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Population Status of Eastern Georges Bank Cod (Unit Areas 5Zj,m) for 1978-2001

État du stock de morue de l'est du Banc Georges (zones-unités 5Zjm) pour la période 1978-2001.

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Abstract

An analytical assessment of the Georges Bank cod stock in 5Zj,m was completed using updated catch-at-age and research survey indices. Catch at age was expanded to include ages 1-10. Results of the assessment provided statistically significant parameter estimates for the 2001 beginning-of-year population at ages 3 through 10**.** Bias and precision for the estimates were within acceptable limits. The adult biomass increased between 1995 and 2001 to about 19,900 t, primarily due to survival and growth of the 1992, 1995 and 1996 year-classes. Exploitation decreased from more than 60% in the early 1990's to about 25% in 1995 to 1997. It decreased further in 1998 to 18%, or slightly above the $F_{0.1}$ reference level and about 12% in 1999-2000. Recruitment in recent years has been poor, with the 1992, 1995 and 1996 year-classes being moderately stronger than adjacent year-classes. The 1997-2000 year-classes appear to be very weak**.** Projections for 2001 indicate a yield of about 3,500 t at the $F_{0.1}$ reference level. However, the stock biomass in 2002 will decline at this level of yield. Only at 2001 yields of 2,000 t or less is there a 50% or better chance of stable or increasing biomass. The adult stock biomass remains below a threshold of 30,000 t, above which chances of good recruitment are improved.

Résumé

Une évaluation analytique du stock de morue du Banc Georges dans 5Zjm a été effectuée à l'aide d'indices à jour de captures par âge et d'indices obtenus par relevés scientifiques. La série de données de captures par âge a été élargie pour inclure les âges allant de un à dix ans. L'évaluation a fourni des estimations statistiquement significatives de paramètres caractérisant la population de morues âgées de trois à dix ans au début de l'année 2001. Le biais et la précision des estimations ne dépassaient pas les limites acceptables. La biomasse des adultes a augmenté de 1995 à 2001, pour atteindre environ 19 900 t, principalement en raison de la survie et la croissance des classes d'âge de 1992, de 1995 et de 1996. Le taux d'exploitation est passé de plus de 60 % au début des années 1990 à environ 25 % durant la période 1995-1997, puis à 18 % en 1998 (soit légèrement au dessus du niveau de référence F0,1) et à environ 12 % en 1999-2000. Depuis quelques années, le recrutement est faible; les classes d'âges de 1992, de 1995 et de 1996 sont modérément plus abondantes que les autres, tandis que les classes d'âge des années 1997 à 2000 semblent être très faibles. Selon les projections, la production de 2001 serait d'environ 3 500 t au niveau de référence F0,1. Toutefois, ce niveau de production entraînerait un déclin de la biomasse du stock en 2002. Seule une production ne dépassant pas 2 000 t en 2001 donnerait une probabilité d'au moins 50 % que la biomasse reste stable ou augmente. La biomasse du stock adulte reste sous le seuil de 30 000 t, au delà duquel les chances d'un bon recrutement sont meilleures.

Introduction

This report incorporates commercial catch data and research survey results for the 1978-2000 time period to estimate the stock status of cod in the two NAFO unit areas 5Zj and 5Zm (5Zj,m) (Fig. 1). Definition of this management unit was based on analysis of tagging results and commercial and survey catch distribution (Hunt, 1990). Hunt and Hatt (2000) reported the status of the stock in 2000 (DFO, 2000).

Cod are taken in 5Zj,m by both Canada and the USA and all data relating to USA catches and research vessel surveys were provided by the National Marine Fisheries Service (NMFS) at the Woods Hole, Mass., Laboratory.

Information presented in this report has been reviewed by the Transboundary Resource Assessment Committee at a meeting to be held in St. Andrews, N. B. in April 2001. Proceedings of that meeting (CSAS, 2001) and the resulting Stock Status Report (DFO, 2001) are available for reference.

The Fishery

Canadian landings of Georges Bank cod 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, Fig. 2). The 2000 Canadian Georges Bank cod fishery was limited to a Canadian allocation of 1,600t, a decrease from the 1,800t allocation in 1999, and remained closed until June, 2000. The 2000 Canadian Management Plan allocations by fleet sector and reported landings (from December 2000 Quota reports) are shown below:
Between 1978-2000, USA landings reached 11,000 t in 1984, then were stable at about

Fleet Sector	Allocation	Landings	Percent of Allocation
Fixed <65’	1042	1025	98
Mobile <65’	458	456	99
Fixed 65-100’	14	13	93
Mobile 65-100’	28	25	89
Vessels >100’	58	52	90
Total	**1600**	**1573**	**98**

6,000 t until 1993 when a closed area was implemented. Landings ranged from 560t to 1,230t between 1994-1999, were 1,150t in 1999 and decreased to 662t in 2000, about the recent average. Almost 100 percent of USA catches in 5Zj,m are taken by otter trawl gear.

Combined USA and Canada landings for 1978-2000 are shown in Table 2 and Figure 2.

Length composition from samples of landings and catches obtained by commercial port samples and at-sea Observer sampling were used to estimate catch at length and age composition for the Canadian fishery (Figure 3a). Comparison of length distributions between the at-sea and on-shore samples showed no substantial differences or trends. A summary of the number of length and age samples used to estimate catch-at-age is shown in Table 3, Figure 3b. The fishery was adequately sampled and about 21,000 length observations and 1436 age determinations were available to construct the catch-at-age for 2000 (Table 4). For 2000, quarterly weight-length relationships were calculated from at-sea

Observer sampling from 1995-2000 and applied to the catch-at-age for 2000. Landings were regulated by 100% dockside monitoring.

Discarding was reported by some fishermen during pre-assessment meetings but the extent and quantity of discards are uncertain. Mobile gear catches by tonnage class group were derived to account for potential differences between large offshore trawlers and tonnage class 2,3 trawlers in areas fished and size composition.

Precision estimates of inter-reader age determinations by the Canadian age reader were completed and results were acceptable with a CV of 2.8 and overall agreement of about 84 percent. A Canada/U. S. otolith exchange was completed and resulted in an overall agreement of about 88 percent with a CV of 2.1. Canadian inter-reader and the Canada/USA exchange age comparisons were made with otoliths from the Canadian 1999 commercial fishery, the Canadian 2000 RV survey and the U. S. 1999 spring survey. Results are summarized in Table 5 and in Figure 4. Further comparisons and discussion with USA age readers will be addressed at an anticipated Canada-USA Aging Workshop in 2001.

Catch-at-age for the reported USA landings in 1994-2000 were estimated from USA length samples. Ages for USA 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. 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 1986-99 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 2000 assessment are shown in Figure 5, and indicate considerable divergence in the contribution of the 1995 and 1996 year-classes at ages 4 and 5. In 2000, the 1996 year-class accounted for almost 50 percent of the catch in numbers, a higher proportion than the projected level of 35 percent. The 1995 year-class accounted for less than 20 percent of the catch compared to the projected level of 35 percent. Both inter and intra-reader age comparisons show an acceptable level of precision and no evidence of bias over the age range. (Figure 4). Catch-at-length and age contributions for 2000 are shown in Figure 6 and indicate considerable overlap in length for adjacent agegroups. Comparison of the 2000 percent catch at age with the short term and long term average is shown in Figure 7. The decline in survey weight-at-age between 1997 and 1998 was reversed in 1999 for some ages and was stable in 2000 and 2001 and also increased for some ages for 2001 (Figure 8).

Indices of Abundance

Research Surveys

Hunt *et al.* (1991) describe 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 surveys started prior to 1978.

The USA spring survey has used two different bottom trawls over the 1978-99 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 Canadian DFO survey showed a decrease from that observed in 2000. The highest catch rates occurred in the Canadian zone in the 5Zj area along the northern edge. The 2001 catch distribution pattern (shown as box symbols in Figure 9) was similar to the average (shown as density contours in Figure 9), however DFO stratum 5Z2 accounts for most of the survey biomass. A sharp reduction in the contribution of 5Z3 between 2000 and 2001 is noted (Figure 10). A single set of over 2t of cod had a strong influence on the average catch per tow for 2001 and reduces the magnitude of the decline between 2000 and 2001.

Results of analysis for each of the surveys are given in Table 8 and Figure 11.

The NMFS fall survey is assumed to be a post-fishery index and spring surveys are assumed to be a pre-fishery index. Therefore, the fall survey is lagged by one year for comparison of indices (ie. fall 1977 age one vs spring 1978 age two).

The three survey indices for ages 3+ biomass, adjusted by the estimated catchability (Q's) at age from recent ADAPT formulations (Gavaris, 1988) are shown in Figure 11 (the 1982 NMFS spring survey is not shown due to scaling). In general, all three surveys appear to track year-class strength and 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, a further increase in 2000 and a decrease in 2001. The 1994 NMFS fall survey catch per tow has a slight increase from 1993, then remained at a low, stable level in 1995 –1997, increased in 1998 and declined in 1999. The 1994 NMFS spring survey was the lowest observed, but increased in 1995 to the recent average level and remained stable until 1997. 1998 saw an increase with a decline in 1999. The 2000 NMFS spring and fall surveys remain at low levels.

Estimates of recruitment at age one and at age two from the surveys are shown in Figure 12 as population numbers derived from catch per tow, adjusted by catchability factors. Both the 1995 USA fall and 1996 Canadian spring surveys indicate an increase in recruitment for the 1995 year-class over the 1993-94 year-classes. Estimates for the 1995 year-class are less than 25% of the large 1990 and 1985 year-classes and similar to the average 1987 year-class. The

index of recruitment of the 1996-1999 year-classes at age one is the lowest in the series. However, the 1996 year-class at age two in the 1998 NMFS spring survey shows better prospects of recruitment.

Commercial Fishery Catch Rates

The mobile gear catch rate was used as an index of abundance in the 1995 evaluation of stock status. 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 are not available.

A summary of catch, effort and catch per day for the mobile, longline and gillnet fleets for 1990-99 is given in Table 9. No standardization to account for possible tonnage class differences was applied 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. For example, only 30% of longline vessels reported effort in 1990, representing 825 fishing days with an average catch of 1.91 t per day. This catch per day was divided into the total reported catch to estimate total fishing days (5202/1.91 = 2724 days). 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 1990-2000 time period are shown in Figure 13. 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 stable since 1996. Landings per day fished declined for all three gear sectors but has remained relatively constant between 1998 and 2000. Generally, catch rates are higher for the fixed gear sector compared to the mobile gear sector.

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). Investigation of the data set indicated that some length frequencies were a subsample of the total caught and an adjustment was made to the total catch using a ratio of calculated to recorded weight. Reported values from Johnston and Hunt (1999) were also adjusted when evidence of subsampling was apparent. Preliminary results for 1996-2000 standardised catch in weight and numbers and for relative abundance of year-classes is shown in Figure 14. An increase in abundance and biomass is evident from 1999 to 2000 but there is no apparent trend over the time series. The catch-at-age for the longline survey shows the 1996 year-class above average at ages 2, 3 and 4. A cohort by cohort comparison of population estimate and longline survey index for ages 3 to 8 show significant correlation (R^2=0.65) (Figure 15).

This utility of this index as an indicator of trends or changes in stock abundance is uncertain and needs to be evaluated.

Partial Recruitment to the Fishery

Hunt and Johnson (1999) derived estimates of partial recruitment to the fishery by gear type for the period 1988-98. They indicate that partial recruitment at ages three and less has declined in the recent part of the time series. Full recruitment is now at age four (see Table 13).

Spawning Stock Biomass (SSB) Calculation

Results of a study reported by Hunt (1995) were updated with more recent DFO spring survey data to estimate the proportion of cod mature at age for the period 1986-2001. A three-year moving average was applied to the annual estimates with the years 1978-85 set to the 1986 value. Results are shown in Table 10 and show an increase from about 30-40% mature at age 2 prior to the mid-1980's to 40-60% in the mid-1990's and over 70% in the latter part of the series. 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.

Further evaluation of changes in the age at first maturity is required including small sample size and the consistency of maturity assignments.

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 2000

$I_{1,a,y}$ = USA fall survey
a=0 to 5 y=1977 to 2000 (used as ages 1 to 6 for 1978-2001)

$I_{2,a,y}$ = USA spring survey (Yankee #41 trawl)
a=1 to 8, y=1978 to 1981

$I_{3,a,y}$ = USA spring survey (Yankee #36 trawl)
a=1 to 8, y=1982 to 2000

$I_{4,a,y}$= Canadian spring survey
a=1 to 8, y=1986 to 2001

$\theta_{a,t'} = \ln \text{population abundance}$ for ages *a* = 2, 3 ... 10 at time $t' =$ 2001

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

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

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

Partitioning of the USA spring survey was introduced in 1998 to account for a change in the survey trawl in1982. 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 spring survey results were compared to beginning of year population abundance. The fall survey for ages 0-5 was also compared to beginning of year population abundance in year t+1 (i.e. fall 1977 ages 0-5 compared to 1978 population ages 1-6). Natural mortality was assumed constant and equal to 0.2 for all age groups. The fishing mortality rate on age 10 was calculated as the unweighed average for ages 5 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 one in 2001 did not result in statistically significant estimates at this age and therefore the 2000 year-class in 2001 was set to an arbitrary low value of 1 million.

The ADAPT model used in this assessment is a modification of the model used in 2000. Catch at age for 1978 to 2000 was extended from ages 1-8 to ages 1-10 and fishing mortality for the oldest age group was estimated as the average of ages 5-9. The previous assesment estimated F_{oldest} with age 4 included in the average but initial trial runs with this model suggest that the resulting F generated a substantially lower estimate of the 1992 year-class at age 1. Examination of the exploitation pattern in 2000 indicated that an average F using ages 4-9 gave an estimate for age 10 that was inconsistent with the observed fishing mortality at ages 6-9. Therefore the model was changed.

Assessment Results

Parameter estimates, bias adjustment and population estimates derived from the above ADAPT formulation are given in Table 11. Population parameter estimates have a relative error of 28% to 54% for ages 3 to 10, similar to those seen in the 2000 ADAPT-based analytical assessment. However, the parameter estimate for age 2 in 2001 was non-significant (SE= 1.01). 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 survey and the NMFS fall survey.

There appear to be year effects in the residuals for survey indices (Figure 16). Negative residuals for age one estimates occur in all three surveys for the last 5 years, suggesting a persistent trend for surveys to underestimate size of recruiting year-classes. The 1982 NMFS spring survey has relatively large positive residuals, while negative residuals predominate in the last several years. The NMFS fall survey and the DFO spring survey appear to overestimate population size (positive residuals). 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 3+ spawning stock biomass between 1990 and 1994 was substantial, and the biomass was the lowest observed in 1995 at 8,600 t (Figure 17, Table 12). However, total biomass shows a gradual increase since 1995 to about 20,200 t. SSB also shows an increase since 1995 and is now at about 19,900 t, but remains well below the long term average of over 30,000 t.

Fishing mortality for fully recruited ages 4+ (Table 12) increased rapidly between 1989 and 1991 and was over three times the $F_{0.1}$ = 0.2 reference level in 1991-93. The decline that began in 1994 is consistent with reduced effort. Fishing mortalities since 1995 were slightly above the $F_{0.1}$ reference level. The rate of exploitation for the stock has been over 30% for most of the time series, above 60% in 1991-94, and close to the $F_{0.1}$ reference level of about 16% since 1998 (Fig. 18).

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. 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 average. The 1992, 1995 and 1996 year-classes show some improvement to above the recent average recruitment, but indications for the 1997 and subsequent year-classes show very poor recruitment prospects (Fig. 17 and Table 12).

Retrospective Analysis

Typically, if present, a retrospective pattern results in overly optimistic estimates for a year-class in the first year with a decline as additional data are added to the model. Similarily, fishing mortality increases as more data are added. Results of the analysis (Figure 19) confirm

a pattern for fishing mortality in the mid-1990's to be under-estimated and abundance over-estimated relative to current estimates. However, a reverse trend to under-estimate initial year-class size is evident for abundance at age one and is most pronounced for the 1996 year-class.

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. Results indicated an $F_{0.1}$ fishing mortality of 0.199 and confirm the value of 0.2 used in previous assessments.

Prognosis

Catch projections were completed using the bias-adjusted beginning of year population abundance for 2001 derived from ADAPT. Partial recruitment was derived from the 1997-2000 fishing mortality matrix with ages 4+ assumed constant (Table 12), to reflect possible changes in PR associated with both gear and season. Mean (1997-2000 fishery) and beginning of year (1998-2001 RV survey) weights-at-age were used to reflect the recent trend in weight-at-age. Recruitment for 2000 and 2001 age one was set to 1.0 million (Table 13).

Yield projection at $F_{0.1}$ for 2001 indicates a **combined** Canada/USA yield of about 3,500 t. Details of the projection are given in Table 13. There is about a 20% relative error associated with the projected catch. At the $F_{0.1}$ yield, **adult biomass will decrease** by about 9% at the beginning of 2002. A stable biomass will occur with a 2001 yield of about 2,000t but even with no catch in 2001 the 2002 biomass only increases by about 10%. The 1995 year-class-at-age 6 and the 1996 year-class at age 5 are expected to account for about 17% and 24%, respectively, of the catch biomass in 2001.

At a combined 2001 Canada/USA yield of about 2,200t, the same as the 2000 yield, there is a low **probability** of exceeding $F_{0.1}$ but there is a 60% probability of a decrease in adult biomass (Figures 20 and 21). At a 2001 yield of 2,000t the probability of a decrease in adult biomass is about 50%. It is also important to note that even small differences in the 2001 yield near the $F_{0.1}$ level substantially increased the chances of deviation from the reference level.

Adult biomass levels and subsequent **recruitment** abundance-at-age 1 is compared in Figure 22 for the 1978-00 time period. Recruits appear to have a positive correlation with biomass and the probability of good recruitment increases at higher biomass levels. The projected 2001 adult biomass of 19,900 t is below the stock size (>25,000t) at which improved recruitment would be expected to occur. Rebuilding to increase the adult biomass above the projected 2001 level would enhance the prospects for the future. It is projected that over 50% by weight of the 2001 yield at $F_{0.1}$ would be comprised of the 1995 and 1996 year-classes. Enhancing survivorship of these year-classes would benefit stock rebuilding. Continuing poor recruitment will lead to reduced prospects for an increase in biomass towards a 25,000t threshold.

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 23) 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.

An analysis of 1992-2000 biomass distribution relative to the international boundary from research surveys shows a seasonal pattern. Virtually all cod of ages 2 and older were found on the Canadian side during the NMFS fall survey, while the proportion found during the DFO and NMFS spring surveys ranged between 40% and 95%.

Percentage of 5Zj,m RV Stock Biomass in the Canadian Zone

Survey Year	DFO February	NMFS March	NMFS October
1992	55	84	94
1993	47	41	100
1994	95	73	100
1995	48	88	94
1996	78	58	95
1997	66	63	100
1998	84	50	100
1999	70	53	100
2000	67	52	100
2001	95	N/A	N/A

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.

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Table 1. Nominal landings(t) of cod by year, gear and month for Canada in unit areas 5Zj,m for 1986-2000. (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. 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	1571.7

Table 2. Summary of total catches (t) by Canada and the USA in unit areas 5Zj,m for 1978-2000. 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	

Table 3. Canadian and USA 5Zj,m commercial landings samples for 1978-2000. At-sea observer samples are included in Canadian length samples since 1994.

	USA			**Canada**		
	Samples	Lengths	Ages	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	129	26663	879
97	2	210	55	118	31882	1244
98	-	-	-	139	26549	1720
99	-	-	-	84	24954	918
2000				107	20782	1436

Table 4. Summary of 2000 Canadian commercial and IOP samples used to estimate catch-at-age. USA catch-at-age for 1994-2000 was provided by the USA, and based on commercial landings samples prorated by market category.

GEAR	MONTH	Catch (t) by Month	#LEN	#AGES	Catch (t) by Quarter
OTB+Misc	Jan				
	Feb				
	Mar				0
	Apr				
	May				
	Jun	102	4312	412	102
	Jul	140	2481	230	
	Aug	82	1813	116	
	Sep	73	341		295
	Oct	70	2012	125	
	Nov	38	455		
	Dec	30	218		138
TotalCanadian		535	11632	883	
TotalUSA		662			
Total		1197			
Longline	Jan				
	Feb				
	Mar				0
	Apr				
	May				
	Jun	41	1696		41
	Jul	191	2264	108	
	Aug	177	476	62	
	Sep	222	1273	97	590
	Oct	138	474	93	
	Nov	15	584	49	
	Dec	16	150		169
Total		800	6917	409	
Gillnet	Jan				
	Feb				
	Mar				0
	Apr				
	May				
	Jun	55	826	47	55
	Jul	76	301	42	
	Aug	28	165		
	Sep	24	201	41	128
	Oct	41	740	14	
	Nov	9			54
	Dec	4			
Total		237	2233	144	
Age Keys	Q1				
	Q2		6834	459	197
	Q3		9315	696	1013
	Q4		4633	281	362
	Mod				
TotalCanadian		**1572**	**20782**	**1436**	**1572**
TotalCanada+USA		**2234**	**20782**	**1436**	

Table 5. Results of Canadian intra-reader and inter-reader (Canada vs. USA) aging comparisons.

Canadian intra-reader comparison

1st Age			2nd Age BH							
BH	1	2	3	4	5	6	7	8	9	Total
1	2									2
2		18	3							21
3		3	91	11						105
4			5	85	5					95
5				4	36	2				42
6				1	4	18	3			26
7						5	19	1		25
8								3		3
9								1	1	2
Total	2	21	99	101	45	25	22	5	1	321

Percent Agreement: 84%
CV: 2.8

Canada vs. USA inter-reader comparison

1st Age		2nd Age - CAN							
US	2	3	4	5	6	7	8	9	Total
2	7								7
3	1	48	2						51
4		5	39	1					45
5			6	23					29
6					7	2			9
7						5			5
8					1		1		3
9								1	1
Total	8	53	47	24	8	7	1	1	150

Percent Agreement: 88%
CV: 2.1

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

Year	1	2	3	4	5	6	7	8	9	10	Total
(000's)											
1978	2	121	3588	1076	307	110	83	21	12	7	5327
1979	10	814	399	1774	545	149	22	45	4	3	3765
1980	1	987	1495	265	916	345	109	20	14	10	4162
1981	19	603	1443	1249	155	595	169	65	21	16	4335
1982	6	2682	1686	1429	1066	189	345	157	21	26	7607
1983	40	1319	3416	1474	466	283	31	71	12	3	7115
1984	10	269	911	1346	511	290	230	31	18	39	3655
1985	12	2792	1221	631	941	224	96	100	9	11	6037
1986	28	326	2188	513	304	400	58	39	9	3	3868
1987	14	3666	865	1099	144	121	167	37	15	6	6134
1988	10	320	3653	646	861	144	102	143	29	29	5937
1989	1	740	652	1837	193	314	56	25	37	18	3873
1990	7	678	3196	962	1195	116	122	10	14	30	6330
1991	11	626	783	1939	953	790	93	56	15	20	5286
1992	86	2358	1251	432	908	250	233	25	21	7	5571
1993	4	414	1967	809	215	332	110	93	17	15	3976
1994	2	182	486	751	246	41	59	26	16	6	1814
1995	0	56	235	120	89	14	4	3	1	2	525
1996	1	39	231	386	75	47	11	3	4	0	796
1997	3	107	155	287	291	70	32	10	4	1	960
1998	0	81	272	136	138	115	18	11	3	2	775
1999	2	46	422	271	80	44	41	9	0	3	919
2000	0	53	116	325	118	30	18	11	2	0	674
Percent											
1978	0.0	2.3	67.4	20.2	5.8	2.1	1.6	0.4	0.2	0.1	100.0
1979	0.3	21.6	10.6	47.1	14.5	4.0	0.6	1.2	0.1	0.1	100.0
1980	0.0	23.7	35.9	6.4	22.0	8.3	2.6	0.5	0.3	0.2	100.0
1981	0.4	13.9	33.3	28.8	3.6	13.7	3.9	1.5	0.5	0.4	100.0
1982	0.1	35.3	22.2	18.8	14.0	2.5	4.5	2.1	0.3	0.3	100.0
1983	0.6	18.5	48.0	20.7	6.5	4.0	0.4	1.0	0.2	0.0	100.0
1984	0.3	7.4	24.9	36.8	14.0	7.9	6.3	0.8	0.5	1.1	100.0
1985	0.2	46.2	20.2	10.5	15.6	3.7	1.6	1.7	0.1	0.2	100.0
1986	0.7	8.4	56.6	13.3	7.9	10.3	1.5	1.0	0.2	0.1	100.0
1987	0.2	59.8	14.1	17.9	2.3	2.0	2.7	0.6	0.2	0.1	100.0
1988	0.2	5.4	61.5	10.9	14.5	2.4	1.7	2.4	0.5	0.5	100.0
1989	0.0	19.1	16.8	47.4	5.0	8.1	1.4	0.6	1.0	0.5	100.0
1990	0.1	10.7	50.5	15.2	18.9	1.8	1.9	0.2	0.2	0.5	100.0
1991	0.2	11.8	14.8	36.7	18.0	14.9	1.8	1.1	0.3	0.4	100.0
1992	1.5	42.3	22.5	7.8	16.3	4.5	4.2	0.4	0.4	0.1	100.0
1993	0.1	10.4	49.5	20.3	5.4	8.4	2.8	2.3	0.4	0.4	100.0
1994	0.1	10.0	26.8	41.4	13.6	2.2	3.2	1.4	0.9	0.3	100.0
1995	0.0	10.6	44.8	22.9	17.0	2.7	0.8	0.6	0.2	0.4	100.0
1996	0.1	4.9	29.0	48.5	9.4	5.9	1.4	0.3	0.5	0.0	100.0
1997	0.3	11.2	16.2	29.8	30.3	7.3	3.4	1.0	0.4	0.1	100.0
1998	0.0	10.4	35.1	17.5	17.8	14.8	2.3	1.4	0.4	0.3	100.0
1999	0.2	5.1	46.0	29.5	8.7	4.8	4.4	1.0	0.0	0.3	100.0
2000	0.0	7.9	17.2	48.2	17.5	4.5	2.7	1.7	0.3	0.0	100.0
Average											
78-90	0.2	20.9	35.5	22.6	11.1	5.4	2.4	1.1	0.3	0.3	100.0
91-00	0.3	12.5	30.2	30.3	15.4	7.0	2.7	1.1	0.4	0.2	100.0

Table 7. Weight-at-age (kg) derived from fishery (mid-year) and from 1987-2001 Canadian surveys (beginning of year) for 5Zj,m cod

Mid-Year

	1	2	3	4	5	6	7	8	9	10
1978	0.71	1.31	2.46	3.47	4.34	5.79	7.37	8.49	10.24	12.26
1979	0.89	1.49	2.15	4.21	4.89	7.18	9.18	10.31	10.24	12.26
1980	0.84	1.46	2.47	3.67	5.65	6.68	8.39	9.09	10.24	12.26
1981	0.88	1.50	2.36	3.42	5.21	7.22	8.57	9.89	10.24	12.26
1982	0.77	1.40	2.66	3.83	5.35	6.51	9.36	9.90	10.24	12.26
1983	0.97	1.49	2.38	3.31	4.64	6.39	7.96	10.29	10.24	12.26
1984	1.05	1.64	2.45	3.62	5.08	6.58	8.91	10.10	10.24	12.26
1985	0.91	1.42	2.09	3.89	5.09	6.41	8.10	10.24	10.24	12.26
1986	0.93	1.48	2.45	3.66	5.60	7.19	8.92	9.96	10.24	12.26
1987	0.73	1.48	2.50	4.19	5.81	7.73	8.95	10.01	10.24	12.26
1988	0.79	1.52	2.36	3.51	5.40	6.65	8.78	9.99	10.24	12.26
1989	0.81	1.62	2.27	3.77	5.40	6.69	8.22	10.72	10.24	12.26
1990	0.83	1.56	2.46	3.52	4.89	6.33	8.46	10.65	10.24	12.26
1991	1.11	1.63	2.55	3.42	4.77	5.89	7.41	10.52	10.24	12.26
1992	1.15	1.54	2.46	3.84	4.70	6.16	7.51	9.85	10.24	12.26
1993	0.88	1.57	2.31	3.08	4.50	5.73	7.08	8.88	10.24	12.26
1994	0.91	1.46	2.41	3.83	4.80	7.09	7.86	8.93	10.24	12.26
1995	0.90	1.49	2.51	3.72	5.22	6.52	11.06	10.12	10.24	12.26
1996	1.03	1.54	2.36	3.34	5.24	6.36	6.92	8.46	10.24	12.26
1997	0.98	1.50	2.23	3.34	4.25	5.80	8.05	8.33	10.24	12.26
1998	0.63	1.48	2.37	3.19	4.27	5.83	6.99	8.30	10.24	12.26
1999	0.80	1.55	2.29	3.53	4.16	6.31	6.78	8.04	10.24	12.26
2000	0.87	1.46	2.13	3.08	4.23	4.92	6.20	7.34	10.24	12.26
78-00	0.88	1.50	2.38	3.58	4.93	6.43	8.13	9.50	10.24	12.26
97-00	0.82	1.50	2.25	3.28	4.23	5.71	7.00	8.00	10.24	12.26

Beginning

1978	0.121	0.806	1.700	2.783	4.202	6.217	7.311	9.307	11.700	13.900
1979	0.121	0.806	1.700	2.783	4.202	6.217	7.311	9.307	11.700	13.900
1980	0.121	0.806	1.700	2.783	4.202	6.217	7.311	9.307	11.700	13.900
1981	0.121	0.806	1.700	2.783	4.202	6.217	7.311	9.307	11.700	13.900
1982	0.121	0.806	1.700	2.783	4.202	6.217	7.311	9.307	11.700	13.900
1983	0.121	0.806	1.700	2.783	4.202	6.217	7.311	9.307	11.700	13.900
1984	0.121	0.806	1.700	2.783	4.202	6.217	7.311	9.307	11.700	13.900
1985	0.121	0.806	1.700	2.783	4.202	6.217	7.311	9.307	11.700	13.900
1986	0.121	0.806	1.700	2.783	4.202	6.217	7.311	9.307	11.700	13.900
1987	0.151	0.843	1.690	2.838	5.800	8.426	8.154	7.464	11.700	13.900
1988	0.126	0.894	1.883	3.002	4.519	6.952	9.028	9.850	11.700	13.900
1989	0.153	0.805	1.669	2.868	4.226	6.588	7.634	8.099	11.700	13.900
1990	0.204	0.787	1.896	3.075	4.581	6.336	8.307	9.491	11.700	13.900
1991	0.086	0.870	1.923	3.181	4.266	5.099	7.308	9.616	11.700	13.900
1992	0.140	0.813	1.972	3.102	4.376	6.195	7.105	8.585	11.700	13.900
1993	0.081	0.936	1.884	3.087	4.791	6.024	6.969	7.581	11.700	13.900
1994	0.076	0.655	1.439	2.865	4.340	7.591	8.091	11.428	11.700	13.900
1995	0.146	0.798	1.567	2.225	3.535	5.132	6.204	7.275	11.700	13.900
1996	0.052	0.729	1.647	2.699	4.124	6.250	5.662	11.000	11.700	13.900
1997	0.100	0.725	1.762	2.352	3.434	6.564	7.529	10.996	11.700	13.900
1998	0.102	0.620	1.349	2.461	3.312	4.811	5.931	8.386	11.700	13.900
1999	0.151	0.999	1.414	2.425	3.317	4.848	7.116	11.222	11.700	13.900
2000	0.118	0.905	1.608	2.423	3.276	4.854	6.189	7.984	11.700	13.900
2001	0.120	0.735	1.500	2.596	3.901	5.311	7.191	7.512	11.700	13.900
87-01	0.120	0.808	1.680	2.747	4.120	6.065	7.228	9.099	11.700	13.900
98-01	0.123	0.815	1.468	2.476	3.452	4.956	6.607	8.776	11.700	13.900

Table 8. Survey indices of abundance (catch per standard tow in numbers) adjusted for vessel and door conversions.

Spring DFO	1	2	3	4	5	6	7	8
1986	1.78	8.19	7.41	0.77	1.6	1.03	0.51	0.08
1987	0.12	4.31	1.55	1.81	0.39	0.21	0.44	0.21
1988	0.36	1.08	12.85	1.36	2.02	0.23	0.19	0.43
1989	0.84	5.22	1.84	4.11	0.62	0.8	0.1	0.2
1990	0.25	1.91	8.36	4.7	10.6	1.29	2.63	0.35
1991	2.83	2.43	3.4	3.93	2.06	2.87	0.36	0.6
1992	0.11	4.93	2.94	0.99	1.55	1.09	0.72	0.22
1993	0.07	0.85	4.15	1.5	0.89	1.82	0.66	0.64
1994	0.03	1.51	1.66	3.1	1.15	0.44	0.88	0.2
1995	0.08	0.45	2.99	1.82	1.25	0.45	0.11	0.16
1996	0.22	0.49	4.2	10.44	3.45	2.49	1.07	0.26
1997	0.07	0.9	1.37	3.19	3.04	0.52	0.12	0.08
1998	0.01	1.42	2.04	0.79	0.77	0.58	0.14	0.07
1999	0.01	0.38	3.12	2.63	1.08	0.76	0.46	0.02
2000	0	1.02	3.12	11.96	5.19	2.48	1.23	0.76
2001	0.01	0.09	1.93	1.25	3.35	1.55	0.8	0.54
Fall NMFS								
1978	0.1	0	6.31	1.26	0.35	0.27		
1979	0.21	2.64	0.26	5.1	0.73	0.11		
1980	0.32	2.96	2.93	0.21	2.71	0.44		
1981	0.6	1.43	0.76	1.21	0.05	0.35		
1982	0.6	4.24	2.19	1.69	0.48	0.02		
1983	0	1.05	1.29	0.08	0.12	0		
1984	1.47	0.12	0.42	0.89	0.05	0.03		
1985	0.06	2.84	0.14	1.03	1.68	0.05		
1986	2.24	0.39	1.8	0.3	0.03	0		
1987	0.22	5.2	0.11	0.35	0	0		
1988	0.29	0.24	1.53	0.23	0.19	0		
1989	0.18	1.02	0.33	2.13	0.25	0.44		
1990	0.41	0.72	1.68	0.28	0.77	0.1		
1991	0.36	0.72	0.79	1.49	0.21	0.37		
1992	0	0.36	0.13	0.16	0.02	0.06		
1993	0	0.37	1.31	0.28	0	0.07		
1994	0	0.14	0.19	0.28	0.03	0		
1995	0.02	0.14	0.54	0.39	0.28	0.14		
1996	0.4	0.05	0.22	0.54	0.12	0.05		
1997	0.02	0.56	0.15	0.56	0.41	0.1		
1998	0	0.29	0.7	0.32	0.1	0.15		
1999	0	0.32	1.29	0.9	0.12	0.2		
2000	0	0.03	0.03	0.45	0.22	0.06		
2001	0	0.1	0.37	0.12	0.16	0.08		
Spring NMFS	Yankee 41							
1978	0.27	0	5.1	1.12	1.61	0.34	1.37	0.19
1979	0.69	2.65	0.22	2.57	1	0.34	0.17	0.22
1980	0.03	2.96	2.9	0.28	3.01	0.59	0.12	0.08
1981	1.7	1.57	2.43	1.73	0.07	0.6	0.31	0.12
Spring NMFS	Yankee 36							
1982	0.79	11.58	24.99	22.29	16.98	0	5.55	1.24
1983	0.69	3.63	6.33	1.36	1.06	0.66	0.28	0.11
1984	0.2	0.22	0.81	1.22	0.48	0.39	0.34	0
1985	0.08	3.67	1.15	1.92	2.75	0.6	0.35	0.45
1986	1.13	0.62	2.05	0.55	0.78	0.98	0.05	0.21
1987	0	2.17	0.46	0.98	0	0.34	0.28	0.06
1988	0.58	0.45	5.05	0.5	0.84	0.08	0.03	0.14
1989	0.21	1.55	0.47	2.39	0.46	0.54	0.07	0.06
1990	0.13	0.62	3.14	1.09	1.18	0.29	0.3	0.03
1991	1.31	1.12	0.92	1.63	0.83	0.69	0.08	0.03
1992	0.14	1.2	0.65	0.17	0.45	0.27	0.29	0.05
1993	0	0.83	2.32	0.47	0.08	0.33	0.08	0.08
1994	0.1	0.37	0.29	0.36	0.09	0.02	0.06	0
1995	0.09	0.52	1.64	0.88	1.63	0.35	0.47	0.06
1996	0.25	0.54	1.78	2.41	0.22	0.17	0.05	0
1997	0.1	0.37	0.11	0.73	0.93	0.1	0.23	0.1
1998	0	1.99	3.8	1.91	1.88	1.17	0.06	0.06
1999	0.04	0.24	1.24	1.14	0.66	0.31	0.18	0.06
2000	0	0.55	1.16	2.43	0.89	0.25	0.09	0.04

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

	Mobile	Gillnet	Longline
1990 Total catch (t)	7854	910	5202
Total with effort (t)	7285	534	1579
Number of Boats	176	14	103
Percent with effort	92.7	58.7	30.4
Effort (fish_days)	3837(4133)	215(367)	825(2724)
Catch per day	1.9	2.48	1.91
1991 Total catch (t)	6698	1688	4706
Total with effort (t)	6395	1084	1581
Number of boats	188	26	118
Percent with effort	95.5	64.2	33.6
Effort (fish_days)	3769(3940)	308(480)	849(2530)
Landings per day	1.7	3.52	1.86
1992 Total catch (t)	5638	1217	4474
Total with effort (t)	5583	684	1893
Number of boats	138	19	130
Percent with effort	99	56.2	42.3
Effort (fish_days)	2051(2073)	389(691)	1076(2542)
Landings per day	2.72	1.76	1.76
1993 Total catch (t)	4890	1175	2387
Total with effort (t)	4877	943	1179
Number of boats	125	20	135
Percent with effort	99.7	80.3	49.4
Effort (fish_days)	2377(2385)	635(789)	1377(2776)
Landings per day	2.05	1.49	0.86
1994 Total catch (t)	1893	1031	2287
Total with effort (t)	1886	79	73
Number of boats	95	21	78
Percent with effort	99.6	7.7	3.2
Effort (fish_days)	1926(1932)	-	-
Landings per day	0.98	-	-
1995 Total catch (t)	313	123	505
Total with effort (t)	313	116	494
Number of boats	64	11	49
Percent with effort	99.9	94.3	97.8
Effort (fish_days)	506(506)	202(216)	522(532)
Landings per day	0.62	0.57	0.95

	Mobile	Gillnet	Longline
1996 Total catch (t)	656	245	984
Total with effort (t)	656	245	984
Number of boats	76	10	102
Percent with effort	100	100	100
Effort (fish_days)	1082	111	852
Landings per day	0.61	2.21	1.15
1997 Total catch (t)	1032	470	1394
Total with effort (t)	1009	409	1152
Number of boats	74	9	74
Percent with effort	97.8	87	82.6
Effort (fish_days)	1159(1186)	164(188)	708(860)
Landings per day	0.87	2.49	1.62
1998 Total catch (t)	640	299	928
Total with effort (t)	626	299	861
Number of boats	71	9	64
Percent with effort	97.8	100	92.8
Effort (fish_days)	1028(1051)	180	578(623)
Landings per day	0.61	1.66	1.49
1999 Total catch (t)	607	264	912
Total with effort (t)	607	264	912
Number of boats	69	7	60
Percent with effort	100	100	100
Effort (fish_days)	915	175	584
Landings per day	0.66	1.51	1.56
2000 Total catch (t)	523	238	794
Total with effort (t)	523	238	794
Number of boats	73	9	57
Percent with effort	100	100	100
Effort (fish_days)	1075	185	601
Landings per day	0.49	1.29	1.32

Table 10. Proportion mature at age for 5Zj,m cod from DFO research survey (see Hunt (1995)), using a three year moving average.

	Age Group									
Year	1	2	3	4	5	6	7	8	9	10
1978	0.024	0.372	0.916	0.991	0.999	1.000	1.000	1.000	1.000	1.000
1979	0.024	0.372	0.916	0.991	0.999	1.000	1.000	1.000	1.000	1.000
1980	0.024	0.372	0.916	0.991	0.999	1.000	1.000	1.000	1.000	1.000
1981	0.024	0.372	0.916	0.991	0.999	1.000	1.000	1.000	1.000	1.000
1982	0.024	0.372	0.916	0.991	0.999	1.000	1.000	1.000	1.000	1.000
1983	0.024	0.372	0.916	0.991	0.999	1.000	1.000	1.000	1.000	1.000
1984	0.024	0.372	0.916	0.991	0.999	1.000	1.000	1.000	1.000	1.000
1985	0.024	0.372	0.916	0.991	0.999	1.000	1.000	1.000	1.000	1.000
1986	0.029	0.345	0.871	0.982	0.998	1.000	1.000	1.000	1.000	1.000
1987	0.038	0.320	0.822	0.974	0.997	1.000	1.000	1.000	1.000	1.000
1988	0.032	0.320	0.878	0.985	0.998	1.000	1.000	1.000	1.000	1.000
1989	0.017	0.320	0.950	0.998	1.000	1.000	1.000	1.000	1.000	1.000
1990	0.016	0.351	0.955	0.999	1.000	1.000	1.000	1.000	1.000	1.000
1991	0.019	0.424	0.956	0.998	1.000	1.000	1.000	1.000	1.000	1.000
1992	0.018	0.525	0.979	0.999	1.000	1.000	1.000	1.000	1.000	1.000
1993	0.018	0.564	0.988	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1994	0.026	0.549	0.982	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1995	0.037	0.507	0.952	0.997	1.000	1.000	1.000	1.000	1.000	1.000
1996	0.035	0.383	0.891	0.991	0.999	1.000	1.000	1.000	1.000	1.000
1997	0.032	0.352	0.881	0.991	0.999	1.000	1.000	1.000	1.000	1.000
1998	0.029	0.537	0.944	0.996	1.000	1.000	1.000	1.000	1.000	1.000
1999	0.013	0.767	0.982	0.998	1.000	1.000	1.000	1.000	1.000	1.000
2000	0.001	0.899	0.978	0.997	1.000	1.000	1.000	1.000	1.000	1.000
2001	0.000	0.953	0.978	0.998	1.000	1.000	1.000	1.000	1.000	1.000

Table11. Statistical properties of estimates for population abundance and survey calibration constants from Bootstrap parameter estimates for 5Zj,m cod estimated from ADAPT.

Parameter	Estimate	Standard Error	Relative Error	Bias	Relative Bias
Population Numbers					
2001 numbers Age 2	414.00	417.00	1.01	79.60	0.19
2001 numbers Age 3	836.00	323.00	0.39	55.20	0.07
2001 numbers Age 4	592.00	233.00	0.39	41.60	0.07
2001 numbers Age 5	1320.00	419.00	0.32	44.00	0.03
2001 numbers Age 6	1110.00	317.00	0.28	74.10	0.07
2001 numbers Age 7	311.00	103.00	0.33	8.77	0.03
2001 numbers Age 8	272.00	91.90	0.34	8.73	0.03
2001 numbers Age 9	195.00	69.40	0.36	8.82	0.05
2001 numbers Age 10	39.20	21.00	0.54	3.01	0.08
Survey Catchabilities					
Can, Spr. Age 1	0.0000311	0.0000066	0.21	0.0000006	0.02
Can, Spr. Age 2	0.0004270	0.0000977	0.23	-0.0000004	0.00
Can, Spr. Age 3	0.0012100	0.0002910	0.24	0.0000264	0.02
Can, Spr. Age 4	0.0015400	0.0003320	0.22	0.0000255	0.02
Can, Spr. Age 5	0.0021000	0.0004660	0.22	0.0000200	0.01
Can, Spr. Age 6	0.0022400	0.0005280	0.24	0.0000705	0.03
Can, Spr. Age 7	0.0025000	0.0005150	0.21	0.0000579	0.02
Can, Spr. Age 8	0.0027000	0.0005900	0.22	0.0000987	0.04
USA Fall Age 1	0.0000325	0.0000070	0.21	-0.0000001	0.00
USA Fall Age 2	0.0001230	0.0000221	0.18	0.0000025	0.02
USA Fall Age 3	0.0001700	0.0000291	0.17	-0.0000034	-0.02
USA Fall Age 4	0.0002640	0.0000472	0.18	0.0000062	0.02
USA Fall Age 5	0.0001760	0.0000340	0.19	0.0000050	0.03
USA Fall Age 6	0.0002370	0.0000492	0.21	0.0000066	0.03
USA Spr1 Age 1	0.0000274	0.0000138	0.50	0.0000026	0.09
USA Spr1 Age 2	0.0002850	0.0001960	0.69	0.0000483	0.17
USA Spr1 Age 3	0.0003370	0.0001640	0.49	0.0000186	0.06
USA Spr1 Age 4	0.0003710	0.0001710	0.46	0.0000339	0.09
USA Spr1 Age 5	0.0005970	0.0002890	0.48	0.0000225	0.04
USA Spr1 Age 6	0.0006560	0.0003010	0.46	0.0000465	0.07
USA Spr1 Age 7	0.0010900	0.0004860	0.45	0.0000542	0.05
USA Spr1 Age 8	0.0013100	0.0007600	0.58	0.0001600	0.12
USA Spr2 Age 1	0.0000461	0.0000110	0.24	0.0000024	0.05
USA Spr2 Age 2	0.0002280	0.0000475	0.21	0.0000025	0.01
USA Spr2 Age 3	0.0004510	0.0001010	0.22	0.0000057	0.01
USA Spr2 Age 4	0.0006200	0.0001250	0.20	0.0000041	0.01
USA Spr2 Age 5	0.0007990	0.0001680	0.21	0.0000161	0.02
USA Spr2 Age 6	0.0007430	0.0001590	0.22	0.0000216	0.03
USA Spr2 Age 7	0.0008590	0.0001950	0.23	0.0000256	0.03
USA Spr2 Age 8	0.0009120	0.0002010	0.22	0.0000239	0.03

Table 12. Population estimates for 5Zj,m cod derived from ADAPT

Abundance (000's)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1+**	**3+**
1978	10935	2166	10185	3517	917	328	249	78	28	21	28424	15323
1979	9554	8951	1664	5124	1914	476	170	130	45	12	28039	9534
1980	9252	7813	6594	1004	2605	1078	256	119	66	33	28820	11755
1981	17366	7574	5508	4055	584	1312	573	112	79	41	37204	12264
1982	6411	14201	5657	3213	2199	339	543	317	34	46	32960	12349
1983	4607	5243	9213	3119	1354	850	109	139	120	9	24763	14912
1984	13475	3736	3108	4484	1238	691	442	62	50	87	27371	10161
1985	4544	11023	2816	1727	2463	556	306	157	23	25	23640	8073
1986	21119	3710	6516	1214	849	1174	255	165	40	11	35052	10223
1987	6983	17266	2741	3361	532	421	601	156	99	24	32184	7936
1988	13500	5704	10839	1469	1766	307	236	342	95	68	34325	15120
1989	3778	11044	4384	5630	630	685	124	103	153	52	26582	11760
1990	5412	3092	8380	3007	2974	344	282	51	62	92	23696	15192
1991	8383	4425	1920	3992	1597	1363	178	122	33	38	22050	9242
1992	2417	6854	3058	872	1538	461	413	62	50	14	15738	6468
1993	3605	1901	3503	1388	329	454	155	132	29	22	11517	6011
1994	2650	2948	1184	1117	417	79	79	30	26	9	8538	2941
1995	1881	2168	2249	534	250	123	29	13	2	7	7256	3207
1996	4272	1540	1724	1630	329	125	88	20	8	1	9736	3925
1997	4288	3497	1225	1201	982	201	60	62	14	3	11532	3748
1998	1248	3508	2766	863	724	541	101	20	42	8	9819	5064
1999	1229	1021	2799	2016	583	467	338	67	7	31	8557	6307
2000	409	1005	794	1911	1407	405	342	240	46	5	6564	5151
2001	1000	334	781	551	1274	1040	302	263	186	36	5767	4433
Biomass												
1978	1319	1745	17311	9788	3853	2036	1822	723	332	285	39214	36150
1979	1152	7211	2828	14260	8042	2957	1239	1207	524	174	39594	31230
1980	1116	6295	11208	2794	10946	6700	1870	1107	770	459	43265	35854
1981	2094	6102	9361	11285	2453	8157	4189	1042	929	574	46186	37990
1982	773	11441	9615	8942	9241	2106	3968	2954	397	641	50079	37864
1983	556	4224	15659	8679	5688	5281	799	1290	1402	127	43705	38925
1984	1625	3010	5282	12479	5200	4294	3230	573	587	1214	37494	32859
1985	548	8881	4786	4806	10349	3457	2239	1459	267	347	37139	27710
1986	2547	2989	11075	3379	3565	7300	1864	1532	465	147	34863	29328
1987	1056	14547	4631	9538	3087	3544	4897	1166	1164	338	43969	28367
1988	1705	5101	20411	4408	7982	2131	2128	3366	1107	944	49283	42478
1989	577	8885	7318	16148	2664	4513	943	831	1791	719	44389	34926
1990	1101	2434	15887	9244	13624	2180	2346	489	722	1283	49311	45775
1991	722	3851	3693	12697	6811	6950	1297	1172	388	528	38109	33536
1992	338	5573	6032	2704	6728	2854	2937	536	583	191	28476	22565
1993	291	1779	6598	4283	1577	2735	1081	998	338	306	19986	17916
1994	202	1931	1704	3201	1809	600	640	341	301	119	10848	8715
1995	275	1729	3524	1189	885	630	177	96	23	95	8622	6617
1996	221	1122	2840	4399	1359	782	496	215	94	10	11538	10195
1997	427	2535	2159	2824	3372	1322	449	678	161	41	13969	11006
1998	128	2177	3731	2122	2397	2604	602	167	486	107	14519	12215
1999	186	1020	3957	4889	1932	2264	2407	748	76	435	17916	16710
2000	48	909	1277	4630	4608	1965	2119	1919	539	73	18087	17130
2001	120	246	1171	1430	4969	5524	2175	1975	2177	503	20290	19924
Fishing Mortality											**4+F**	**%Exp**
1978	0.000	0.064	0.487	0.408	0.457	0.459	0.454	0.352	0.620	0.468	0.420	31
1979	0.001	0.106	0.305	0.476	0.374	0.420	0.154	0.478	0.104	0.306	0.440	32
1980	0.000	0.150	0.286	0.342	0.486	0.432	0.626	0.204	0.266	0.403	0.440	33
1981	0.001	0.092	0.339	0.412	0.344	0.683	0.391	0.995	0.343	0.551	0.470	34
1982	0.001	0.233	0.396	0.664	0.751	0.932	1.165	0.774	1.112	0.947	0.760	49
1983	0.010	0.323	0.520	0.724	0.473	0.454	0.373	0.816	0.117	0.446	0.610	42
1984	0.001	0.083	0.388	0.399	0.600	0.613	0.836	0.794	0.498	0.668	0.490	35
1985	0.003	0.326	0.641	0.510	0.541	0.580	0.421	1.173	0.565	0.656	0.550	39
1986	0.001	0.102	0.462	0.624	0.502	0.471	0.290	0.304	0.290	0.371	0.510	36
1987	0.002	0.266	0.424	0.443	0.352	0.379	0.364	0.301	0.181	0.315	0.410	31
1988	0.001	0.063	0.455	0.646	0.747	0.709	0.632	0.603	0.404	0.619	0.680	45
1989	0.000	0.076	0.177	0.438	0.405	0.686	0.675	0.308	0.305	0.476	0.460	34
1990	0.001	0.276	0.542	0.433	0.580	0.462	0.640	0.240	0.286	0.442	0.500	36
1991	0.001	0.169	0.590	0.754	1.043	0.993	0.844	0.695	0.680	0.851	0.860	53
1992	0.040	0.471	0.590	0.774	1.020	0.889	0.944	0.572	0.617	0.808	0.920	55
1993	0.001	0.272	0.943	1.002	1.227	1.548	1.447	1.434	1.019	1.335	1.180	64
1994	0.001	0.070	0.590	1.296	1.017	0.818	1.594	2.542	1.122	1.419	1.240	66
1995	0.000	0.028	0.121	0.278	0.493	0.136	0.176	0.288	0.833	0.386	0.310	25
1996	0.000	0.028	0.159	0.301	0.282	0.541	0.147	0.151	0.804	0.385	0.310	24
1997	0.001	0.033	0.146	0.296	0.383	0.452	0.896	0.189	0.380	0.460	0.350	27
1998	0.000	0.025	0.111	0.183	0.225	0.254	0.189	0.903	0.080	0.330	0.220	18
1999	0.001	0.047	0.172	0.152	0.152	0.102	0.129	0.129	0.016	0.106	0.140	12
2000	0.000	0.046	0.149	0.189	0.095	0.083	0.058	0.050	0.023	0.062	0.130	11

Table 13. Catch projection results for the 2001 fishery and 2002 population using bootstrap bias adjusted point estimates for a target of $F_{0.1}$ =0.2

		Age Group													
January Abundance		1	2	3	4	5	6	7	8	9	10				
	2001	1000	334	781	551	1274	1040	302	263	186	36				
	2002	1000	819	261	538	369	854	697	203	176	125				
Fishing Mortality															
	2001	0	0.048	0.172	0.2	0.2	0.2	0.2	0.2	0.2	0.2				
Natural Mortality															
	2001	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2				
Partial Recruitment															
(mean 1997-2000)	2001	0	0.24	0.86	1	1	1	1	1	1	1				
January Weights															
	2001	0.12	0.81	1.47	2.48	3.45	4.96	6.61	8.78	11.7	13.9				
	2002	0.12	0.81	1.47	2.48	3.45	4.96	6.61	8.78	11.7	13.9				
Projected Biomass												1+	2+	3+	4+
	2001	123	272	1146	1364	4397	5155	1998	2307	2177	503	19442	19320	19047	17901
	2002	123	667	383	1333	1274	4232	4606	1779	2062	1734	18193	18070	17403	17020
Projected Catch (000's)															
	2001	0	14	112	91	210	171	50	43	31	6				
Mid-Year Weight															
	2001	0.82	1.50	2.25	3.28	4.23	5.71	7.00	8.00	10.24	12.26				
Projected Catch Biomass															
	2001	0	21	253	298	888	980	349	347	314	73	**3523**	3523	3502	3249

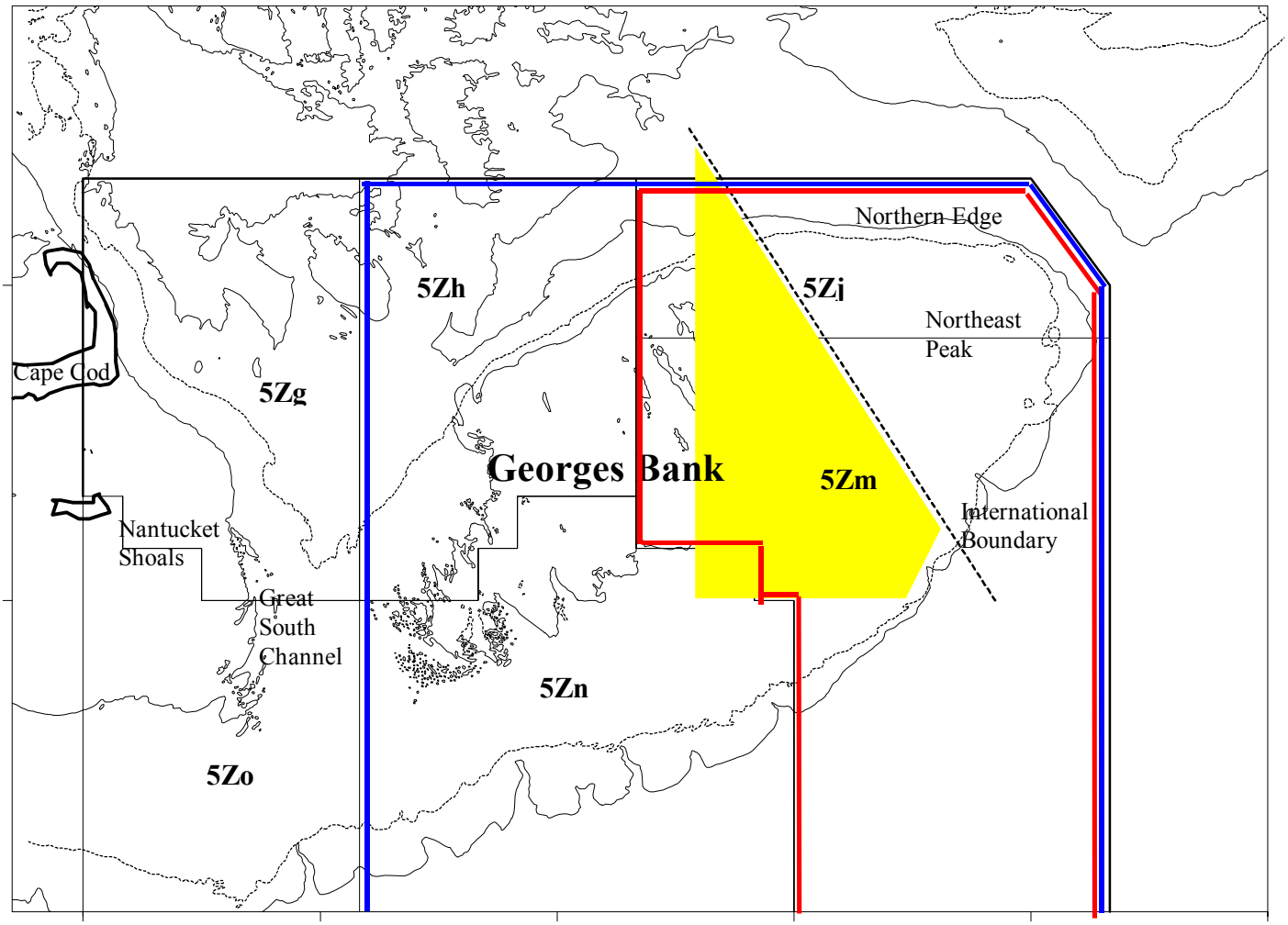


Figure 1. Map of the Georges Bank area showing the 5Zj,m management unit. Shaded area indicates USA closed area II.

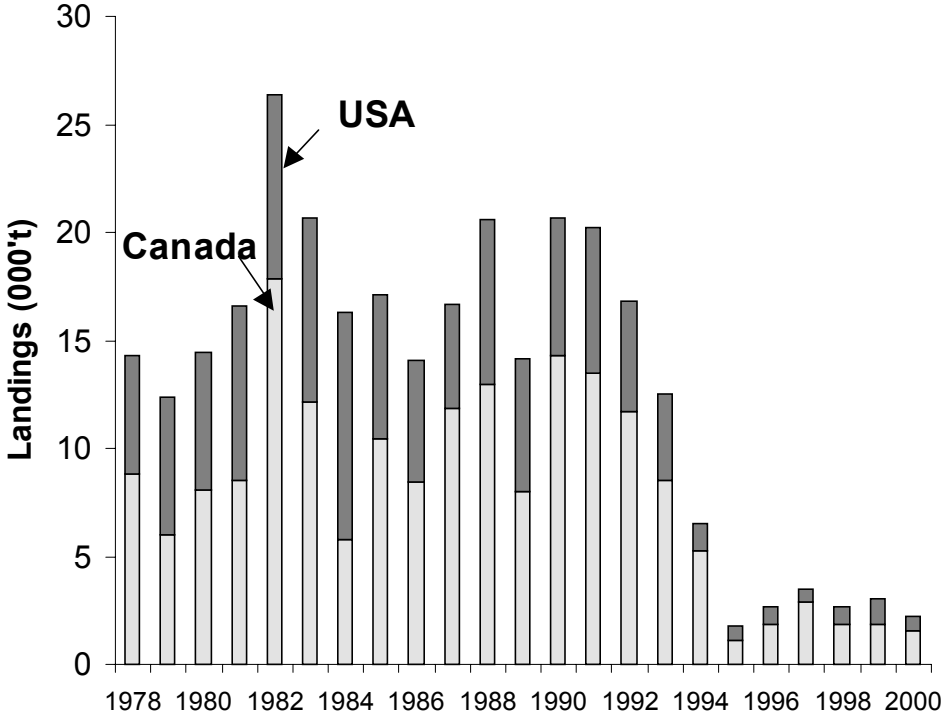


Figure 2. Landings of 5Zj,m cod by Canada and the USA

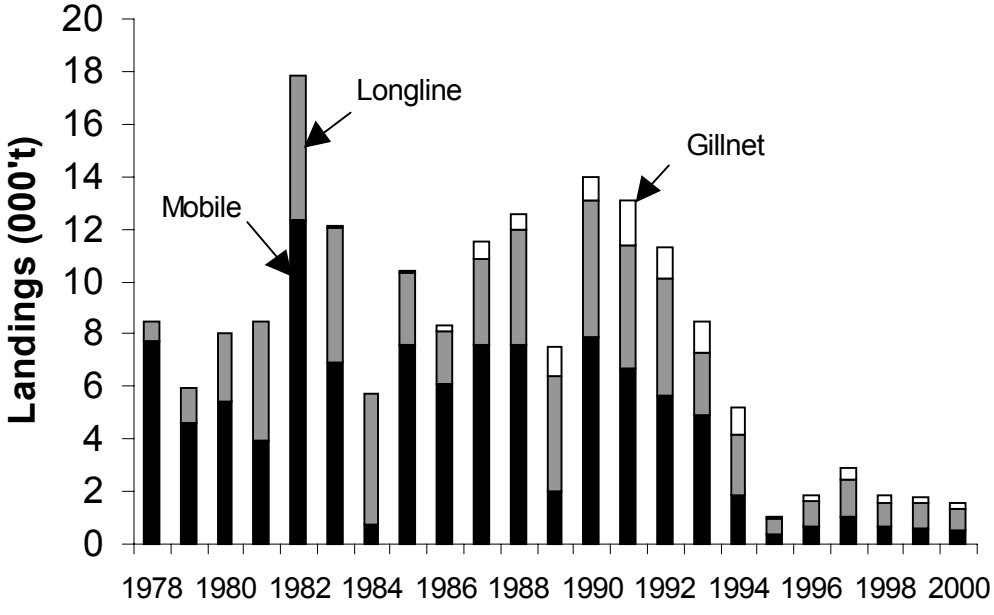


Figure 3a. Landings of 5Zj,m cod by gear type for Canadian fisheries.

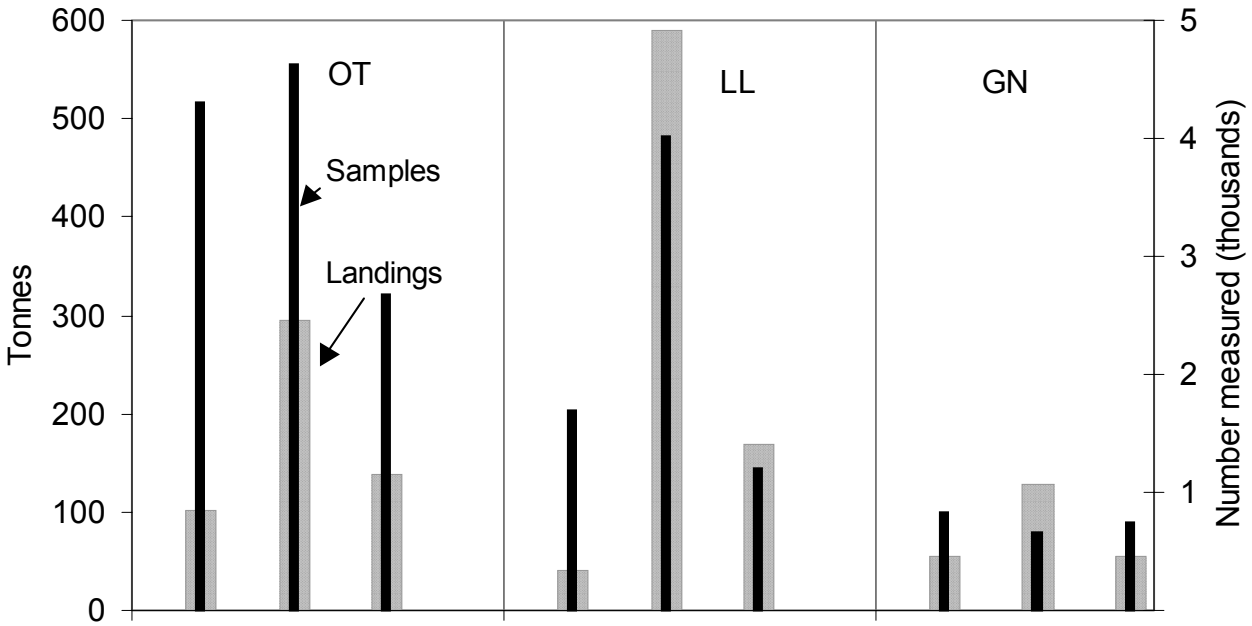
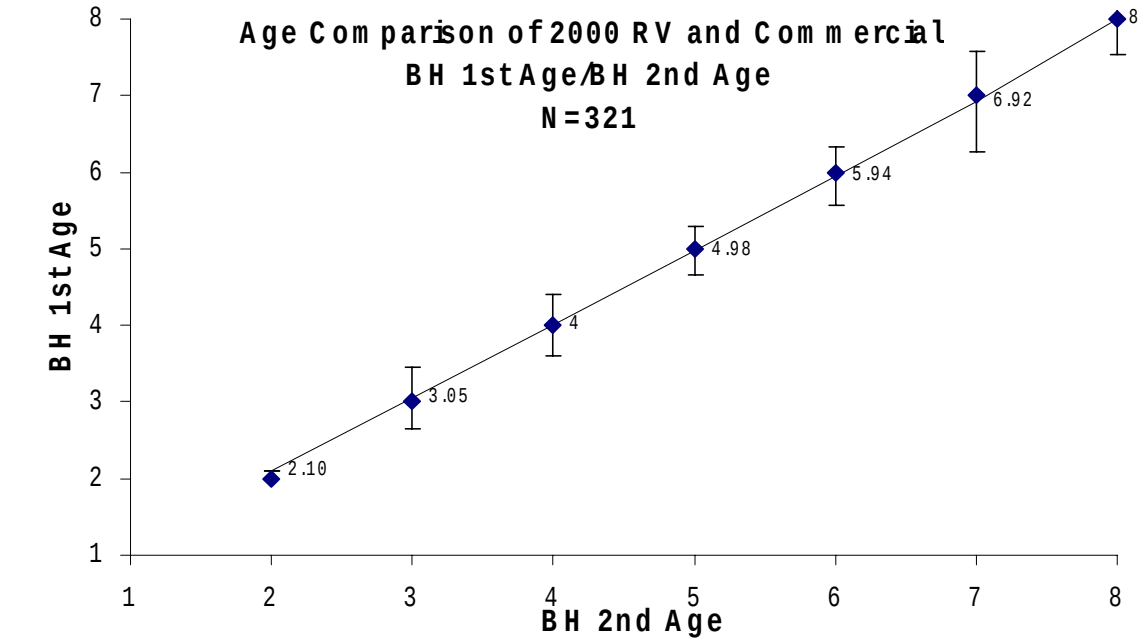


Figure 3b. Summary of Canadian landings by gear sector and corresponding length samples used in determining catch at age



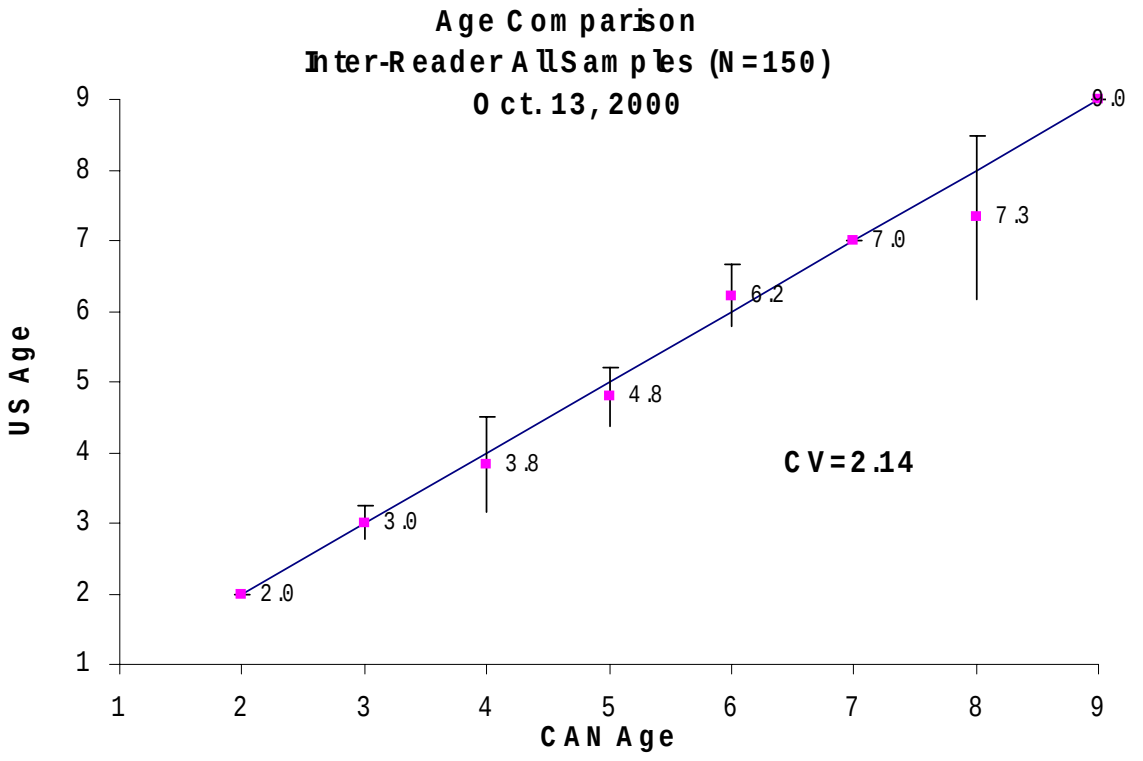
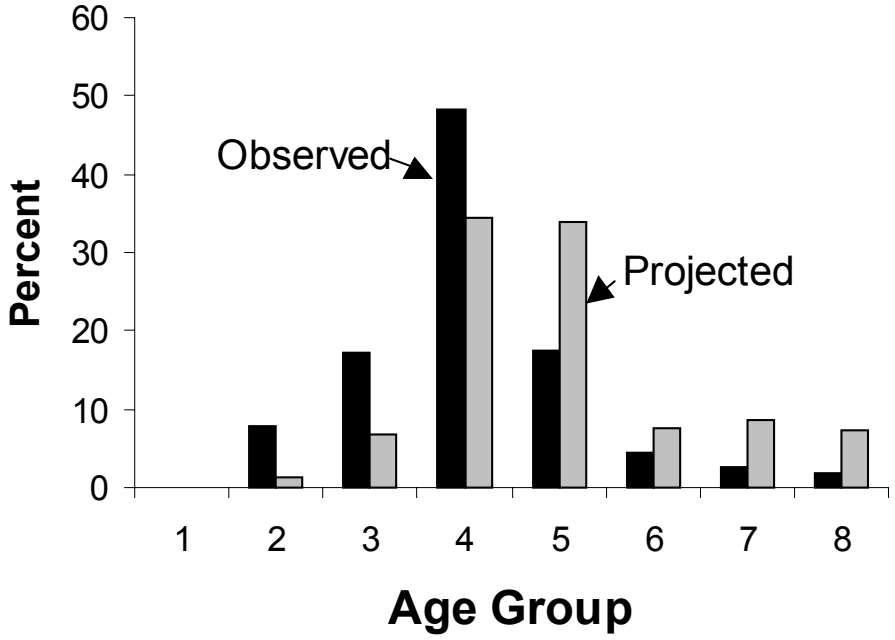


Figure 4. Canadian intra-reader age comparisons showing the average age and variance relative to first and second reading; inter-reader age comparisons showing the average age and variance relative to Canadian and USA age. For example, the average BH age for cod aged as 5 years old was 4.98 for the second reading.

A



B

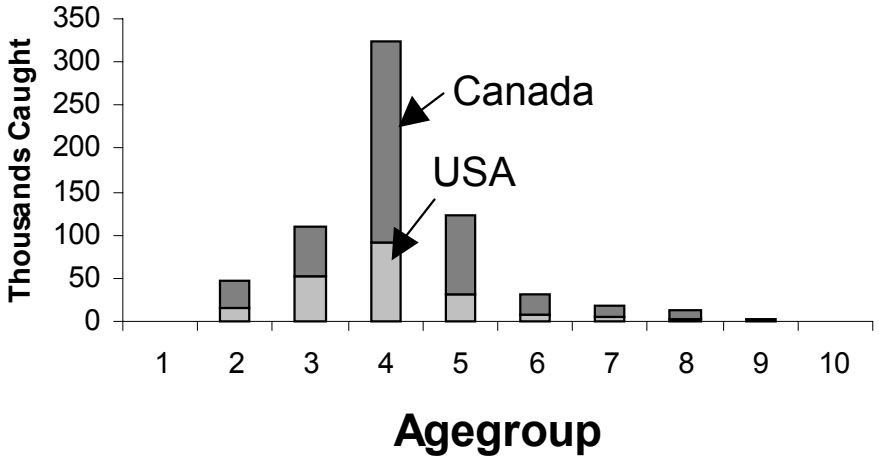


Figure 5. Observed and predicted percent catch at age for the 2000 (A). Numbers caught in the combined Canadian and USA 5Zj,m cod fishery in 2000 (B)

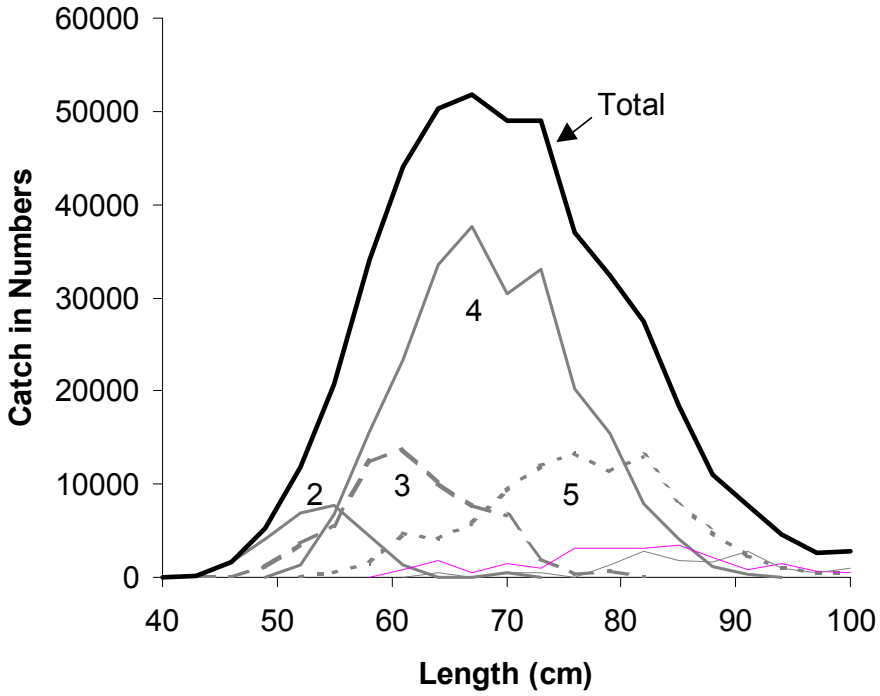


Figure 6. Length composition by agegroup for the 2000 Canadian 5Zj,m cod fishery

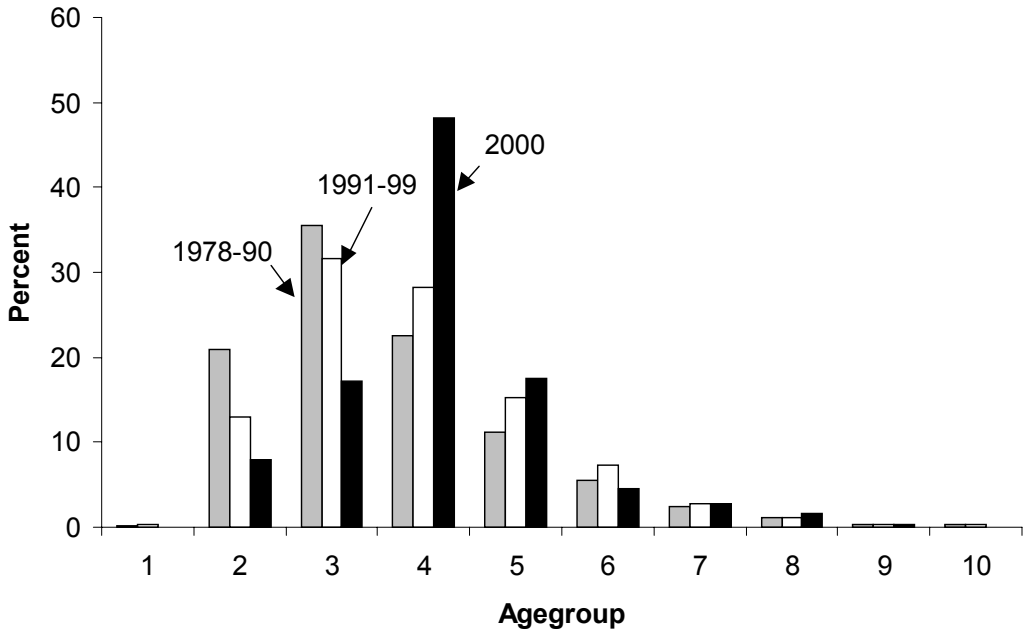


Figure 7. Comparison of the observed percent catch at age in 2000 with the percent catch at age from earlier time periods.

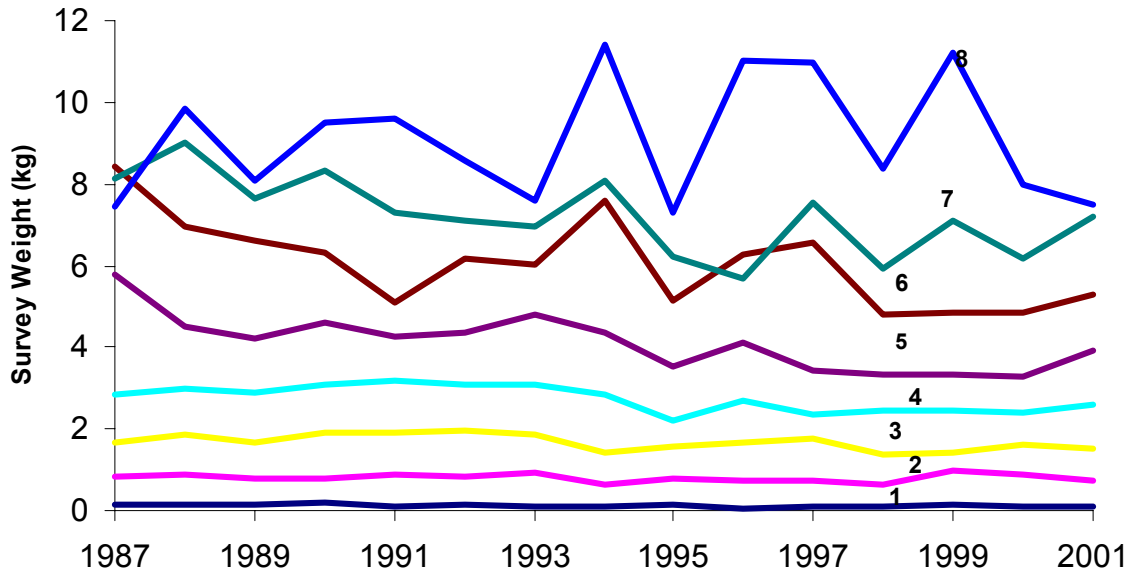


Figure 8. Beginning of year mean weight (kg) at age for cod derived from Canadian research surveys.

Cod Distribution (number/tow), 1996-2000 density and 2001

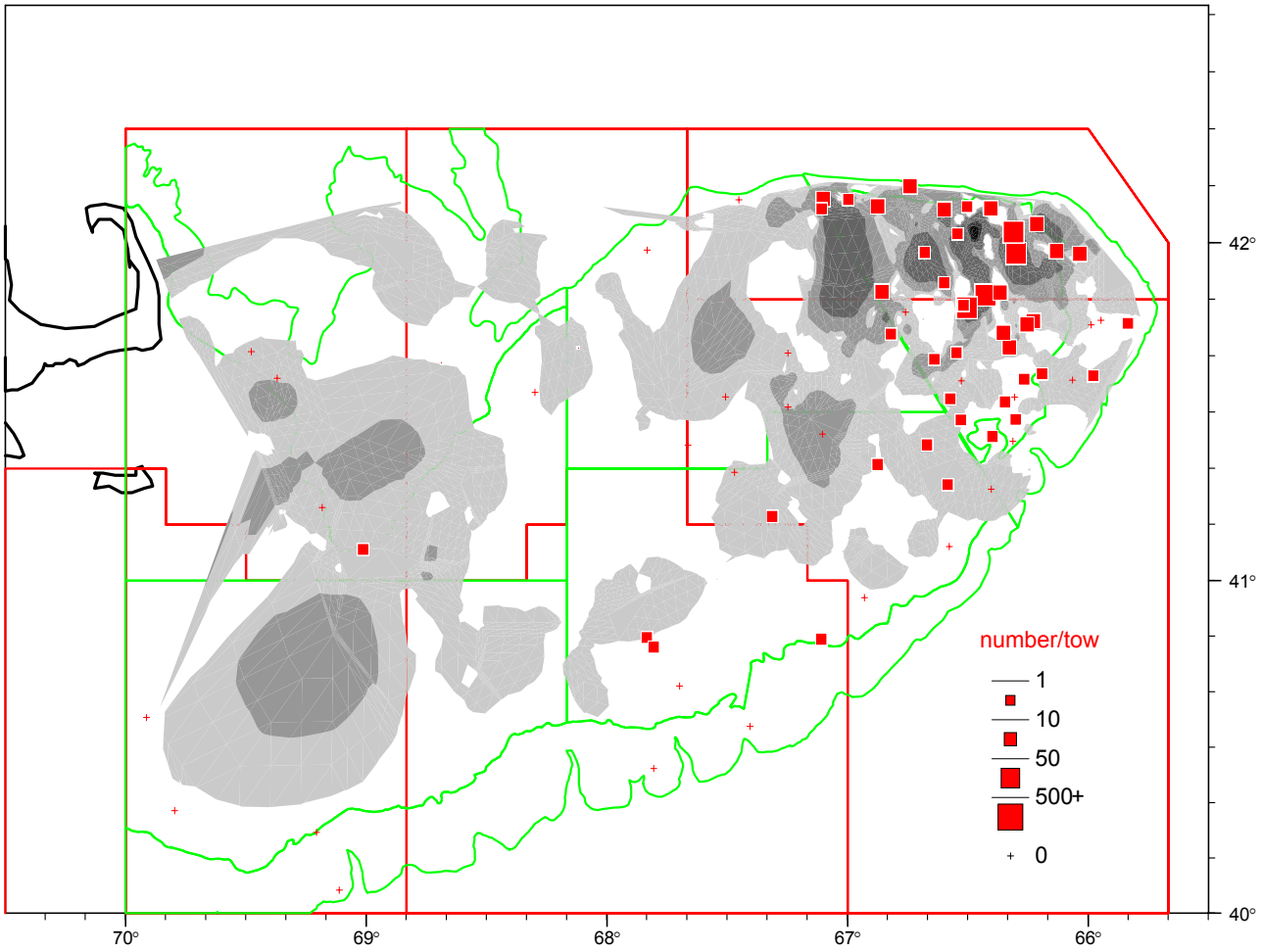


Figure 9. Comparison of cod per standard tow (kg/tow) from the 2001 Canadian research survey (box symbol) with average density gradient distribution for the 1995-2000 surveys

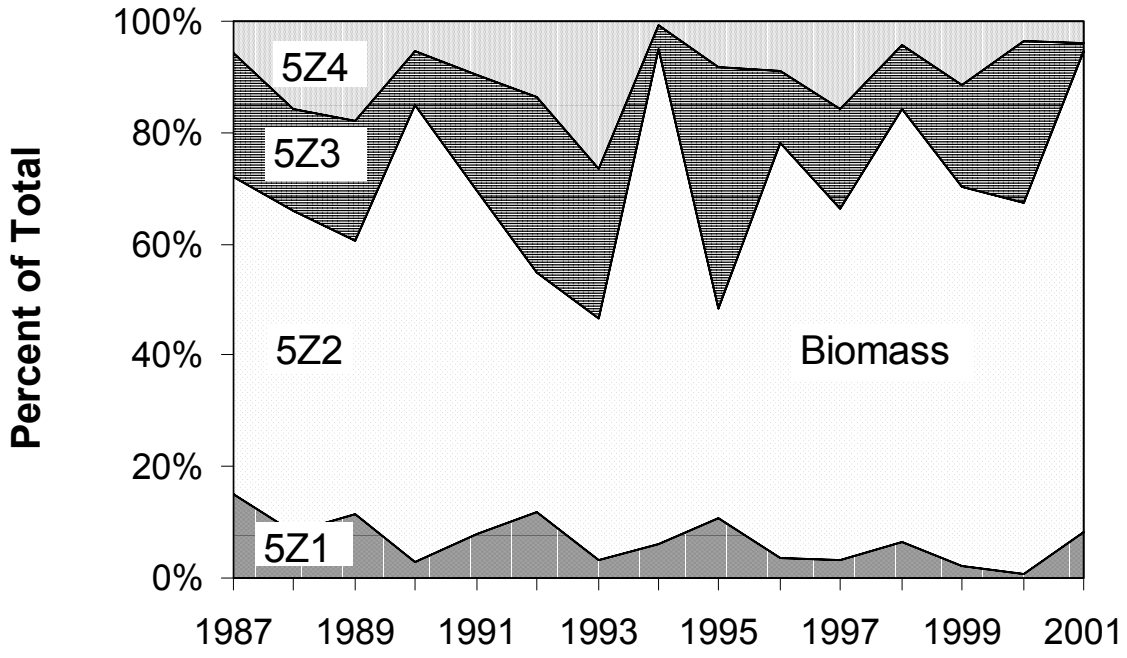


Figure 10. DFO spring survey biomass index for 1987-2001 by stratum. Area labels refer to survey strata, where 5Z1 = 50-100fm and 5Z2 = <50fm in the Canadian zone and 5Z3 and 5Z4 are in the USA zone.

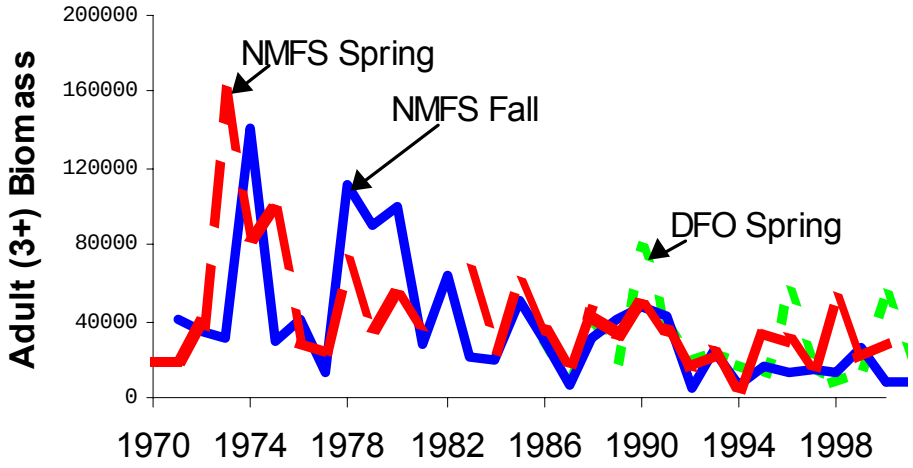


Figure 11. Estimates of adult biomass (t) indices for 5Zj,m cod from the DFO spring and NMFS spring and fall surveys in 5Zj,m

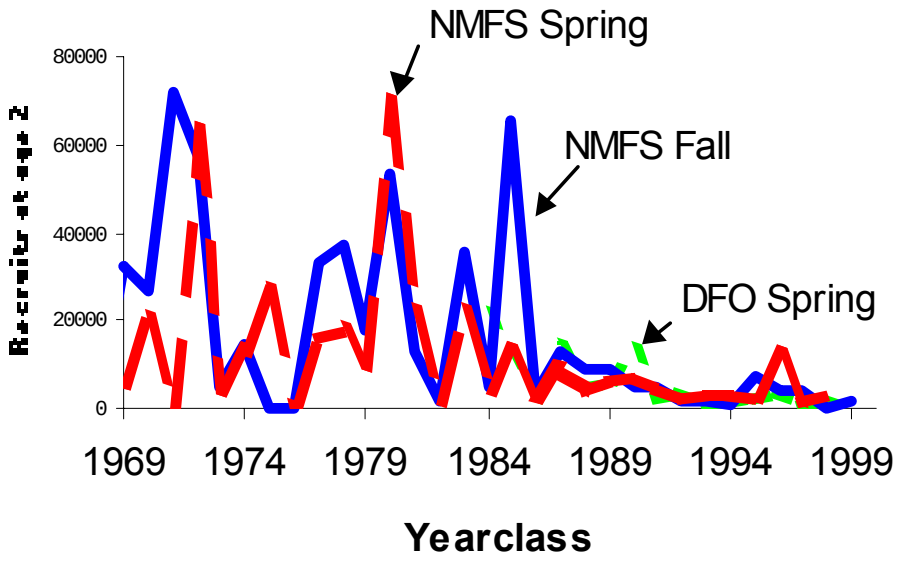


Figure 12. Estimates of recruitment at age 2 for 5Zj,m cod from the DFO spring and NMFS spring and fall surveys in 5Zj,m

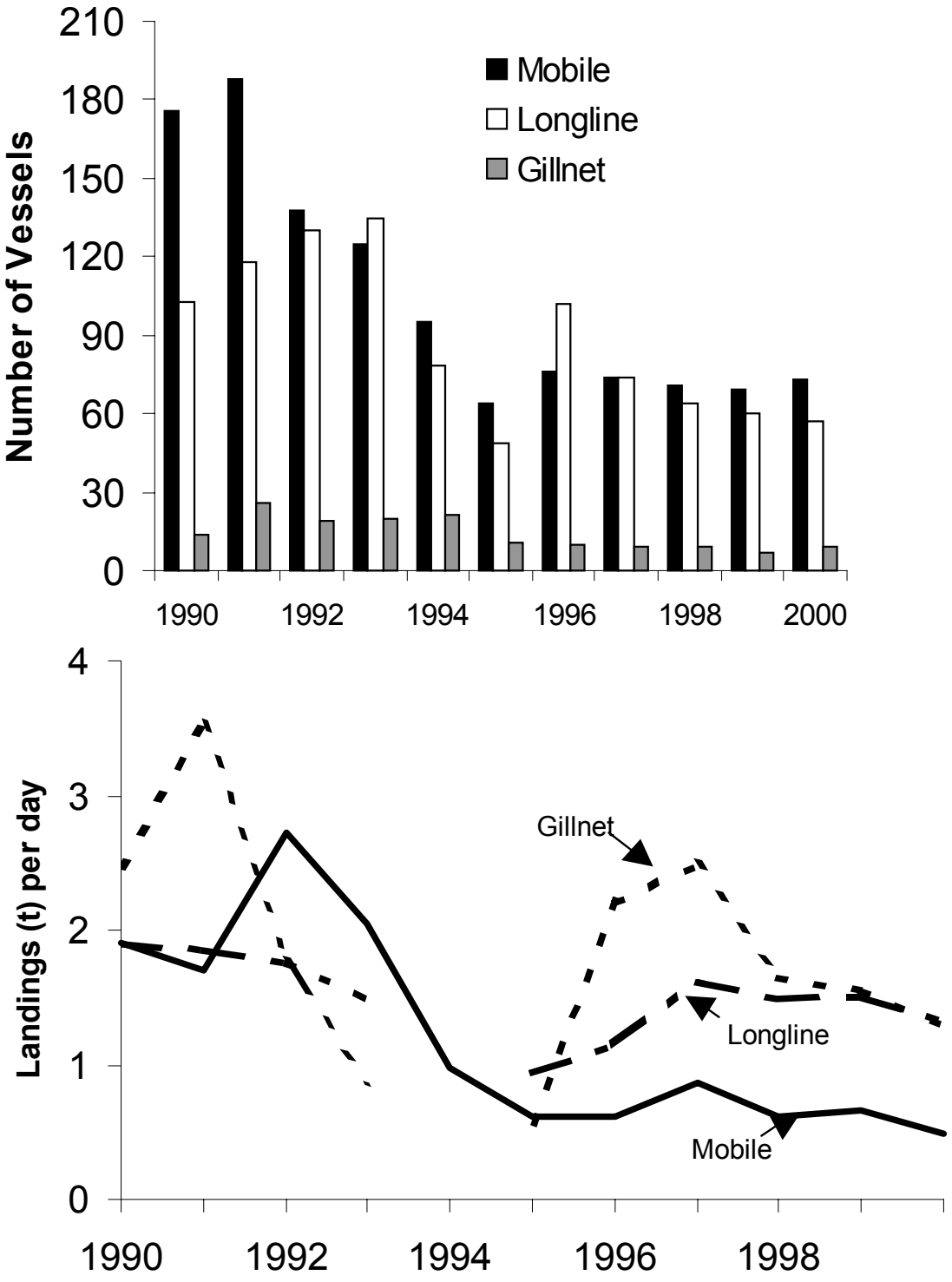


Figure 13. Number of Canadian vessels (upper panel) and landings per day fished (lower panel) by gear type for trips with >500kg cod landings. Effort data for 1994 fixed gear was not available.

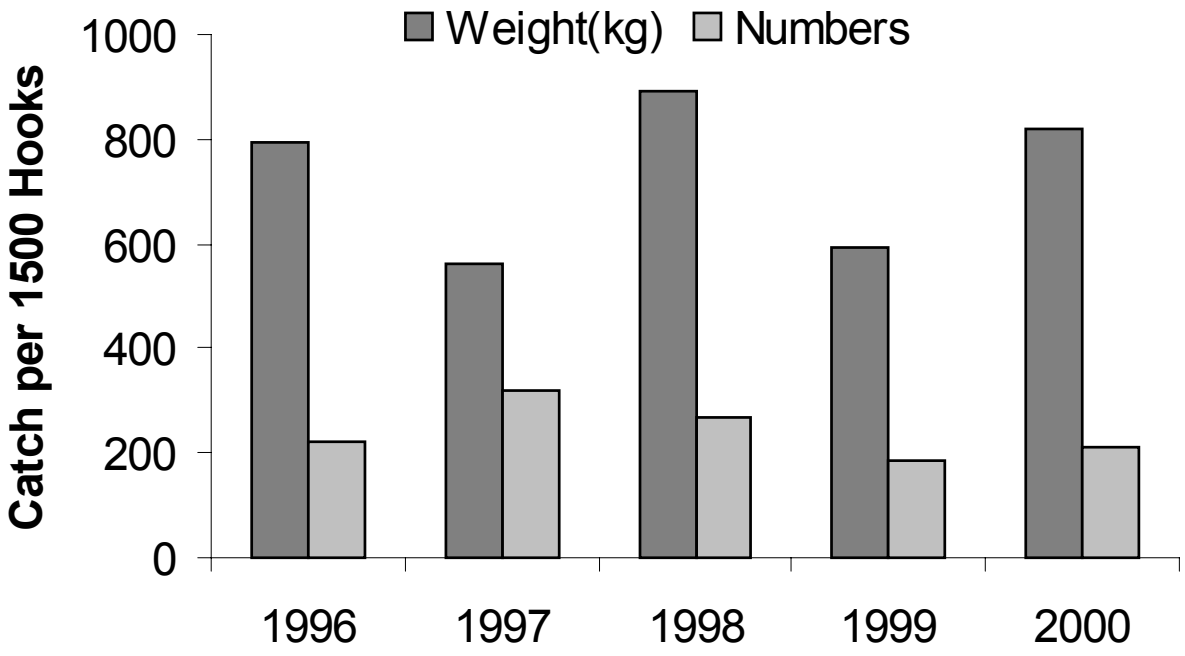


Figure 14. Results of Canadian longline industry survey showing the annual average weight and number caught per 1500 hooks.

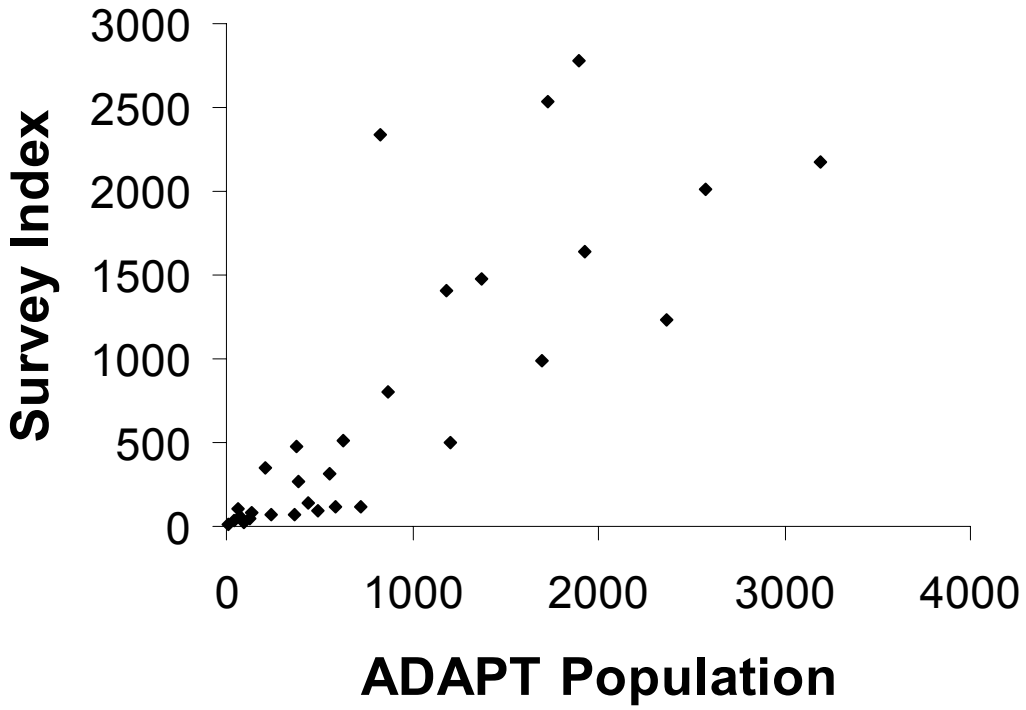


Figure 15.Comparison of ADAPT population cohort estimates with longline survey index cohort estimates

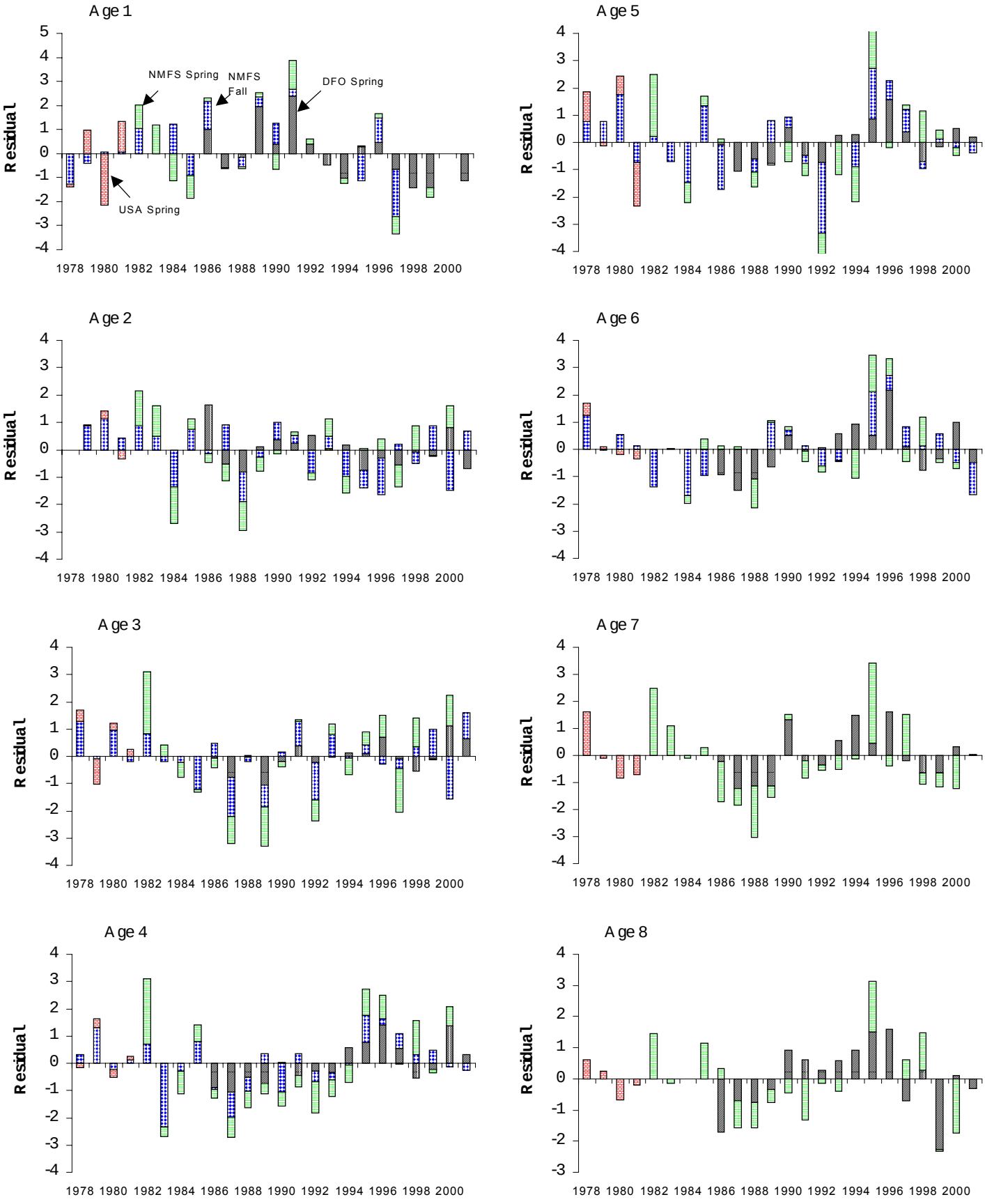


Figure 16. Standardized residuals at age from ADAPT for the DFO spring 1986-2001), NMFS fall (1977-2000), NMFS spring (1978-81,Yankee 41) and NMFS spring (1982-2000, Yankee 36) research indices.

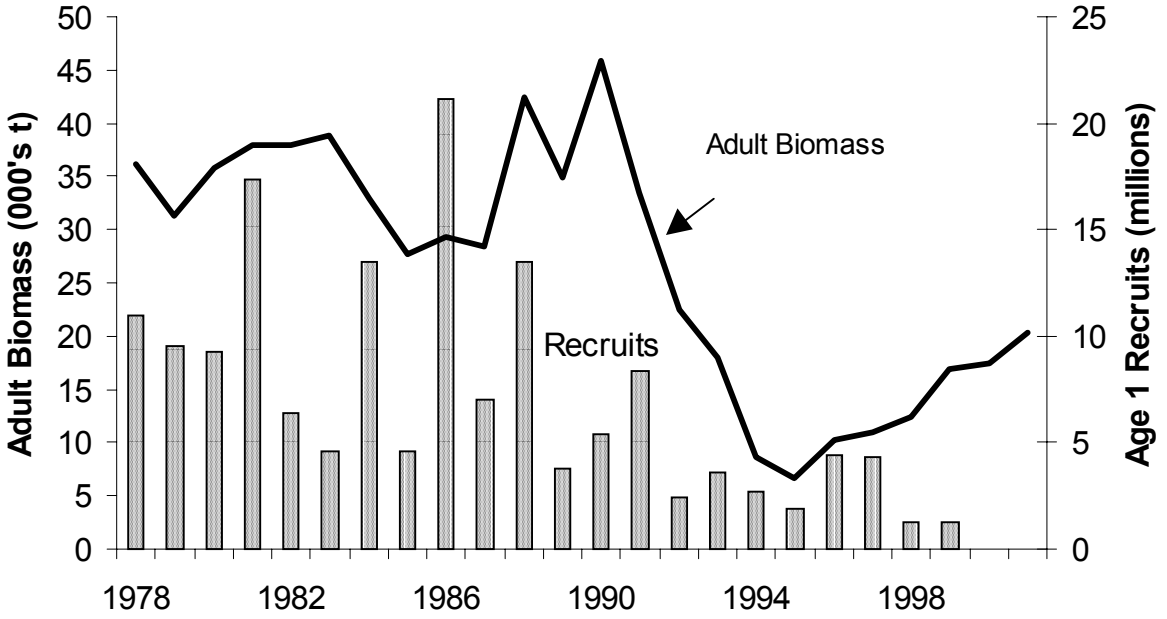


Figure17. Adult 3+ biomass and recruits at age one from ADAPT for 5Zj,m cod.

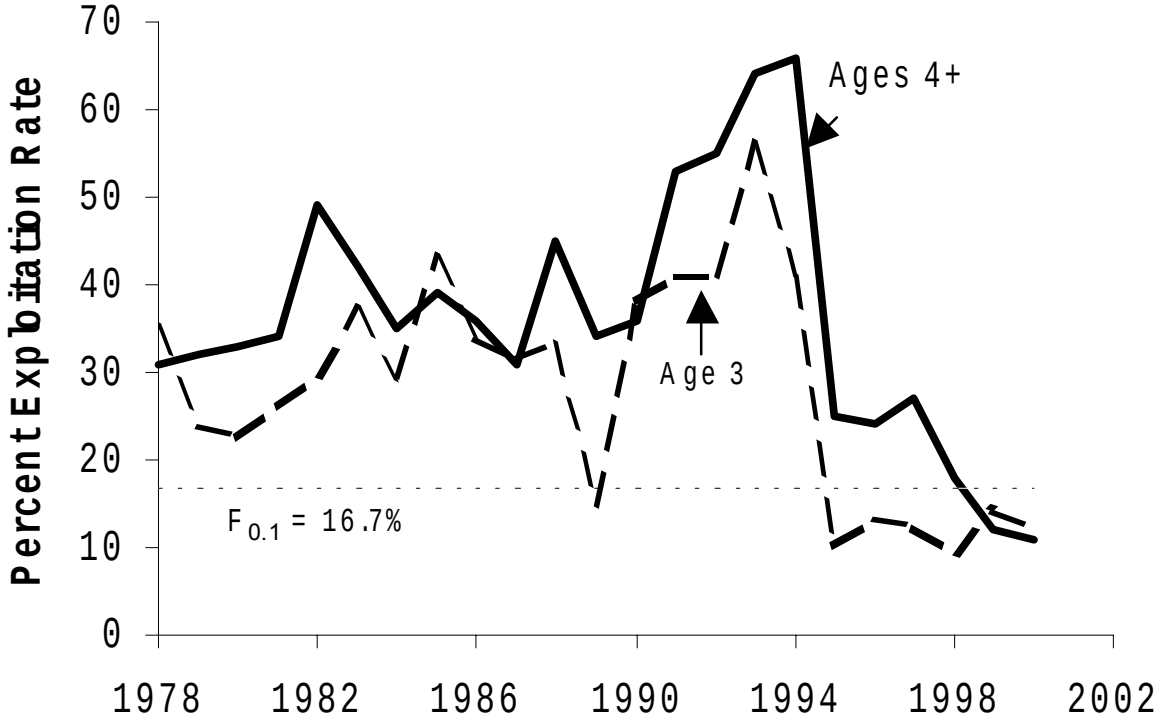


Figure 18. Percent exploitation rate at ages 4+ and age 3 for 5Zj,m cod derived from ADAPT

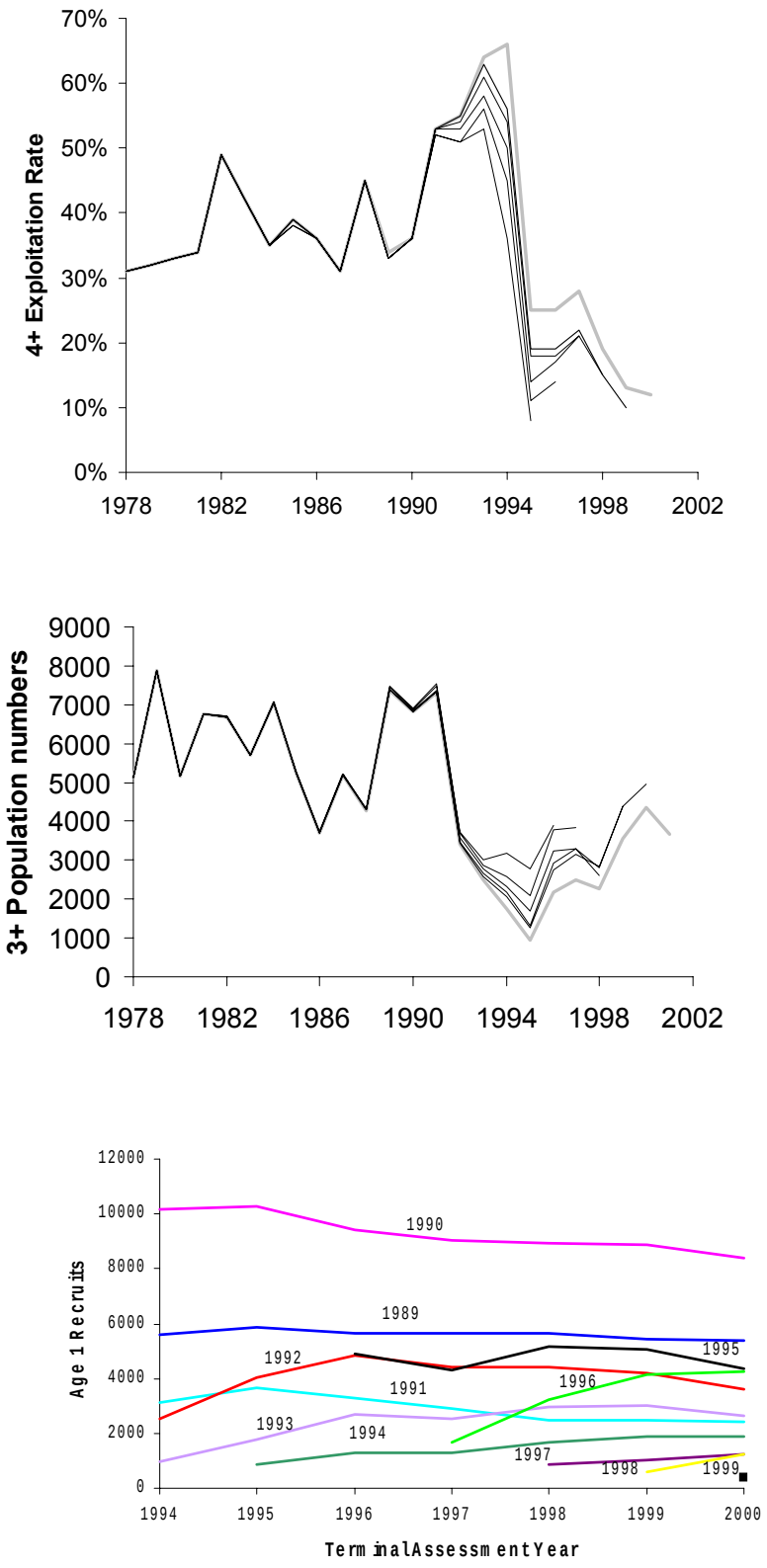


Figure 19. Retrospective pattern in fishing mortality (upper panel), population abundance (middle panel) and recruitment (lower panel) for 5Zj,m cod from ADAPT

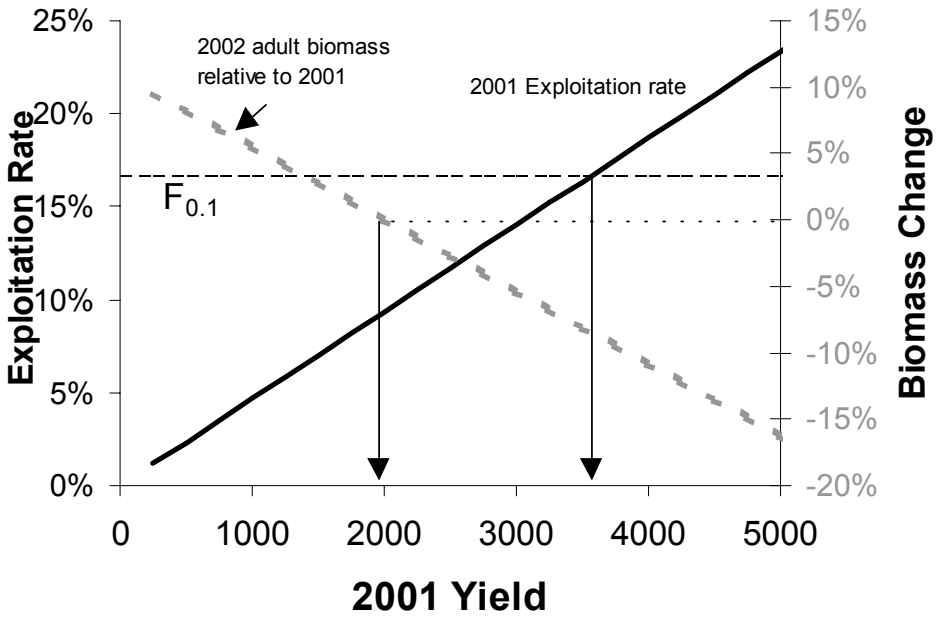


Figure 20. Projected exploitation rate and the 2002 beginning of year biomass at different levels of yield in 2001.

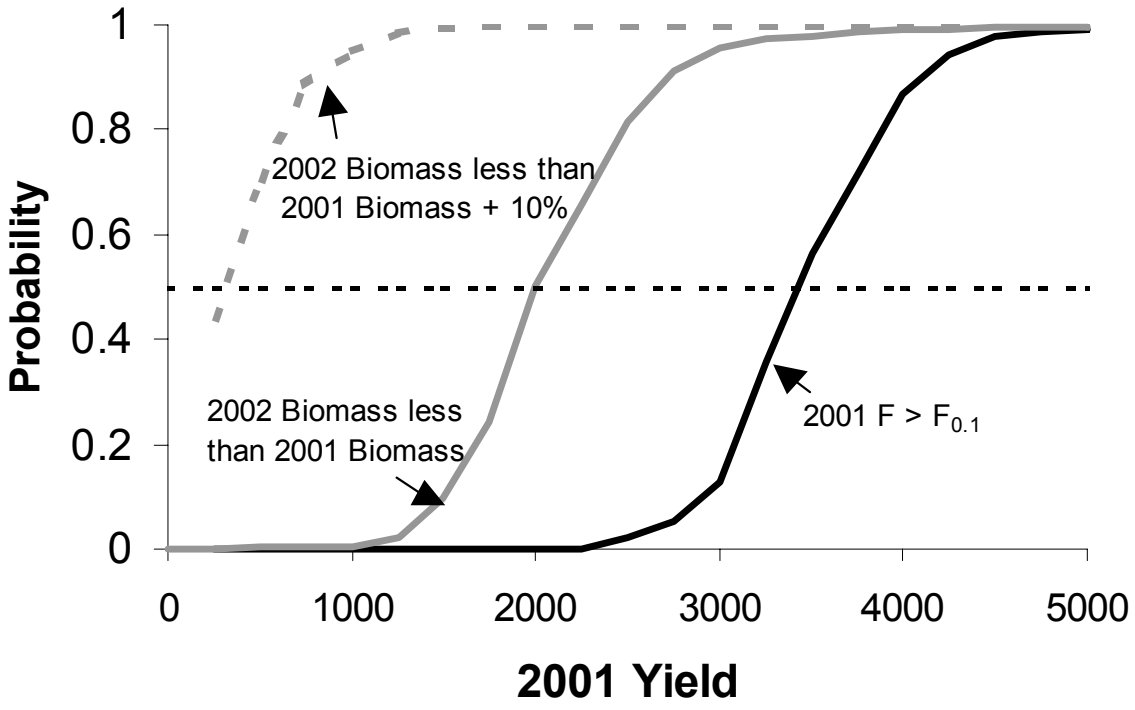


Figure 21. Probability of projected change in 5Zj,m cod spawning stock biomass from 2001 to 2002 at different yields in 2001.

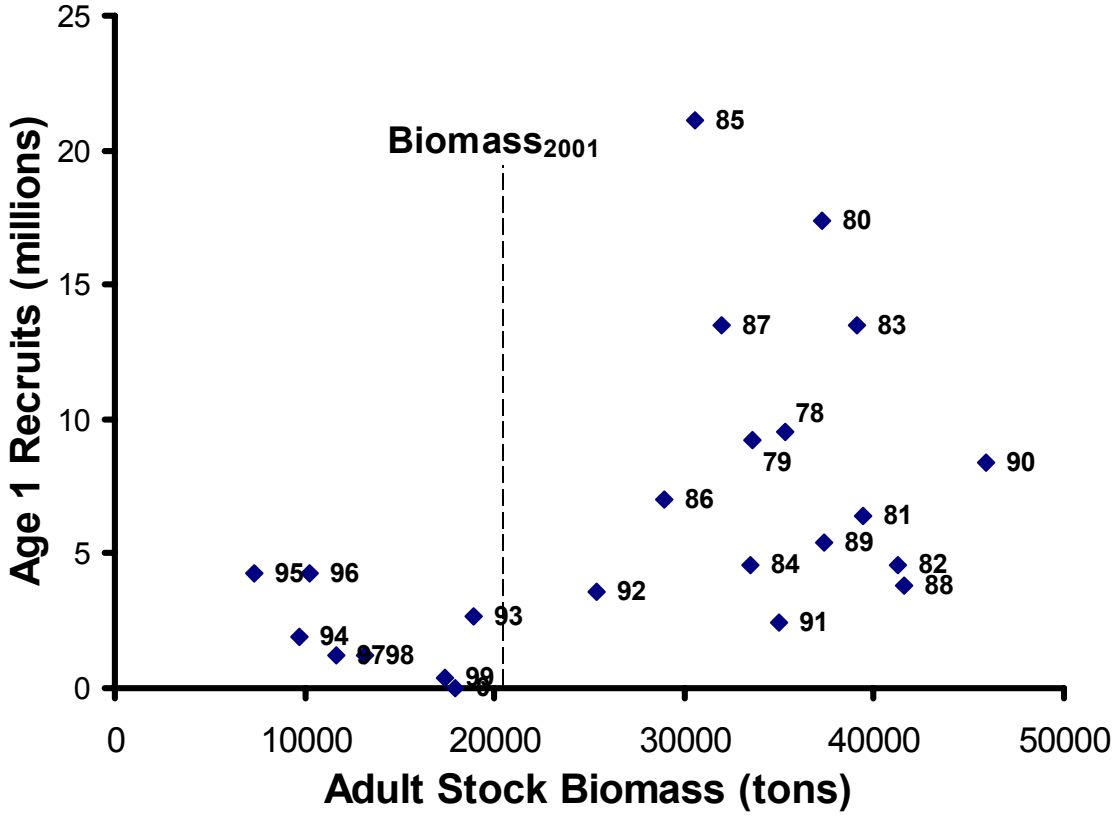


Figure 22. Comparison of recruits at age 1 and spawning stock biomass for 5Zj,m cod, 1978-2001.

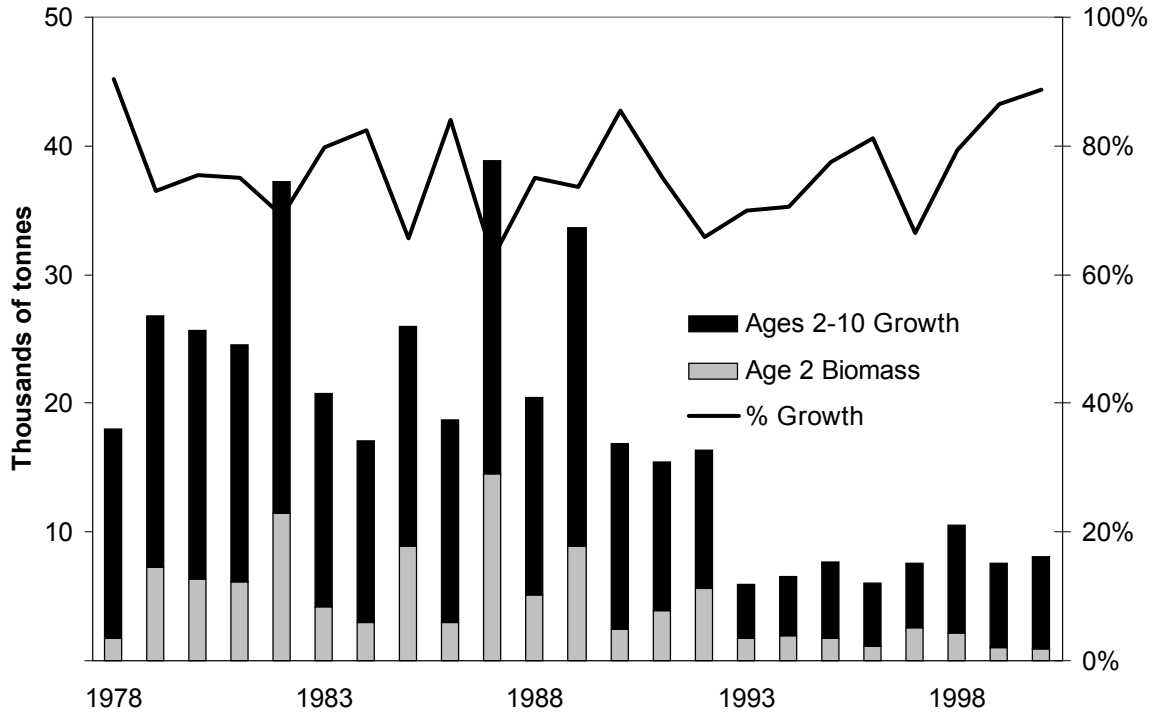


Figure 23. Comparison of stock production derived from growth and from recruitment for 5Zj,m cod, 1978-2001.