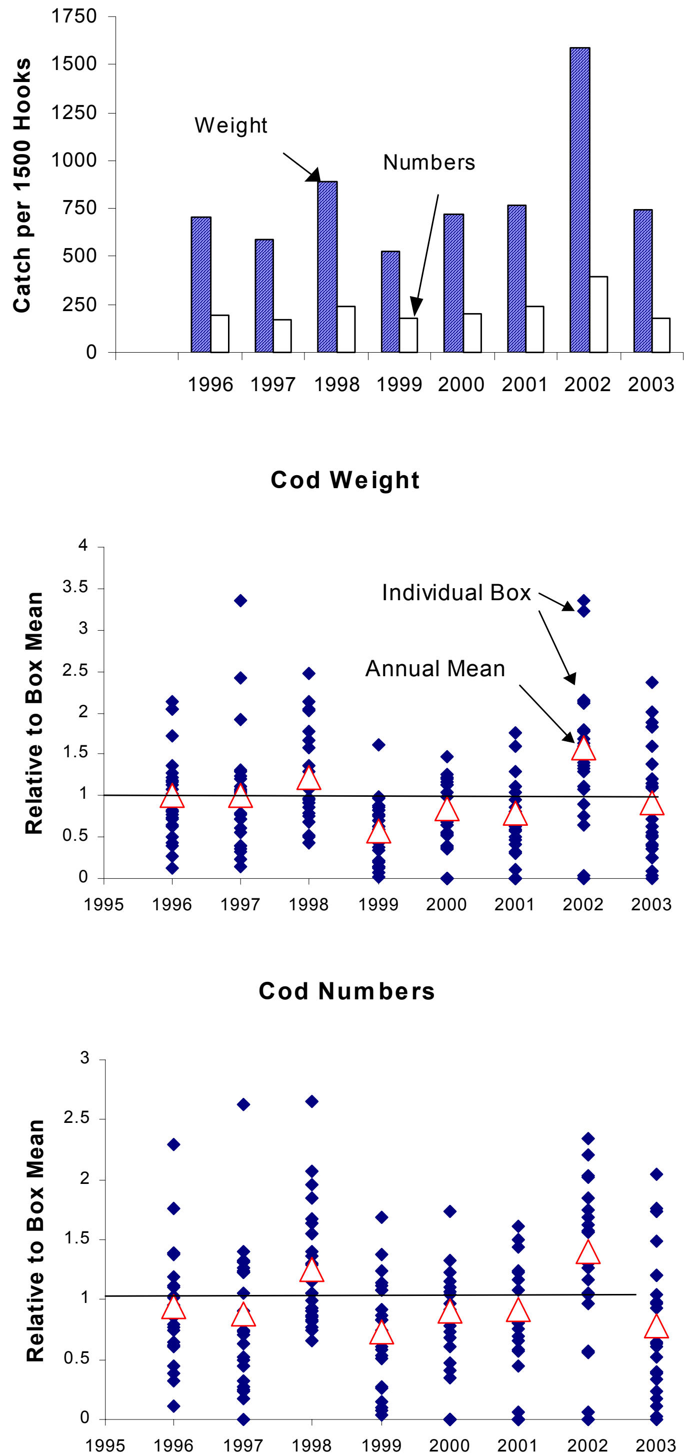


Figure 17. Results of Canadian longline industry survey showing the annual average weight and number caught per 1500 hooks and annual catch rate relative to mean of sampling units.

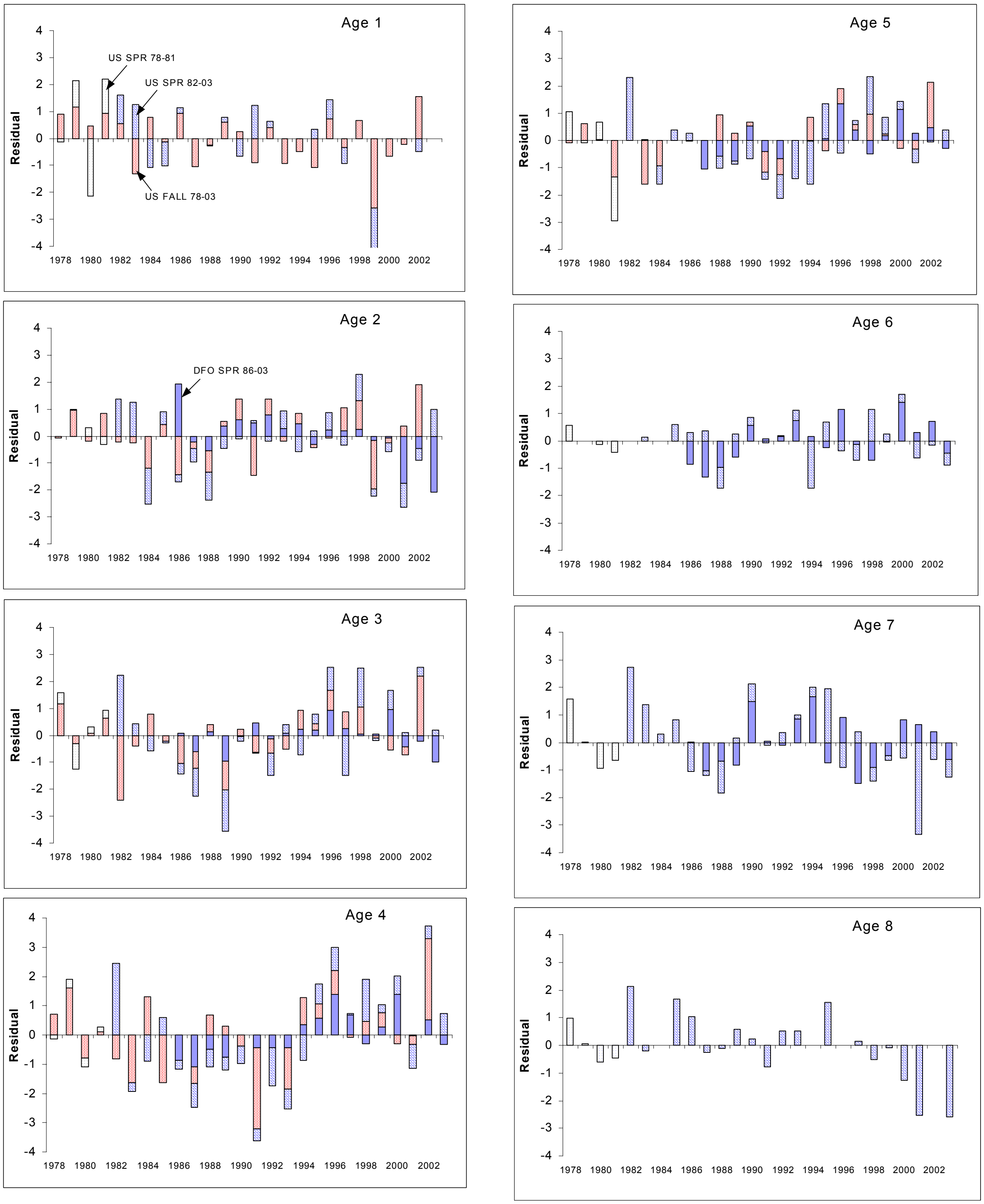


Figure 18. Standardized residuals at age from ADAPT for the DFO spring 1986-2003), NMFS fall (1977-2002), NMFS spring (1978-81,Yankee 41) and NMFS spring (1982-2003, Yankee 36) research indices.

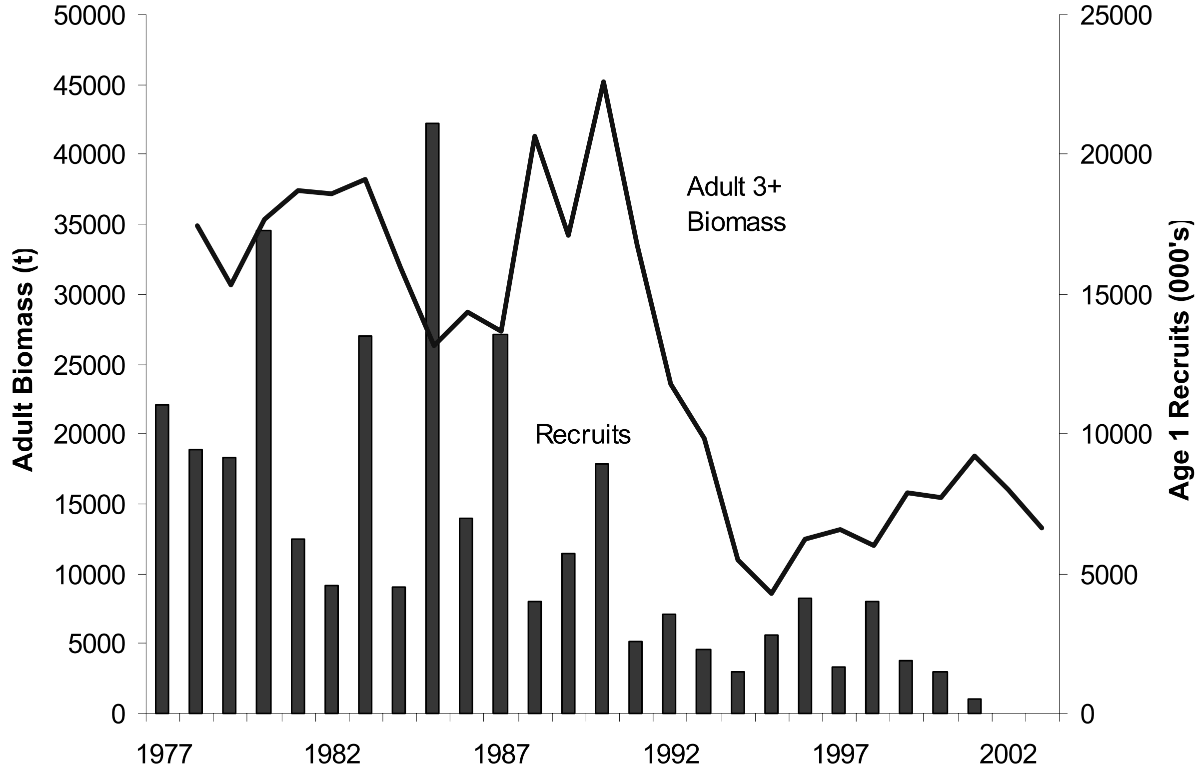


Figure 19. Spawning stock biomass and recruits at age one from ADAPT for 5Zj,m cod.

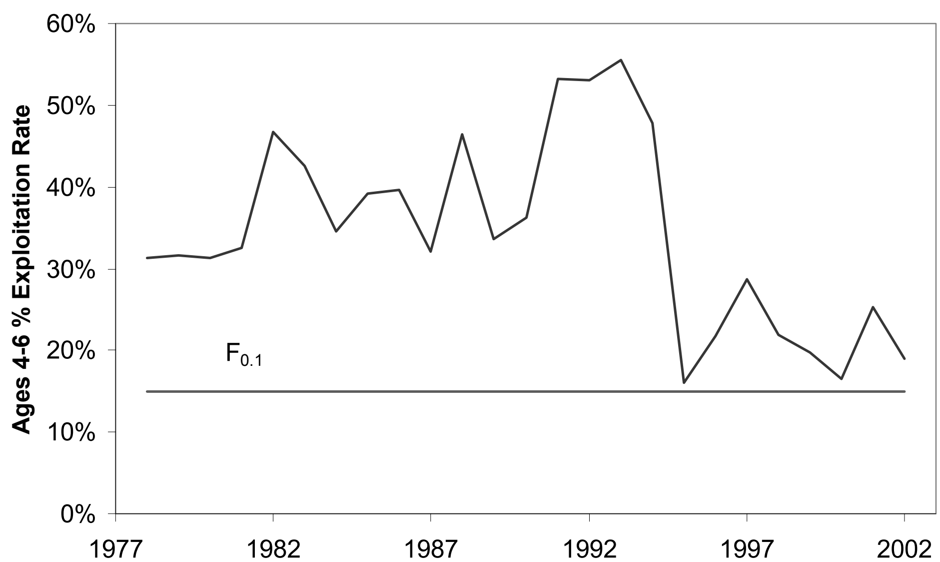


Figure 20. Exploitation rate at ages 4-6 cod derived from ADAPT.

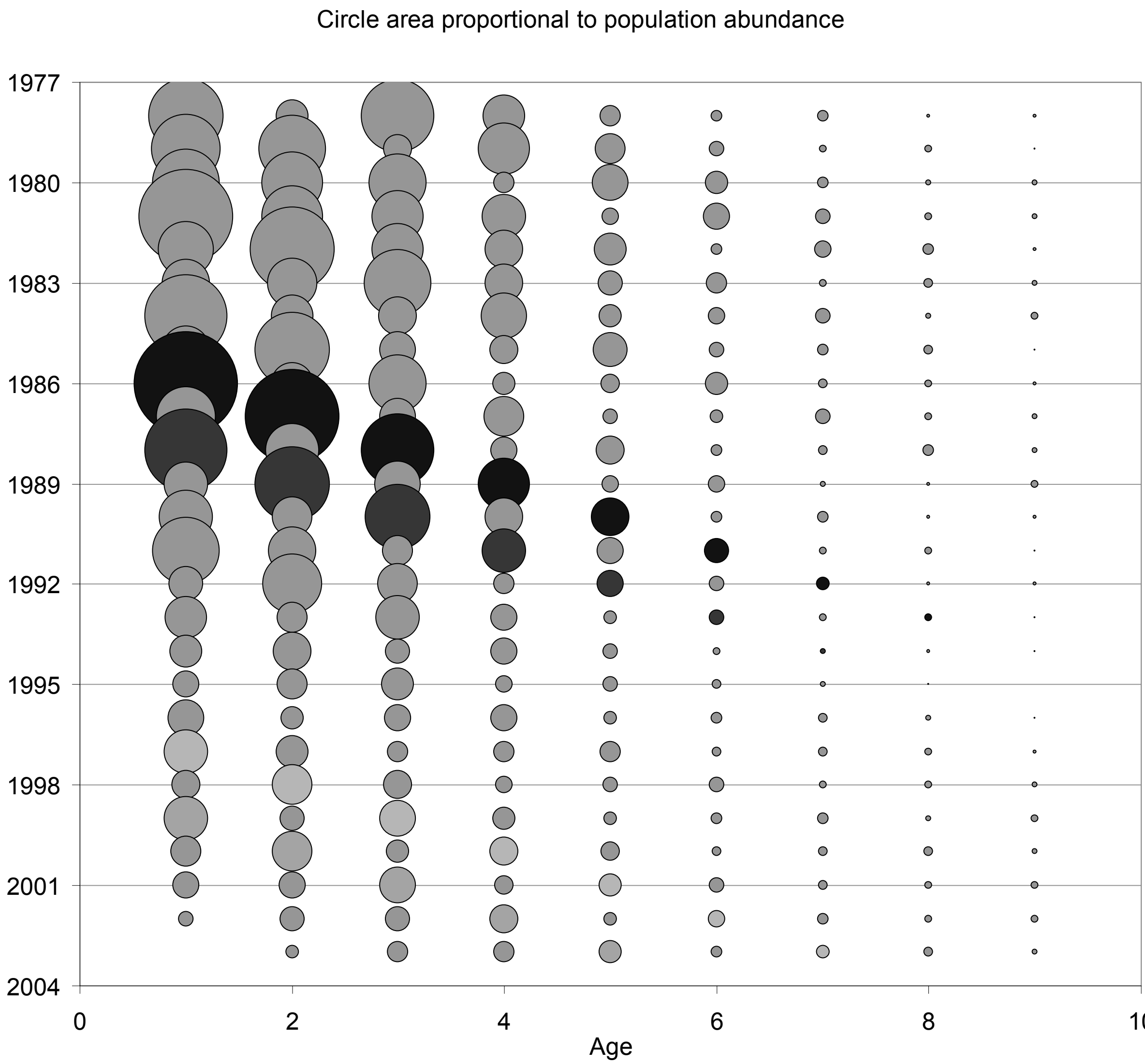


Figure 21: Relative abundance at age for 5Zj,m cod for 1978-2003.

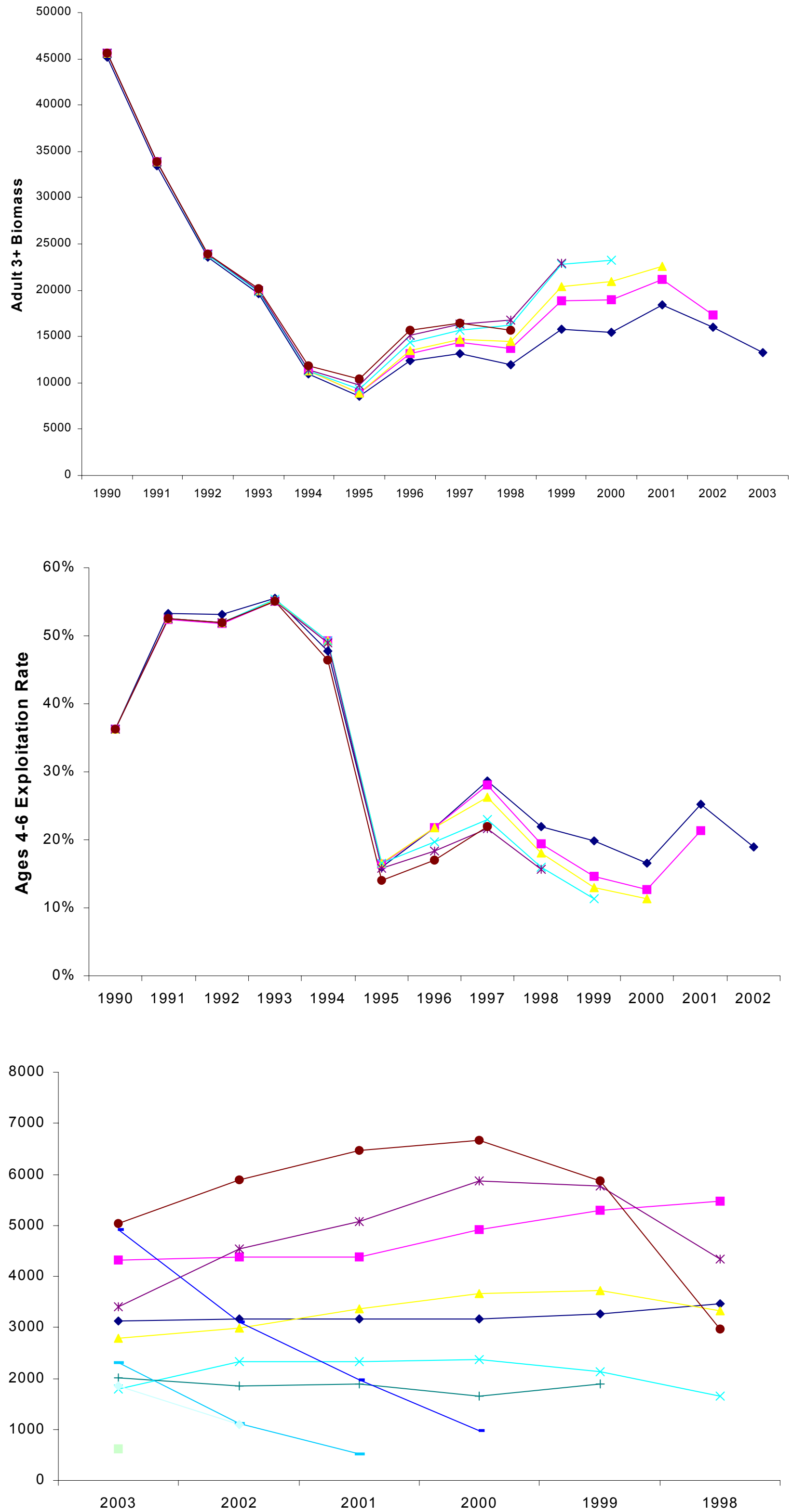


Figure 22. Retrospective pattern in population abundance (upper panel), exploitation rates on ages 4-6 (middle panel), and recruitment (lower panel) for 5Zj,m cod from ADAPT.

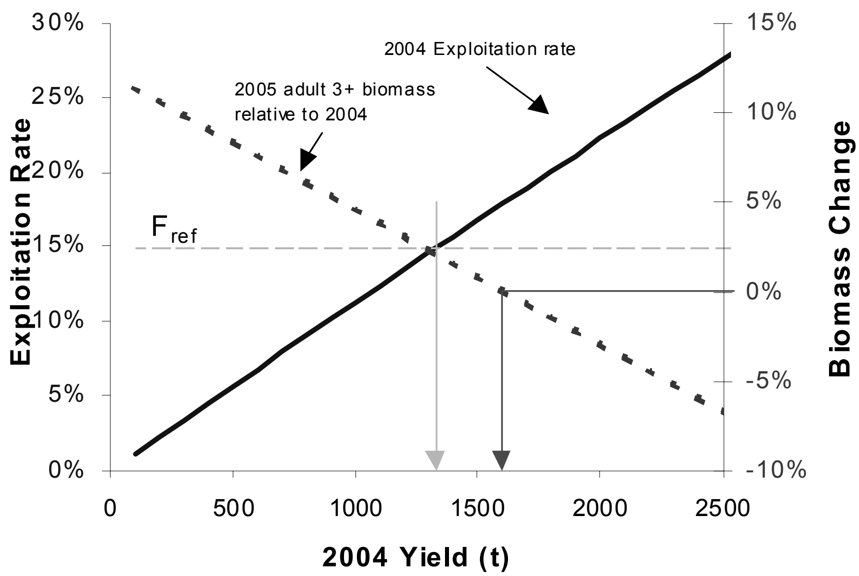


Figure 23. Projected exploitation rate and the % change in 3+ biomass in 2005 relative to 2004 at different levels of yield in 2004.

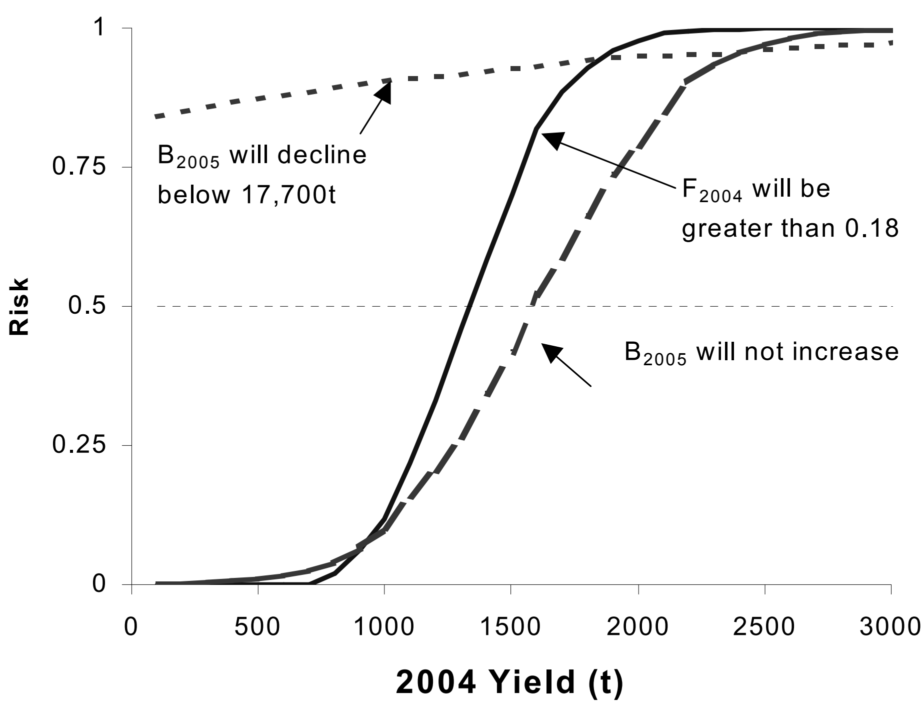


Figure 24. Probability of projected change in 5Zj,m cod adult stock biomass from 2004 to 2005 and exploitation rate in 2004 at different yields in 2004 and assuming a 2003 yield of 2,800t.

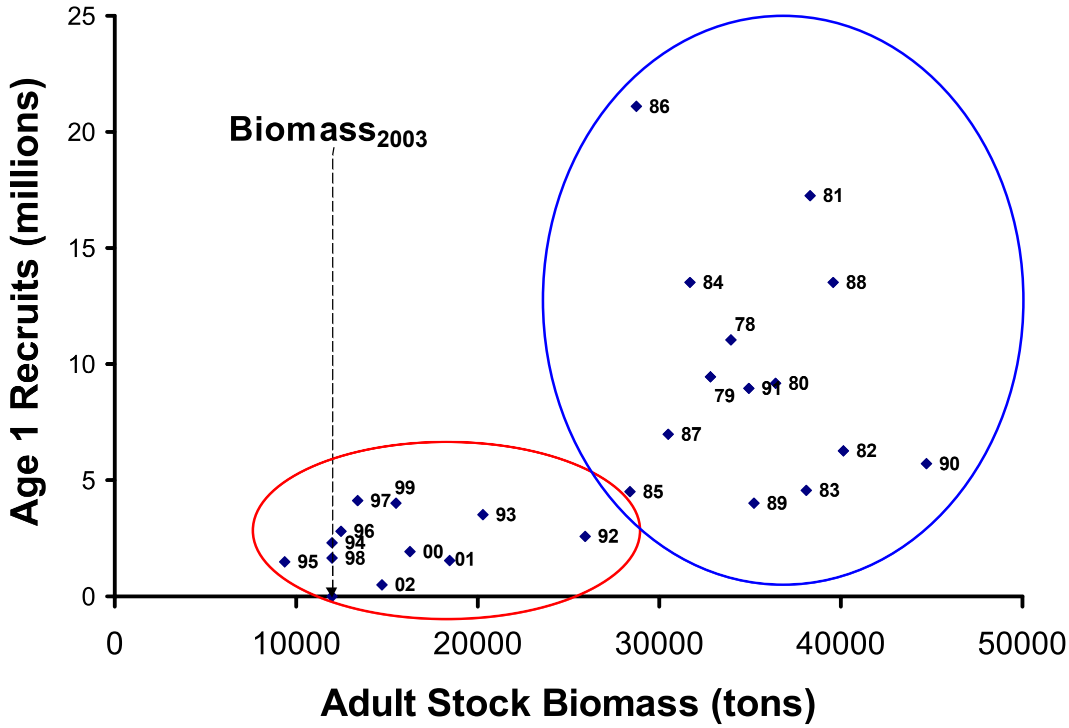


Figure 25. Comparison of recruits at age 1 and adult stock biomass for 5Zj,m cod, 1978-2003.

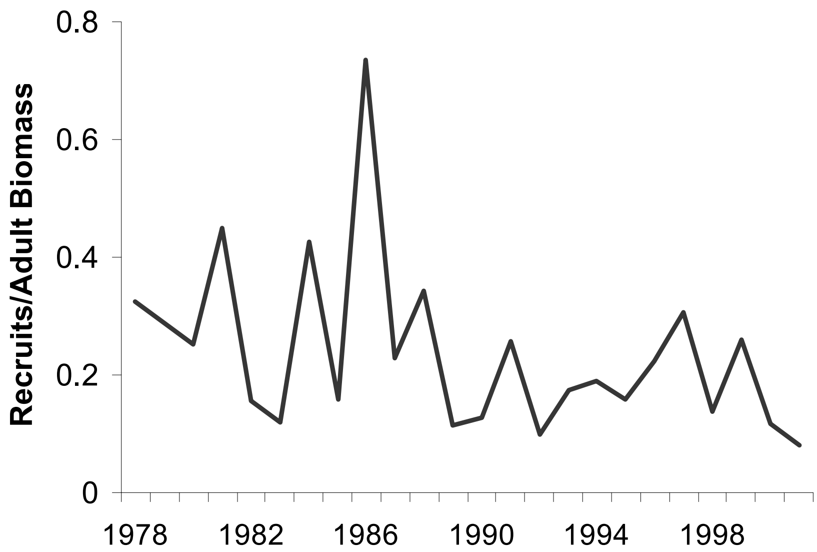


Figure 26. Relationship between recruits and spawning stock biomass (R/SSB) for 5Zj,m cod, 1978-2003.

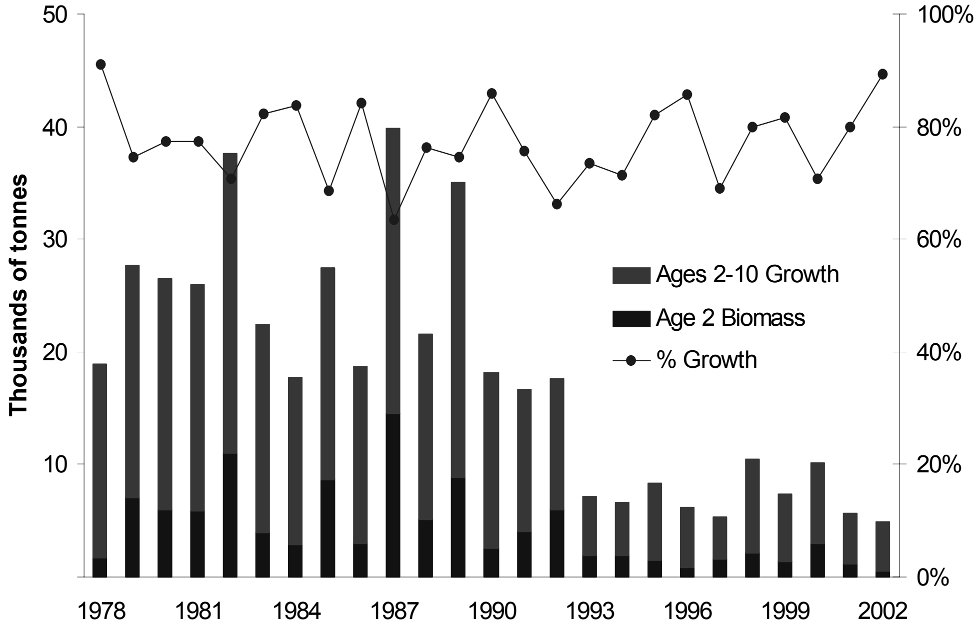


Figure 27. Comparison of stock production derived from growth and from recruitment for 5Zj,m cod, 1978-2002.

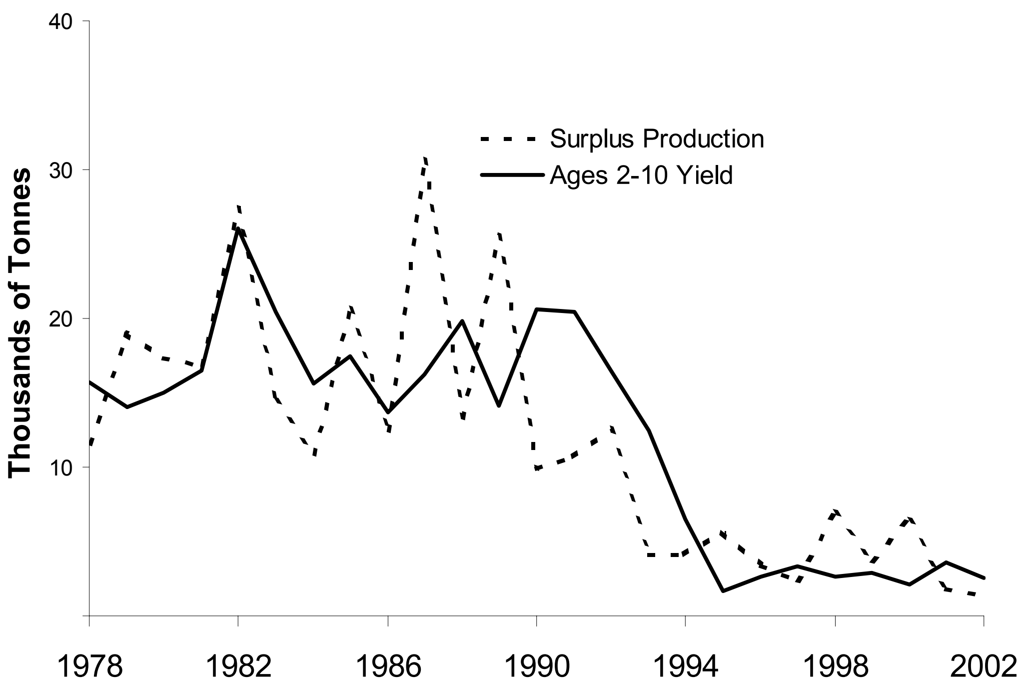


Figure 28. Comparison of surplus production and yields for 5Zj,m cod, 1978-2002.