# Population Status of Eastern Georges Bank Cod
# (Unit Areas 5Zj,m) for 1978-99

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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 1978-98 and research survey indices. Results of the assessment provided statistically significant parameter estimates for the 1999 beginning-of-year population at ages 1 through 8. Bias and precision for the estimates were within acceptable limits. The adult biomass increased between 1995 and 1998 to about 19,200 t, primarily due to survival and growth of the 1992 and 1995 year-classes. Exploitation decreased from more than 60% in the early 1990's to slightly above the $F_{0.1}$ = 16% reference level in 1995 to 1997. It decreased further in 1998 to 15%, or slightly below the $F_{0.1}$ reference level. Recruitment in recent years has been poor, with the 1992 and 1995 year-classes being only moderately stronger than adjacent year-classes. The 1997 and 1998 year-classes appear to be very weak. Projections for 1999 indicate a yield of about 3,700 t at the $F_{0.1}$ reference level. However, the stock biomass in 2000 may decline at this level of yield. The stock biomass remains below a threshold of 25,000 t, above which chances of good recruitment are improved.

# RÉSUMÉ

Une évaluation analytique du stock de morue du banc Georges en 5Zj,m a été effectuée à l'aide de valeurs à jour des prises selon l'âge pour 1978-1998 et des indices des relevés de recherche. Les résultats de l'évaluation ont donné des estimations de paramètres statistiquement significatives pour la population des âges 1 à 8 en début d'année de 1999. Le biais et la précision des estimations demeuraient dans des limites acceptables. La biomasse des adultes a augmenté entre 1995 et 1998 pour atteindre 19 200 t environ, surtout à cause des taux de survie et de croissance des classes d'âge de 1992 et 1995. Le taux d'exploitation a diminué de plus de 60 % au début des années 1990 pour atteindre une valeur légèrement supérieure au niveau de référence $F_{0.1}$ = 16 % de 1995 à 1997. Il a ensuite diminué encore plus, à 15 %, en 1998, pour se situer légèrement en deçà du niveau de référence. Le recrutement des dernières années a été faible, les classes de 1992 et 1995 ne sont que légèrement supérieures aux classes voisines. Celles de 1997 et 1998 semblent très faibles. Des prévisions réalisées pour 1999 donnent un rendement de 3 700 t environ au niveau de référence $F_{0.1}$. La biomasse du stock en l'an 2000 pourrait cependant diminuer à un tel niveau de rendement. La biomasse demeure en deçà du seuil de 25 000 t qui correspond à une meilleure probabilité d'un bon recrutement.

# Introduction

This report incorporates commercial catch data and research survey results for the 1978-99 time period to estimate the stock status of cod in the two 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 Buzeta (1997) reported the status of the stock in 1997.

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 was reviewed by the Transboundary Resource Assessment Committee at a meeting held in St. Andrews, NB in April 1999. Proceedings of that meeting (CSAS, 1999) and the resulting Stock Status Report (DFO, 1999) 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 1998 Canadian Georges Bank cod fishery was limited to a Canadian allocation of 1,900 t and remained closed until June, 1998. The 1998 Canadian Management Plan allocations by fleet sector and reported landings (from Quota reports) are shown below:

| Fleet Sector | Allocation | Landings | Percent |
|---|---|---|---|
| Fixed <65' | 1187 | 1187 | 100 |
| Mobile <65' (ITQ) | 594 | 550 | 93 |
| Fixed 66 - 100' | 17 | 17 | 100 |
| Mobile 65 - 100' | 19 | 17 | 89 |
| Vessels >100' | 83 | 74 | 89 |
| **Total all sectors** | **1900** | **1845** | **97** |

Between 1978-98, USA landings reached 11,000 t in 1984, then were stable at about 6,000 t until 1993 when a closed area was implemented. Landings were 1229t in 1994, 665t in 1995, 773 t in 1996, 557t in 1997 and increased slightly to 795t in 1998. Almost 100 percent of USA catches in 5Zj,m are taken by otter trawl gear.

Combined USA and Canada landings for 1978-1998 are shown in Table 2 and Figure 3.

Samples of landings and catches (Commercial samples and Observer program) were used to estimate catch at length and age composition for the Canadian fishery. A summary of the number of length and age samples used to estimate catch-at-age is shown in Table 3. About 26,000 length observations and 1720 age determinations were available to construct the catch-at-age for 1998 (Table 4). The number of trips that included an Observer increased in 1998 and landings were regulated by 100% dockside monitoring. Regulations introduced in July, 1998 required that all vessels fishing in waters less than 90 fm have an Observer on board. Comparison of 1998

on-shore samples with Observer at-sea samples showed some evidence of smaller fish in the observed trips. Discarding was reported by some fishermen during pre-assessment meetings but the extent and quantity of discards are uncertain.

Precision estimates of age determinations by the Canadian age reader were completed and results were acceptable. Canadian intra-reader age comparisons were made with otoliths from the 1998 commercial fishery. Otolith exchanges, to estimate inter-reader precision between the Canadian and USA readers, were made using the 1998 Spring USA survey, and the 1998 Canadian Commercial fishery. Results for all comparisons are summarized in Table 5. There is a one year overall intra-reader negative bias in 1998. The apparent decreasing agreement and the onset of a bias noted in the last two years will be addressed at a Canada-USA Ageing Workshop, now scheduled for 1999.

Catch-at-age for the reported USA landings in 1994-98 was 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 weight are given in Table 7. Fishery weights were used for estimating catch at age. Calculations of the population biomass using weight-at-age have previously been made using a growth equation that backcalculates from the midyear (fishery) weights (Hunt and Buzeta, 1997). However, due to concerns that this method overestimates the biomass of partially recruited ages, this year's biomass calculations were made using weights-at-age obtained from Canadian spring survey data. 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.

In 1998, the 1992 year-class accounted for about 37% of the catch in numbers and the 1995 year-class for about 14% (Figure 4). Catch-at-length and age contributions for 1998 are shown in Figure 5. Comparisons between observed catch-at-age and projected catch-at-age from the 1998 assessment are shown in Figure 6, and indicate good agreement. The decline in survey weight-at-age between 1997 and 1998 was reversed in 1999 for some ages but the overall trend of lower weight at age remains (Figure 7).

## 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 strata area 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 Delaware II to 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), and preliminary work to evaluate conversion factors for trawl doors was completed in 1997. Results indicate that reported factors

may overestimate the impact of different trawl doors on survey catches, but further work is required to fully assess door conversion effects.

The USA spring survey has used two different bottom trawls over the 1978-98 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 1999 Canadian survey showed a slight increase following the decline observed in 1996 and 1997. Highest catch rates were in the Canadian zone with relatively small catches west of the International Boundary. The 1999 catch distribution pattern (shown as open boxes in Figure 8) was similar to the 1994-98 average (shown as density contours in Figure 8).

The Canadian survey was initiated in 1986, while the USA surveys started prior to 1978. Results of analysis for each of the surveys are given in Table 8 and Figure 9.

The USA 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 Canadian 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. The 1994 USA fall survey catch per tow has a slight increase from 1993, then remained at a low, stable level in 1995 –1997, and increased in 1998. The 1994 USA spring survey was the lowest observed, but increased in 1995 to the recent average level and remained stable until 1997. 1998 saw an increase. The three surveys for ages 3+ biomass, adjusted by the estimated catchability (Q's) at age from recent ADAPT (Gavaris, 1988) formulations and excluding the USA spring 1982 survey, are shown in Figure 9. In general, all three surveys appear to track year-class strength and provide a consistent index.

Estimates of recruitment at age one from the surveys are shown in Figure 9b as population numbers derived from catch per tow, adjusted by catchability factors. Both the 1995 USA fall and 1996 Canadian spring survey indicate an increase in recruitment for the 1995 year-class over the 1993-94 year-classes. However, 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 1996-1998 year-classes is the lowest in the series.

**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. Gear was standardized between vessels (number of hooks, hook size, bait, etc) to minimize between vessel variance and boxes were assigned to vessels to achieve a mix of high and low expected catch rates. The survey was repeated in 1996-1998 with a modification to the box design to include the 50 and 100 fm depth contour as a box boundary. A detailed description of methods, results and comparison of the annual results with Sequential Population Analysis (SPA) population estimates is reported by Johnston and Hunt (1999). This index will require

additional years of data and consistency in sampling protocol before trends or changes in stock abundance can be evaluated.

**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 1990-98 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 1990-98 time period is shown in Figure 10. Overall, the number of vessels declined between 1990 and 1995 with an increase in 1996. Most of this increase was due to the addition of about 20 tonnage class one longline vessels in 1996. The number of mobile and gillnet vessels remained stable from 1996 to 1998, while the number of longline vessels decreased. Landings per day fished declined for all three gear sectors, with the greatest decline by the gillnet fleet.

**Partial Recruitment to the Fishery**

Estimates of partial recruitment to the fishery by gear type for the period 1988-98 were derived from the unweighted fishing mortality and standardized to one within each year. Averages for the two periods 1988-94 and 1995-98, re-standardized to a maximum of one, are shown in Table 10 and summarised in Figure 11. Overall, partial recruitment at ages three and less has declined in the recent part of the time series, although selection by the longline gear appears to have increased. For the total fishery, full recruitment is now at age four.

# ESTIMATION OF STOCK PARAMETERS

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

$C_{a,y}$ = catch
a=1 to 8, y=1978 to 1998


$I_{1,a,y}$ = USA fall survey

a=0 to 5 y=1977 to 1998

$I_{2,a,y}$ = 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 1998

$I_{4,a,y}$ = Canadian spring survey
a=1 to 8, y=1986 to 1999

$\theta_{a,t'}$ = ln population abundance for ages $a$ = 1, 2, ... 8 at time $t'$ = 1999
$\kappa_{s,a}$ = 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 $N_{a,t}\left(\hat{\theta}\right)$ 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 trawls for cod are not available and further investigation of trawl 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. The fishing mortality rate on age 8 was calculated as the unweighed average for ages 5 to 7 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.

A model formulation using *ln* population abundance at the end of the terminal year (beginning of year y = t+1) as parameters was used. Natural log population abundance was used because this parameterization displayed a more "close to linear" behaviour, improving performance of the search algorithm. ADAPT was used to solve for the parameters using the techniques described by Gavaris (1988) and Hunt and Buzeta (1997).

## Assessment Results

Population estimates derived from the above ADAPT formulation are given in Table 11, and parameter estimates and bias adjustment are given in Table 12. Population parameter estimates have a relative error of 31% to 54% for ages 2 to 8, somewhat lower than those seen in the 1997 ADAPT-based analytical assessment. The estimate for the 1998 year-class (age 1 in 1999) is very low at 0.263 million, but also has a high coefficient of variation of 93%. In general, catchabilities for survey indices show a flat topped selection-at-ages 4 and older. Catchabilities were highest for the Canadian spring survey, followed by the USA spring survey and the USA fall survey.

There appear to be year effects in the residuals for survey indices. The 1982 USA spring survey has relatively large positive residuals, and negative residuals predominate in the last several years. The USA fall survey and the Canadian spring survey appear to overestimate population size (positive residuals) (Figure 12). 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 USA 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 biomass (ages 3+) between 1990 and 1994 was substantial, and the biomass was the lowest observed in 1994 at 8,700 t. However, biomass shows a gradual increase in 1995-99 to about 19,200 t but still well below the long term average of about 30,000 t (Figure 13).

In the past, exploitation patterns for this stock have been related to ages 3+, assuming full recruitment to the fishery for these ages. Examination of selection patterns for the recent 1985-98 time period now indicates full recruitment at ages 4+, which is consistent with changes to larger mesh size in the fishery (see Partial Recruitment section). Fishing mortality (Table 10) 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 are close to or below 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 1995 (Fig. 14).

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 and 1995 year-classes show some improvement to above the recent average recruitment, but

indications for the 1996 and subsequent year-classes show very poor recruitment prospects (Fig. 12 and Table 10).

## Retrospective Analysis

A retrospective analysis was completed in 1998. 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. However, in the 1998 analysis the reverse was evident for the 1991-94 year-classes with the terminal year having the highest estimate of abundance. Other year-classes did not show substantial evidence of a trend. The impact of shortening the Canadian spring survey index time series in this type of analysis may be the main contributing factor rather than a model bias in the ADAPT formulation.

## Yield Per Recruit Analysis

Due to the recent change in partial recruitment, a yield per recruit analysis was conducted 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, very close to the value of 0.2 used in previous assessments. Results are shown in Table 13. Therefore, no adjustment was made from $F_{0.1} = 0.2$ for yield projections.

## Prognosis

Catch projections were completed using the bias-adjusted beginning of year population abundance for 1999 derived from ADAPT. Partial recruitment was derived from the 1995-98 fishing mortality matrix (Table 11), to reflect possible changes in PR associated with both gear and season. Mean (1995-98 fishery) and beginning of year (1996-99) weights-at-age were used to reflect the recent trend in weight at age. Recruitment for 1999 age one was set to 0.147 million, the bias adjusted value from ADAPT, and to 2.0 million, about half the recent average recruitment, for 2000. Input for the catch projection is shown in Table 14.

The **combined** Canada and USA $F_{0.1}$ catch in 1999 is estimated to be about 3,700 t and details of the projection are given in Table 15. There is about a 20% relative error associated with the projected catch. Fishing at the $F_{0.1}$ reference level in 1999 is projected to result in a decrease in adult stock biomass from 19,200t in 1999 to about 18,600 t in 2000. The 1995 year-class-at-age 4 is expected to account for about 40% of the catch numbers and about 22% of the catch biomass in 1999. Yield and biomass projections at a range of exploitation rates are shown in Figure 15. Only a small increase above the $F_{0.1}$ reference yield will result in a further biomass decrease in 2000, and even with zero yield in 1999 the 2000 biomass would increase by only 3,000 t. Given the very low spawning stock biomass in 1999 (19,200 t compared to the longterm average of 30,000 t) and low levels of recruitment since 1990, a stock rebuilding strategy should be considered.

**Uncertainty** associated with the yield projection indicates that even at $F_{0.1}$, there is almost a 50% probability that the adult biomass will decrease in 2000. A yield of about 2,700t, the 1998 catch, in 1999 reduces this probability to about 20%. Yields of less than 1,500t would provide a probability of 50% or higher that the adult biomass would

increase in 2000. It is also important to note that even small increases in the 1999 yield above the $F_{0.1}$ level substantially increased the chances that biomass in 2000 will decline. Results are shown in Figure 16.

Adult biomass levels and subsequent **recruitment** abundance-at-age 1 is compared in Figure 17 for the 1978-99 time period. Recruits appear to have a positive correlation with biomass and the probability of good recruitment increases at higher biomass levels. The projected 1999 adult biomass of 19,000 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 1999 level would enhance the prospects for the furture.

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). Surplus production is defined as the gains in fishable biomass which are in excess of the needs to offset losses from natural mortality. When the fishery yield is less than the surplus production, there is a net increase in the population biomass. Over the long term, about 60-90% of the total **stock production** (Figure 18) 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. **Surplus production**, or the amount exceeding that required to maintain biomass, has declined since the late 1980's (Figure 19). Catches in the early to mid 1990's exceeded the surplus production and in recent years have been close to it.

# Acknowledgements

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Table 1. Nominal landings(t) of cod by gear and month for Canada in unit areas 5Zj,m.(OT-ottertrawl; LL-longline; GN-gillnet; MISC-miscellaneous. TOT - total).

| YEAR | GEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOT |
|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1978 | OT | 166 | 762 | 187 | 26 | 304 | 1808 | 1095 | 75 | 219 | 1633 | 1487 | 0 | 7762 |
|  | LL | 0 | 0 | 0 | 0 | 10 | 308 | 241 | 77 | 74 | 19 | 0 | 0 | 729 |
|  | MISC | 0 | 0 | 55 | 1 | 0 | 17 | 102 | 0 | 0 | 14 | 98 | 0 | 287 |
|  | TOT | 166 | 762 | 242 | 27 | 314 | 2133 | 1438 | 152 | 293 | 1666 | 1585 | 0 | **8778** |
| 1979 | OT | 72 | 302 | 178 | 78 | 74 | 1634 | 649 | 674 | 648 | 293 | 28 | 7 | 4637 |
|  | LL | 0 | 0 | 0 | 5 | 20 | 529 | 334 | 306 | 134 | 10 | 0 | 0 | 1338 |
|  | MISC | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
|  | TOT | 72 | 302 | 179 | 84 | 95 | 2163 | 983 | 980 | 782 | 303 | 28 | 7 | **5978** |
| 1980 | OT | 24 | 86 | 3 | 52 | 111 | 1373 | 1593 | 771 | 633 | 591 | 68 | 100 | 5405 |
|  | LL | 0 | 0 | 0 | 0 | 208 | 951 | 596 | 496 | 337 | 47 | 0 | 0 | 2635 |
|  | MISC | 0 | 0 | 1 | 2 | 1 | 2 | 1 | 16 | 0 | 0 | 0 | 0 | 23 |
|  | TOT | 24 | 86 | 4 | 54 | 320 | 2326 | 2190 | 1283 | 970 | 638 | 68 | 100 | **8063** |
| 1981 | OT | 2 | 205 | 55 | 7 | 38 | 529 | 1005 | 744 | 1013 | 36 | 229 | 97 | 3960 |
|  | LL | 0 | 0 | 1 | 2 | 538 | 1476 | 1044 | 837 | 284 | 281 | 57 | 5 | 4525 |
|  | MISC | 0 | 0 | 0 | 1 | 0 | 12 | 0 | 0 | 1 | 0 | 0 | 0 | 14 |
|  | TOT | 2 | 205 | 56 | 10 | 576 | 2017 | 2049 | 1581 | 1298 | 317 | 286 | 102 | **8499** |
| 1982 | OT | 90 | 73 | 0 | 0 | 11 | 845 | 4289 | 2109 | 1507 | 2360 | 934 | 119 | 12337 |
|  | LL | 0 | 11 | 26 | 193 | 772 | 1035 | 1388 | 1082 | 635 | 308 | 33 | 4 | 5487 |
|  | MISC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | TOT | 90 | 84 | 26 | 193 | 783 | 1880 | 5677 | 3191 | 2142 | 2668 | 967 | 123 | **17824** |
| 1983 | OT | 179 | 41 | 9 | 6 | 35 | 2209 | 1095 | 2115 | 956 | 171 | 76 | 11 | 6903 |
|  | GN | 0 | 0 | 0 | 0 | 0 | 4 | 8 | 3 | 5 | 0 | 0 | 0 | 20 |
|  | LL | 0 | 0 | 171 | 147 | 440 | 1440 | 698 | 574 | 1303 | 311 | 89 | 0 | 5173 |
|  | MISC | 0 | 0 | 0 | 0 | 0 | 5 | 28 | 0 | 0 | 1 | 0 | 0 | 34 |
|  | TOT | 179 | 41 | 180 | 153 | 475 | 3658 | 1829 | 2692 | 2264 | 483 | 165 | 11 | **12130** |
| 1984 | OT | 5 | 3 | 13 | 0 | 37 | 267 | 92 | 240 | 60 | 19 | 0 | 0 | 736 |
|  | GN | 0 | 0 | 0 | 0 | 0 | 34 | 3 | 0 | 0 | 0 | 0 | 0 | 37 |
|  | LL | 0 | 0 | 167 | 152 | 112 | 1193 | 1209 | 1183 | 605 | 286 | 50 | 0 | 4957 |
|  | MISC | 0 | 0 | 0 | 1 | 3 | 21 | 7 | 1 | 0 | 0 | 0 | 0 | 33 |
|  | TOT | 5 | 3 | 180 | 153 | 152 | 1515 | 1311 | 1424 | 665 | 305 | 50 | 0 | **5763** |
| 1985 | OT | 0 | 2 | 0 | 0 | 0 | 1336 | 2565 | 2440 | 693 | 435 | 5 | 80 | 7556 |
|  | GN | 0 | 0 | 0 | 0 | 0 | 14 | 4 | 9 | 0 | 0 | 0 | 0 | 27 |
|  | LL | 0 | 29 | 54 | 181 | 151 | 414 | 230 | 540 | 647 | 501 | 29 | 29 | 2805 |
|  | MISC | 0 | 1 | 2 | 14 | 15 | 6 | 9 | 2 | 3 | 2 | 0 | 1 | 55 |
|  | TOT | 0 | 32 | 56 | 195 | 166 | 1770 | 2808 | 2991 | 1343 | 938 | 34 | 110 | **10443** |
| 1986 | OT | 14 | 9 | 0 | 15 | 6 | 2364 | 3138 | 477 | 49 | 11 | 4 | 22 | 6109 |
|  | GN | 0 | 0 | 0 | 0 | 0 | 44 | 82 | 75 | 29 | 0 | 0 | 0 | 230 |
|  | LL | 0 | 58 | 86 | 12 | 24 | 146 | 120 | 538 | 606 | 409 | 12 | 0 | 2011 |
|  | MISC | 0 | 2 | 9 | 15 | 10 | 3 | 7 | 1 | 14 | 0 | 0 | 0 | 61 |
|  | TOT | 14 | 69 | 95 | 42 | 40 | 2557 | 3347 | 1091 | 698 | 420 | 16 | 22 | **8411** |
| 1987 | OT | 19 | 1 | 3 | 0 | 0 | 2485 | 3941 | 890 | 145 | 2 | 78 | 44 | 7608 |
|  | GN | 0 | 0 | 0 | 0 | 0 | 109 | 249 | 308 | 38 | 0 | 0 | 0 | 704 |
|  | LL | 0 | 6 | 112 | 68 | 8 | 293 | 591 | 1032 | 747 | 310 | 12 | 33 | 3212 |
|  | MISC | 5 | 11 | 15 | 17 | 9 | 33 | 88 | 82 | 51 | 2 | 6 | 2 | 321 |
|  | TOT | 24 | 18 | 130 | 85 | 17 | 2920 | 4869 | 2312 | 981 | 314 | 96 | 79 | **11845** |
| 1988 | OT | 23 | 520 | 56 | 0 | 13 | 3247 | 3181 | 428 | 17 | 98 | 29 | 8 | 7620 |
|  | GN | 0 | 0 | 0 | 0 | 0 | 180 | 224 | 141 | 50 | 21 | 0 | 0 | 616 |
|  | LL | 54 | 86 | 68 | 205 | 27 | 1247 | 1685 | 392 | 426 | 134 | 10 | 1 | 4335 |
|  | MISC | 2 | 9 | 12 | 10 | 16 | 41 | 95 | 97 | 53 | 0 | 20 | 2 | 357 |
|  | TOT | 79 | 615 | 136 | 215 | 56 | 4715 | 5185 | 1058 | 546 | 253 | 59 | 11 | **12928** |
| 1989 | OT | 5 | 140 | 7 | 0 | 2 | 1553 | 86 | 70 | 2 | 87 | 33 | 2 | 1987 |
|  | GN | 0 | 0 | 0 | 0 | 0 | 131 | 359 | 440 | 175 | 9 | 0 | 0 | 1114 |
|  | LL | 41 | 202 | 250 | 92 | 268 | 909 | 1057 | 1210 | 331 | 65 | 0 | 0 | 4425 |
|  | MISC | 7 | 7 | 9 | 22 | 47 | 126 | 85 | 151 | 15 | 3 | 3 | 0 | 475 |
|  | TOT | 53 | 349 | 266 | 114 | 317 | 2719 | 1587 | 1871 | 523 | 164 | 36 | 2 | **8001** |

Table .1 Continued

| YEAR | GEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOT |
|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1990 | OT | 0 | 0 | 0 | 0 | 1 | 3187 | 1744 | 1547 | 929 | 436 | 9 | 1 | 7854 |
| | GN | 0 | 0 | 0 | 0 | 0 | 114 | 344 | 309 | 143 | 0 | 0 | 0 | 910 |
| | LL | 125 | 149 | 260 | 0 | 129 | 1156 | 1448 | 1098 | 581 | 252 | 4 | 0 | 5202 |
| | MISC | 6 | 12 | 19 | 19 | 10 | 62 | 77 | 58 | 63 | 5 | 11 | 2 | 344 |
| | TOT | 131 | 161 | 279 | 19 | 140 | 4519 | 3613 | 3012 | 1716 | 693 | 24 | 3 | **14310** |
| 1991 | OT | 348 | 33 | 22 | 1 | 0 | 3455 | 1536 | 672 | 316 | 296 | 14 | 6 | 6698 |
| | GN | 0 | 0 | 0 | 0 | 17 | 427 | 696 | 364 | 163 | 20 | 0 | 0 | 1688 |
| | LL | 49 | 335 | 187 | 230 | 202 | 597 | 1028 | 860 | 699 | 363 | 113 | 43 | 4706 |
| | MISC | 8 | 8 | 7 | 25 | 15 | 59 | 71 | 104 | 51 | 6 | 9 | 0 | 363 |
| | TOT | 405 | 376 | 216 | 256 | 234 | 4538 | 3331 | 2000 | 1229 | 685 | 136 | 49 | **13455** |
| 1992 | OT | 261 | 375 | 0 | 1 | 12 | 2835 | 972 | 287 | 214 | 541 | 132 | 9 | 5638 |
| | GN | 0 | 0 | 0 | 0 | 1 | 294 | 350 | 342 | 203 | 26 | 2 | 0 | 1217 |
| | LL | 114 | 340 | 475 | 275 | 237 | 799 | 676 | 612 | 509 | 337 | 101 | 0 | 4474 |
| | MISC | 9 | 13 | 19 | 21 | 24 | 141 | 75 | 47 | 0 | 4 | 8 | 1 | 383 |
| | TOT | 384 | 726 | 494 | 296 | 274 | 4068 | 2073 | 1287 | 945 | 909 | 243 | 10 | **11712** |
| 1993 | OT | 826 | 998 | 77 | 380 | 0 | 1203 | 590 | 162 | 123 | 237 | 178 | 114 | 4890 |
| | GN | 0 | 0 | 0 | 0 | 0 | 287 | 367 | 261 | 212 | 48 | 0 | 0 | 1175 |
| | LL | 4 | 30 | 166 | 76 | 148 | 422 | 515 | 462 | 261 | 122 | 118 | 63 | 2387 |
| | MISC | 9 | 4 | 10 | 14 | 17 | 4 | 5 | 1 | 0 | 1 | 2 | 0 | 67 |
| | TOT | 839 | 1032 | 253 | 470 | 165 | 1916 | 1477 | 886 | 596 | 408 | 298 | 177 | **8519** |
| 1994 | OT | 0 | 0 | 0 | 0 | 0 | 777 | 410 | 115 | 128 | 263 | 117 | 83 | 1893 |
| | GN | 0 | 0 | 0 | 0 | 0 | 133 | 539 | 243 | 97 | 19 | 0 | 0 | 1031 |
| | LL | 0 | 0 | 0 | 0 | 0 | 409 | 481 | 869 | 492 | 5 | 30 | 0 | 2287 |
| | MISC | 7 | 7 | 10 | 14 | 9 | 6 | 4 | 2 | 0 | 1 | 3 | 1 | 66 |
| | TOT | 7 | 7 | 10 | 14 | 9 | 1327 | 1434 | 1229 | 717 | 288 | 150 | 84 | **5276** |
| 1995 | OT | 0 | 0 | 0 | 0 | 0 | 100 | 62 | 57 | 82 | 25 | 41 | 27 | 395 |
| | GN | 0 | 0 | 0 | 0 | 0 | 17 | 39 | 0 | 70 | 0 | 0 | 0 | 126 |
| | LL | 0 | 0 | 0 | 0 | 0 | 116 | 161 | 122 | 98 | 20 | 20 | 7 | 544 |
| | MISC | 1 | 4 | 4 | 5 | 4 | 5 | 8 | 3 | 1 | 0 | 0 | 0 | 35 |
| | TOT | 1 | 4 | 4 | 5 | 4 | 238 | 271 | 182 | 251 | 45 | 61 | 34 | **1100** |
| 1996 | OT | 0 | 0 | 0 | 0 | 0 | 217 | 96 | 100 | 58 | 42 | 40 | 103 | 656 |
| | GN | 0 | 0 | 0 | 0 | 0 | 26 | 137 | 81 | 0 | 0 | 0 | 0 | 245 |
| | LL | 0 | 0 | 0 | 0 | 0 | 29 | 381 | 269 | 81 | 137 | 65 | 21 | 984 |
| | MISC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | TOT | 0 | 0 | 0 | 0 | 0 | 272 | 614 | 450 | 139 | 179 | 105 | 124 | **1885** |
| 1997 | OT | 0 | 0 | 0 | 0 | 0 | 360 | 166 | 210 | 135 | 56 | 52 | 53 | 1032 |
| | GN | 0 | 0 | 0 | 0 | 0 | 133 | 133 | 107 | 50 | 47 | 0 | 0 | 470 |
| | LL | 0 | 0 | 0 | 0 | 0 | 176 | 432 | 383 | 236 | 132 | 15 | 21 | 1395 |
| | MISC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | TOT | 0 | 0 | 0 | 0 | 0 | 670 | 731 | 700 | 421 | 235 | 67 | 74 | **2898** |
| 1998 | OT | 0 | 0 | 0 | 0 | 0 | 173 | 70 | 138 | 95 | 99 | 39 | 27 | 641 |
| | GN | 0 | 0 | 0 | 0 | 0 | 76 | 90 | 63 | 25 | 46 | 0 | 0 | 300 |
| | LL | 0 | 0 | 0 | 0 | 0 | 74 | 331 | 221 | 177 | 86 | 21 | 18 | 928 |
| | MISC | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| | TOT | 0 | 0 | 0 | 0 | 0 | 328 | 491 | 422 | 297 | 231 | 60 | 45 | **1874** |

Table 2.Summary of total catches (t) by Canada and the USA in unit
areas 5Zj,m for 1978-1998.

```
YEAR    CANADA      USA      TOTAL

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     8411      5696      14107
1987    11845      4792      16637
1988    12932      7645      20577
1989     8001      6182      14183
1990    14310      6378      20688
1991    13455      6777      20232
1992    11712      5080      16792
1993     8519      4019      12538
1994     5277      1229       6505
1995     1100       665       1765
1996     1885       773       2658
1997     2898       557       3455
1998     1874       795       2669
```

Table 3. Canadian and USA 5Zj,m commercial landings samples for 1978-98.
Since 1994, Canadian lengths include at-sea observer samples.

| | 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 |

Table 4. Summary of 1998 Canadian commercial and IOP samples used to estimate catch-at-age. USA catch-at-age for 1994-98. 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 | 178 | 2607 | 366 | 178 |
| | Jul | 70 | 6653 | 242 | |
| | Aug | 138 | 2116 | 185 | |
| | Sep | 95 | 1546 | 116 | 303 |
| | Oct | 99 | 1803 | 114 | |
| | Nov | 39 | 964 | 40 | |
| | Dec | 27 | 458 | 37 | 164 |
| Total Canadian | | 645 | 16147 | 1100 | |
| Total USA | | 795 | | | |
| Total | | 1440 | | | |
| **Longline** | Jan | | | | |
| | Feb | | | | |
| | Mar | | | | 0 |
| | Apr | | | | |
| | May | | | | |
| | Jun | 74 | 620 | 54 | 74 |
| | Jul | 331 | 3391 | 222 | |
| | Aug | 221 | 185 | 51 | |
| | Sep | 177 | 7863 | 56 | 729 |
| | Oct | 86 | 1999 | 69 | |
| | Nov | 21 | | | |
| | Dec | 18 | | | 125 |
| Total | | 928 | 14058 | 452 | |
| **Gillnet** | Jan | | | | |
| | Feb | | | | |
| | Mar | | | | 0 |
| | Apr | | | | |
| | May | | | | |
| | Jun | 76 | 370 | 79 | 76 |
| | Jul | 90 | 408 | 37 | |
| | Aug | 63 | 485 | 41 | |
| | Sep | 25 | 1994 | | 178 |
| | Oct | 46 | 255 | | |
| | Nov | | | | |
| | Dec | | | | 46 |
| Total | | 300 | 3512 | 157 | |
| **Age Keys** | Q1 | | 0 | 0 | |
| | Q2 | | 3597 | 499 | 328 |
| | Q3 | | 24641 | 950 | 1210 |
| | Q4 | | 5479 | 260 | 335 |
| | Mod | | | 11 | |
| **TOTAL CANADIAN** | | 1874 | 33717 | 1720 | 1874 |
| **TOTAL Canada + USA** | | 2669 | 33717 | 1720 | |

Table 5. Age determination for 1998  a) precision estimates for Canadian age reader and b) age comparisons between Canada and USA age readers.

a). Canadian age reader

| 1st Age | 2nd Age | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | |
| 2 | 38 | 6 | | | | | | | | | 44 |
| 3 | 1 | 118 | 7 | | 1 | | | | | | 127 |
| 4 | | 7 | 61 | 10 | | | | | | | 78 |
| 5 | | 1 | 10 | 83 | 17 | | | | | | 111 |
| 6 | | | 2 | 9 | 126 | 6 | | 1 | | | 144 |
| 7 | | | | 1 | 4 | 15 | 6 | | | | 26 |
| 8 | | | | | 1 | | 16 | 2 | 1 | 1 | 21 |
| 9 | | | | | | 1 | | 1 | 1 | | 3 |
| 10 | | | | | | | | 1 | | | 1 |
| Total | 39 | 132 | 80 | 103 | 149 | 22 | 22 | 5 | 2 | 1 | 555 |
| Percent Agreement | | | | | | | | | | | 82% |
| Coefficient of Variation | | | | | | | | | | | 2.88 |

b) Canadian versus USA age

| Canadian | USA | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| 2 | 5 | | | | | | | 5 |
| 3 | 2 | 12 | | | | | | 14 |
| 4 | | 1 | 6 | | | | | 7 |
| 5 | | | 4 | 7 | 1 | | | 12 |
| 6 | | | | 1 | 11 | | | 12 |
| 7 | | | | | | 1 | | 1 |
| 8 | | | | | | | 1 | 1 |
| Total | 7 | 13 | 10 | 8 | 12 | 1 | 1 | 52 |
| Percent Agreement | | | | | | | | 83% |
| Coefficient of Variation | | | | | | | | 3.18 |

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

Age

**Numbers**

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | total |
|------|---|---|---|---|---|---|---|---|-------|
| 78 | 2 | 121 | 3588 | 1076 | 307 | 110 | 83 | 21 | 5308 |
| 79 | 10 | 814 | 399 | 1774 | 545 | 149 | 22 | 45 | 3758 |
| 80 | 1 | 987 | 1495 | 265 | 916 | 345 | 109 | 20 | 4138 |
| 81 | 19 | 603 | 1443 | 1249 | 155 | 595 | 169 | 65 | 4298 |
| 82 | 6 | 2682 | 1686 | 1429 | 1066 | 189 | 345 | 157 | 7560 |
| 83 | 40 | 1319 | 3416 | 1474 | 466 | 283 | 31 | 71 | 7100 |
| 84 | 10 | 269 | 911 | 1346 | 511 | 290 | 230 | 31 | 3598 |
| 85 | 12 | 2792 | 1221 | 631 | 941 | 224 | 96 | 100 | 6017 |
| 86 | 28 | 326 | 2188 | 513 | 304 | 400 | 58 | 39 | 3856 |
| 87 | 14 | 3666 | 865 | 1099 | 144 | 121 | 167 | 37 | 6113 |
| 88 | 10 | 320 | 3653 | 646 | 861 | 144 | 102 | 143 | 5879 |
| 89 | 1 | 740 | 652 | 1837 | 193 | 314 | 56 | 25 | 3818 |
| 90 | 7 | 678 | 3196 | 962 | 1195 | 116 | 122 | 10 | 6286 |
| 91 | 11 | 626 | 783 | 1939 | 953 | 790 | 93 | 56 | 5251 |
| 92 | 86 | 2358 | 1251 | 432 | 908 | 250 | 233 | 25 | 5543 |
| 93 | 4 | 414 | 1967 | 809 | 215 | 332 | 110 | 93 | 3944 |
| 94 | 2 | 182 | 486 | 751 | 246 | 41 | 59 | 26 | 1799 |
| 95 | 0 | 56 | 235 | 120 | 89 | 14 | 4 | 3 | 522 |
| 96 | 1 | 39 | 231 | 386 | 75 | 47 | 11 | 3 | 792 |
| 97 | 3 | 107 | 155 | 287 | 291 | 70 | 32 | 10 | 955 |
| 98 | - | 57 | 196 | 94 | 88 | 73 | 14 | 8 | 534 |

Age

**Percent**

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|------|---|---|---|---|---|---|---|---|
| 78 | 0.0 | 2.3 | 67.6 | 20.3 | 5.8 | 2.1 | 1.6 | 0.4 |
| 79 | 0.3 | 21.7 | 10.6 | 47.2 | 14.5 | 4.0 | 0.6 | 1.2 |
| 80 | 0.0 | 23.9 | 36.1 | 6.4 | 22.1 | 8.3 | 2.6 | 0.5 |
| 81 | 0.4 | 14.0 | 33.6 | 29.1 | 3.6 | 13.8 | 3.9 | 1.5 |
| 82 | 0.1 | 35.5 | 22.3 | 18.9 | 14.1 | 2.5 | 4.6 | 2.1 |
| 83 | 0.6 | 18.6 | 48.1 | 20.8 | 6.6 | 4.0 | 0.4 | 1.0 |
| 84 | 0.3 | 7.5 | 25.3 | 37.4 | 14.2 | 8.1 | 6.4 | 0.9 |
| 85 | 0.2 | 46.4 | 20.3 | 10.5 | 15.6 | 3.7 | 1.6 | 1.7 |
| 86 | 0.7 | 8.5 | 56.7 | 13.3 | 7.9 | 10.4 | 1.5 | 1.0 |
| 87 | 0.2 | 60.0 | 14.2 | 18.0 | 2.4 | 2.0 | 2.7 | 0.6 |
| 88 | 0.2 | 5.4 | 62.1 | 11.0 | 14.6 | 2.4 | 1.7 | 2.4 |
| 89 | 0.0 | 19.4 | 17.1 | 48.1 | 5.1 | 8.2 | 1.5 | 0.7 |
| 90 | 0.1 | 10.8 | 50.8 | 15.3 | 19.0 | 1.8 | 1.9 | 0.2 |
| 91 | 0.2 | 11.9 | 14.9 | 36.9 | 18.1 | 15.0 | 1.8 | 1.1 |
| 92 | 1.6 | 42.5 | 22.6 | 7.8 | 16.4 | 4.5 | 4.2 | 0.5 |
| 93 | 0.1 | 10.5 | 49.9 | 20.5 | 5.5 | 8.4 | 2.8 | 2.4 |
| 94 | 0.1 | 10.1 | 27.1 | 41.9 | 13.7 | 2.3 | 3.3 | 1.4 |
| 95 | 0.0 | 10.7 | 45.1 | 23.0 | 17.1 | 2.8 | 0.8 | 0.6 |
| 96 | 0.1 | 4.9 | 29.2 | 48.7 | 9.5 | 5.9 | 1.4 | 0.3 |
| 97 | 0.3 | 11.2 | 16.3 | 30.0 | 30.5 | 7.4 | 3.4 | 1.0 |
| 98 | 0.0 | 10.7 | 36.7 | 17.6 | 16.5 | 13.7 | 2.6 | 1.5 |

Table 7. Weight-at-age (kg) derived from fishery (mid-year) and from 1987-99 Canadian surveys (beginning of year)

Average Midyear (fishery) Weights

| | Age | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1978 | 0.71 | 1.31 | 2.46 | 3.47 | 4.34 | 5.79 | 7.37 | 8.49 |
| 1979 | 0.89 | 1.49 | 2.15 | 4.21 | 4.89 | 7.18 | 9.18 | 10.31 |
| 1980 | 0.84 | 1.46 | 2.47 | 3.67 | 5.65 | 6.68 | 8.39 | 9.09 |
| 1981 | 0.88 | 1.50 | 2.36 | 3.42 | 5.21 | 7.22 | 8.57 | 9.89 |
| 1982 | 0.77 | 1.40 | 2.66 | 3.83 | 5.35 | 6.51 | 9.36 | 9.90 |
| 1983 | 0.97 | 1.49 | 2.38 | 3.31 | 4.64 | 6.39 | 7.96 | 10.29 |
| 1984 | 1.05 | 1.64 | 2.45 | 3.62 | 5.08 | 6.58 | 8.91 | 10.10 |
| 1985 | 0.91 | 1.42 | 2.09 | 3.89 | 5.09 | 6.41 | 8.10 | 10.24 |
| 1986 | 0.93 | 1.48 | 2.45 | 3.66 | 5.60 | 7.19 | 8.92 | 9.96 |
| 1987 | 0.73 | 1.48 | 2.50 | 4.19 | 5.81 | 7.73 | 8.95 | 10.01 |
| 1988 | 0.79 | 1.52 | 2.36 | 3.51 | 5.40 | 6.65 | 8.78 | 9.99 |
| 1989 | 0.81 | 1.62 | 2.27 | 3.77 | 5.40 | 6.69 | 8.22 | 10.72 |
| 1990 | 0.83 | 1.56 | 2.46 | 3.52 | 4.89 | 6.33 | 8.46 | 10.65 |
| 1991 | 1.11 | 1.63 | 2.55 | 3.42 | 4.77 | 5.89 | 7.41 | 10.52 |
| 1992 | 1.15 | 1.54 | 2.46 | 3.84 | 4.70 | 6.16 | 7.51 | 9.85 |
| 1993 | 0.88 | 1.57 | 2.31 | 3.08 | 4.50 | 5.73 | 7.08 | 8.88 |
| 1994 | 0.91 | 1.46 | 2.41 | 3.83 | 4.80 | 7.09 | 7.86 | 8.93 |
| 1995 | 0.90 | 1.49 | 2.51 | 3.72 | 5.22 | 6.52 | 11.06 | 10.12 |
| 1996 | 1.03 | 1.54 | 2.36 | 3.34 | 5.24 | 6.36 | 6.92 | 8.46 |
| 1997 | 0.98 | 1.50 | 2.23 | 3.34 | 4.25 | 5.80 | 8.05 | 8.33 |
| 1998 | 0.63 | 1.48 | 2.37 | 3.19 | 4.27 | 5.83 | 6.99 | 8.30 |
| | | | | | | | | |
| 78-98 | 0.89 | 1.50 | 2.39 | 3.61 | 5.00 | 6.51 | 8.29 | 9.67 |
| 95-98 | 0.89 | 1.50 | 2.37 | 3.40 | 4.75 | 6.13 | 8.25 | 8.80 |

Beginning of Year Weight from Surveys

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1978 | 0.15 | 0.84 | 1.69 | 2.84 | 5.80 | 8.43 | 8.15 | 7.46 |
| 1979 | 0.15 | 0.84 | 1.69 | 2.84 | 5.80 | 8.43 | 8.15 | 7.46 |
| 1980 | 0.15 | 0.84 | 1.69 | 2.84 | 5.80 | 8.43 | 8.15 | 7.46 |
| 1981 | 0.15 | 0.84 | 1.69 | 2.84 | 5.80 | 8.43 | 8.15 | 7.46 |
| 1982 | 0.15 | 0.84 | 1.69 | 2.84 | 5.80 | 8.43 | 8.15 | 7.46 |
| 1983 | 0.15 | 0.84 | 1.69 | 2.84 | 5.80 | 8.43 | 8.15 | 7.46 |
| 1984 | 0.15 | 0.84 | 1.69 | 2.84 | 5.80 | 8.43 | 8.15 | 7.46 |
| 1985 | 0.15 | 0.84 | 1.69 | 2.84 | 5.80 | 8.43 | 8.15 | 7.46 |
| 1986 | 0.15 | 0.84 | 1.69 | 2.84 | 5.80 | 8.43 | 8.15 | 7.46 |
| 1987 | 0.15 | 0.84 | 1.69 | 2.84 | 5.80 | 8.43 | 8.15 | 7.46 |
| 1988 | 0.13 | 0.89 | 1.88 | 3.00 | 4.52 | 6.95 | 9.03 | 9.85 |
| 1989 | 0.15 | 0.80 | 1.67 | 2.87 | 4.23 | 6.59 | 7.63 | 8.10 |
| 1990 | 0.20 | 0.79 | 1.90 | 3.07 | 4.58 | 6.34 | 8.31 | 9.49 |
| 1991 | 0.09 | 0.87 | 1.92 | 3.18 | 4.27 | 5.10 | 7.31 | 9.62 |
| 1992 | 0.14 | 0.81 | 1.97 | 3.10 | 4.38 | 6.20 | 7.10 | 8.59 |
| 1993 | 0.08 | 0.94 | 1.88 | 3.09 | 4.79 | 6.02 | 6.97 | 7.58 |
| 1994 | 0.08 | 0.66 | 1.44 | 2.86 | 4.34 | 7.59 | 8.09 | 11.43 |
| 1995 | 0.15 | 0.80 | 1.57 | 2.22 | 3.54 | 5.13 | 6.20 | 7.28 |
| 1996 | 0.05 | 0.73 | 1.65 | 2.70 | 4.12 | 6.25 | 5.66 | 11.00 |
| 1997 | 0.10 | 0.72 | 1.76 | 2.35 | 3.43 | 6.56 | 7.53 | 11.00 |
| 1998 | 0.10 | 0.62 | 1.35 | 2.46 | 3.31 | 4.81 | 5.93 | 8.39 |
| 1999 | 0.15 | 1.00 | 1.41 | 2.42 | 3.32 | 4.85 | 7.12 | 11.22 |
| | | | | | | | | |
| 87-99 | 0.159 | 0.858 | 1.756 | 2.836 | 4.236 | 6.207 | 7.297 | 9.250 |
| 96-99 | 0.110 | 0.774 | 1.548 | 2.432 | 3.545 | 5.521 | 6.488 | 9.776 |

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

| Spring Canada | 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 | 4.20 | 10.44 | 3.45 | 2.49 | 1.07 | 0.26 |
| 1997 | 0.07 | 0.90 | 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 |
| Fall USA | | | | | | | | |
| 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 | | |
| Spring USA1 | | | | | | | | |
| 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 USA2 | | | | | | | | |
| 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 |

Table 9. Summary of Canadian catch in tonnes and effort data 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 | 1.90 | 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 | 1.70 | 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 | 99.0 | 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 |
| | | | |
| **1996** Total catch (t) | 656 | 245 | 984 |
| Total with effort (t) | 656 | 245 | 984 |
| Number of boats | 76 | 10 | 102 |
| Percent with effort | 100.0 | 100.0 | 100.0 |
| 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 | 87.0 | 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 | 100.0 | 92.8 |
| Effort (fish_days) | 1028(1051) | 180 | 578(623) |
| Landings per day | 0.61 | 1.66 | 1.49 |

Table 10. Partial recruitment for 1988-98 by gear type derived from the SPA fishing mortality estimates.

| Otter Trawl | Age | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1988-94 Average | 1995-98 Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| | 2 | 0.09 | 0.14 | 0.57 | 0.19 | 0.60 | 0.22 | 0.07 | 0.10 | 0.18 | 0.14 | 0.18 | 0.32 | 0.16 |
| | 3 | 0.59 | 0.29 | 1.00 | 0.63 | 0.72 | 0.72 | 0.59 | 0.33 | 0.68 | 0.85 | 0.49 | 0.78 | 0.64 |
| | 4 | 0.82 | 0.53 | 0.71 | 0.77 | 0.84 | 0.72 | 0.95 | 0.74 | 1.00 | 0.95 | 1.00 | 0.91 | 1.00 |
| | 5 | 0.84 | 0.37 | 0.82 | 1.00 | 1.00 | 0.76 | 0.92 | 0.94 | 0.80 | 1.00 | 0.65 | 0.98 | 0.92 |
| | 6 | 1.00 | 0.73 | 0.56 | 0.93 | 0.63 | 1.00 | 0.66 | 0.59 | 0.83 | 0.95 | 0.38 | 0.94 | 0.74 |
| | 7 | 0.79 | 1.00 | 0.71 | 0.96 | 0.64 | 0.74 | 1.00 | 1.00 | 0.53 | 0.80 | 0.20 | 1.00 | 0.69 |
| | 8 | 0.51 | 0.18 | 0.54 | 0.62 | 0.33 | 0.96 | 0.70 | 0.89 | 0.82 | 0.93 | 0.21 | 0.66 | 0.77 |
| Longline | | | | | | | | | | | | | | |
| | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 2 | 0.00 | 0.00 | 0.04 | 0.07 | 0.08 | 0.08 | 0.02 | 0.06 | 0.07 | 0.07 | 0.16 | 0.04 | 0.11 |
| | 3 | 0.08 | 0.04 | 0.21 | 0.26 | 0.21 | 0.35 | 0.21 | 0.27 | 0.39 | 0.43 | 0.40 | 0.20 | 0.46 |
| | 4 | 0.18 | 0.25 | 0.24 | 0.34 | 0.37 | 0.63 | 0.53 | 0.76 | 0.61 | 0.74 | 1.00 | 0.38 | 0.96 |
| | 5 | 0.33 | 0.37 | 0.46 | 0.52 | 0.52 | 1.00 | 0.72 | 1.00 | 0.75 | 0.62 | 0.86 | 0.59 | 1.00 |
| | 6 | 0.29 | 0.57 | 0.53 | 0.46 | 0.67 | 0.74 | 0.66 | 0.47 | 1.00 | 1.00 | 0.76 | 0.60 | 1.00 |
| | 7 | 0.81 | 0.90 | 0.99 | 0.49 | 0.71 | 0.81 | 1.00 | 0.00 | 0.85 | 0.94 | 0.81 | 0.87 | 0.80 |
| | 8 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.67 | 0.91 | 0.00 | 0.81 | 0.81 | 1.00 | 1.00 | 0.81 |
| Gillnet | | | | | | | | | | | | | | |
| | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 2 | 0.02 | 0.01 | 0.03 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.02 | 0.00 |
| | 3 | 0.18 | 0.04 | 0.12 | 0.16 | 0.09 | 0.08 | 0.05 | 0.02 | 0.07 | 0.07 | 0.14 | 0.12 | 0.09 |
| | 4 | 0.32 | 0.09 | 0.20 | 0.31 | 0.20 | 0.42 | 0.43 | 0.10 | 0.33 | 0.41 | 0.78 | 0.32 | 0.46 |
| | 5 | 0.51 | 0.15 | 0.46 | 0.45 | 0.40 | 0.79 | 0.69 | 0.40 | 0.54 | 0.55 | 0.96 | 0.57 | 0.70 |
| | 6 | 0.68 | 0.16 | 0.71 | 0.70 | 0.40 | 1.00 | 0.68 | 0.33 | 1.00 | 0.97 | 1.00 | 0.71 | 0.95 |
| | 7 | 1.00 | 0.65 | 1.00 | 0.93 | 0.69 | 0.82 | 1.00 | 0.67 | 0.88 | 1.00 | 0.75 | 1.00 | 0.95 |
| | 8 | 0.69 | 1.00 | 0.47 | 1.00 | 1.00 | 0.59 | 0.91 | 1.00 | 0.64 | 0.91 | 0.93 | 0.93 | 1.00 |
| Fishery | | | | | | | | | | | | | | |
| | Age 3 | 0.51 | 0.23 | 0.87 | 0.59 | 0.65 | 0.64 | 0.42 | 0.38 | 0.61 | 0.61 | 0.63 | | |
| | Age 4 | 0.75 | 0.57 | 0.69 | 0.74 | 0.85 | 0.78 | 0.84 | 0.92 | 0.95 | 0.90 | 1.00 | | |

Table 11. Population estimates derived from ADAPT analysis

| | | | | Age | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1+ | 3+ |
| **Numbers (000's)** | | | | | | | | | | |
| 1978 | 11265 | 2191 | 10438 | 3497 | 1077 | 243 | 310 | 62 | 29083 | 15627 |
| 1979 | 9320 | 9221 | 1685 | 5330 | 1898 | 606 | 101 | 179 | 28341 | 9799 |
| 1980 | 9069 | 7622 | 6816 | 1021 | 2773 | 1065 | 362 | 63 | 28791 | 12099 |
| 1981 | 17029 | 7425 | 5351 | 4236 | 598 | 1449 | 562 | 199 | 36848 | 12395 |
| 1982 | 6192 | 13925 | 5535 | 3085 | 2347 | 350 | 654 | 309 | 32397 | 12280 |
| 1983 | 4488 | 5064 | 8988 | 3019 | 1250 | 969 | 118 | 228 | 24125 | 14572 |
| 1984 | 13365 | 3639 | 2962 | 4300 | 1157 | 606 | 540 | 69 | 26636 | 9633 |
| 1985 | 4482 | 10933 | 2736 | 1607 | 2313 | 490 | 237 | 236 | 23036 | 7621 |
| 1986 | 21210 | 3659 | 6443 | 1150 | 751 | 1052 | 201 | 108 | 34574 | 9705 |
| 1987 | 7034 | 17340 | 2702 | 3314 | 483 | 343 | 503 | 113 | 31831 | 7457 |
| 1988 | 13507 | 5746 | 10900 | 1436 | 1728 | 266 | 172 | 262 | 34017 | 14764 |
| 1989 | 3751 | 11049 | 4416 | 5649 | 599 | 647 | 90 | 51 | 26251 | 11450 |
| 1990 | 5340 | 3071 | 8379 | 3028 | 2978 | 317 | 249 | 24 | 23385 | 14974 |
| 1991 | 8672 | 4365 | 1904 | 3999 | 1616 | 1369 | 156 | 95 | 22176 | 9139 |
| 1992 | 2621 | 7090 | 3010 | 859 | 1544 | 477 | 418 | 45 | 16063 | 6352 |
| 1993 | 4555 | 2068 | 3690 | 1346 | 318 | 457 | 168 | 135 | 12736 | 6114 |
| 1994 | 2986 | 3725 | 1321 | 1270 | 383 | 70 | 82 | 40 | 9877 | 3165 |
| 1995 | 1626 | 2443 | 2886 | 646 | 372 | 96 | 21 | 15 | 8106 | 4037 |
| 1996 | 4975 | 1331 | 1950 | 2151 | 421 | 225 | 66 | 14 | 11132 | 4826 |
| 1997 | 3127 | 4073 | 1055 | 1388 | 1414 | 277 | 142 | 44 | 11519 | 4319 |
| 1998 | 824 | 2558 | 3238 | 724 | 879 | 895 | 163 | 87 | 9368 | 5986 |
| 1999 | 137 | 674 | 2021 | 2406 | 471 | 595 | 629 | 118 | 7051 | 6240 |
| **Biomass (Tonnes)** | | | | | | | | | | |
| 1978 | 1359 | 1765 | 17741 | 9733 | 4525 | 1512 | 2267 | 573 | 39473 | 36349 |
| 1979 | 1124 | 7429 | 2863 | 14834 | 7974 | 3768 | 737 | 1669 | 40398 | 31845 |
| 1980 | 1094 | 6141 | 11584 | 2840 | 11653 | 6618 | 2649 | 584 | 43163 | 35928 |
| 1981 | 2054 | 5982 | 9094 | 11788 | 2511 | 9011 | 4110 | 1851 | 46400 | 38365 |
| 1982 | 747 | 11219 | 9407 | 8586 | 9861 | 2176 | 4784 | 2873 | 49652 | 37687 |
| 1983 | 541 | 4080 | 15275 | 8401 | 5251 | 6027 | 865 | 2127 | 42567 | 37946 |
| 1984 | 1612 | 2932 | 5033 | 11967 | 4859 | 3767 | 3945 | 642 | 34758 | 30214 |
| 1985 | 541 | 8808 | 4651 | 4473 | 9718 | 3048 | 1735 | 2199 | 35173 | 25824 |
| 1986 | 2558 | 2948 | 10950 | 3199 | 3156 | 6539 | 1472 | 1009 | 31832 | 26326 |
| 1987 | 1064 | 14609 | 4564 | 9404 | 2800 | 2891 | 4102 | 842 | 40277 | 24604 |
| 1988 | 1706 | 5138 | 20525 | 4310 | 7807 | 1850 | 1557 | 2582 | 45476 | 38632 |
| 1989 | 573 | 8889 | 7371 | 16203 | 2530 | 4260 | 684 | 410 | 40920 | 31458 |
| 1990 | 1087 | 2417 | 15885 | 9310 | 13640 | 2009 | 2070 | 225 | 46643 | 43140 |
| 1991 | 747 | 3799 | 3662 | 12718 | 6895 | 6979 | 1138 | 916 | 36853 | 32307 |
| 1992 | 367 | 5765 | 5937 | 2664 | 6755 | 2953 | 2972 | 385 | 27797 | 21666 |
| 1993 | 367 | 1935 | 6952 | 4154 | 1523 | 2754 | 1168 | 1025 | 19877 | 17575 |
| 1994 | 227 | 2441 | 1901 | 3638 | 1664 | 532 | 660 | 454 | 11517 | 8849 |
| 1995 | 238 | 1949 | 4521 | 1436 | 1316 | 493 | 132 | 110 | 10196 | 8009 |
| 1996 | 257 | 970 | 3212 | 5806 | 1735 | 1405 | 372 | 150 | 13906 | 12679 |
| 1997 | 312 | 2952 | 1859 | 3265 | 4854 | 1818 | 1067 | 483 | 16610 | 13346 |
| 1998 | 84 | 1587 | 4367 | 1781 | 2911 | 4308 | 969 | 730 | 16738 | 15066 |
| 1999 | 21 | 674 | 2858 | 5834 | 1561 | 2887 | 4479 | 1320 | 19633 | 18938 |

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | F4+ | % Exp 4+ |
|---|---|---|---|---|---|---|---|---|---|---|
| **Fishing Mortality** | | | | | | | | | | |
| 1978 | 0.000 | 0.063 | 0.472 | 0.411 | 0.375 | 0.680 | 0.348 | 0.468 | 0.410 | 31 |
| 1979 | 0.001 | 0.102 | 0.301 | 0.453 | 0.378 | 0.314 | 0.274 | 0.322 | 0.420 | 31 |
| 1980 | 0.000 | 0.154 | 0.276 | 0.335 | 0.449 | 0.438 | 0.400 | 0.429 | 0.420 | 31 |
| 1981 | 0.001 | 0.094 | 0.351 | 0.390 | 0.335 | 0.595 | 0.400 | 0.443 | 0.430 | 32 |
| 1982 | 0.001 | 0.238 | 0.406 | 0.704 | 0.684 | 0.885 | 0.852 | 0.807 | 0.730 | 47 |
| 1983 | 0.010 | 0.337 | 0.537 | 0.759 | 0.524 | 0.386 | 0.339 | 0.416 | 0.620 | 42 |
| 1984 | 0.001 | 0.085 | 0.411 | 0.420 | 0.658 | 0.737 | 0.626 | 0.674 | 0.510 | 36 |
| 1985 | 0.003 | 0.329 | 0.667 | 0.561 | 0.588 | 0.690 | 0.583 | 0.620 | 0.590 | 41 |
| 1986 | 0.001 | 0.103 | 0.465 | 0.667 | 0.584 | 0.538 | 0.380 | 0.500 | 0.580 | 40 |
| 1987 | 0.002 | 0.264 | 0.432 | 0.451 | 0.396 | 0.488 | 0.452 | 0.445 | 0.450 | 33 |
| 1988 | 0.001 | 0.063 | 0.457 | 0.675 | 0.783 | 0.888 | 1.026 | 0.899 | 0.770 | 49 |
| 1989 | 0.000 | 0.077 | 0.177 | 0.440 | 0.436 | 0.753 | 1.129 | 0.773 | 0.480 | 35 |
| 1990 | 0.001 | 0.278 | 0.540 | 0.428 | 0.577 | 0.511 | 0.762 | 0.617 | 0.510 | 37 |
| 1991 | 0.001 | 0.172 | 0.596 | 0.752 | 1.021 | 0.985 | 1.044 | 1.017 | 0.870 | 53 |
| 1992 | 0.037 | 0.453 | 0.605 | 0.794 | 1.017 | 0.846 | 0.930 | 0.931 | 0.920 | 56 |
| 1993 | 0.001 | 0.247 | 0.867 | 1.055 | 1.311 | 1.523 | 1.238 | 1.358 | 1.210 | 65 |
| 1994 | 0.001 | 0.054 | 0.508 | 1.024 | 1.180 | 0.986 | 1.485 | 1.217 | 1.100 | 62 |
| 1995 | 0.000 | 0.025 | 0.091 | 0.222 | 0.303 | 0.178 | 0.244 | 0.242 | 0.250 | 20 |
| 1996 | 0.000 | 0.031 | 0.135 | 0.210 | 0.208 | 0.258 | 0.198 | 0.221 | 0.220 | 18 |
| 1997 | 0.001 | 0.028 | 0.168 | 0.246 | 0.239 | 0.302 | 0.282 | 0.274 | 0.270 | 21 |
| 1998 | 0.000 | 0.032 | 0.090 | 0.213 | 0.176 | 0.137 | 0.114 | 0.142 | 0.180 | 15 |

Table 12. Bootstrap parameters estimated from ADAPT, with standard errors and bias

| Population Numbers | Estimate | Standard Error | Relative Error | Bias | Relative Bias |
|---|---|---|---|---|---|
| 1999 numbers Age 1 | 263 | 405 | 1.54 | 126 | 0.48 |
| 1999 numbers Age 2 | 781 | 479 | 0.61 | 106 | 0.14 |
| 1999 numbers Age 3 | 2180 | 732 | 0.34 | 159 | 0.07 |
| 1999 numbers Age 4 | 2550 | 785 | 0.31 | 148 | 0.06 |
| 1999 numbers Age 5 | 487 | 152 | 0.31 | 16 | 0.03 |
| 1999 numbers Age 6 | 625 | 190 | 0.31 | 29 | 0.05 |
| 1999 numbers Age 7 | 663 | 233 | 0.35 | 34 | 0.05 |
| 1999 numbers Age 8 | 124 | 48 | 0.39 | 6 | 0.05 |
| **Survey Catchability** | | | | | |
| Can, Spr. Age 1 | 0.00004 | 0.000009 | 0.25 | 0.000001 | 0.02 |
| Can, Spr. Age 2 | 0.00043 | 0.000103 | 0.24 | 0.000008 | 0.02 |
| Can, Spr. Age 3 | 0.00104 | 0.000230 | 0.22 | 0.000019 | 0.02 |
| Can, Spr. Age 4 | 0.00130 | 0.000311 | 0.24 | 0.000045 | 0.04 |
| Can, Spr. Age 5 | 0.00191 | 0.000473 | 0.25 | 0.000066 | 0.04 |
| Can, Spr. Age 6 | 0.00205 | 0.000511 | 0.25 | 0.000056 | 0.03 |
| Can, Spr. Age 7 | 0.00239 | 0.000619 | 0.26 | 0.000125 | 0.05 |
| Can, Spr. Age 8 | 0.00300 | 0.000736 | 0.25 | 0.000075 | 0.03 |
| USA Fall Age 1 | 0.00003 | 0.000007 | 0.21 | 0.000000 | 0.00 |
| USA Fall Age 2 | 0.00013 | 0.000026 | 0.21 | 0.000001 | 0.01 |
| USA Fall Age 3 | 0.00017 | 0.000034 | 0.20 | 0.000002 | 0.01 |
| USA Fall Age 4 | 0.00026 | 0.000050 | 0.19 | 0.000002 | 0.01 |
| USA Fall Age 5 | 0.00017 | 0.000036 | 0.21 | 0.000003 | 0.02 |
| USA Fall Age 6 | 0.00024 | 0.000054 | 0.22 | 0.000004 | 0.02 |
| USA Spr1 Age 1 | 0.00003 | 0.000013 | 0.46 | 0.000002 | 0.09 |
| USA Spr1 Age 2 | 0.00029 | 0.000159 | 0.56 | 0.000031 | 0.11 |
| USA Spr1 Age 3 | 0.00033 | 0.000161 | 0.48 | 0.000030 | 0.09 |
| USA Spr1 Age 4 | 0.00036 | 0.000170 | 0.47 | 0.000035 | 0.10 |
| USA Spr1 Age 5 | 0.00056 | 0.000281 | 0.50 | 0.000051 | 0.09 |
| USA Spr1 Age 6 | 0.00065 | 0.000324 | 0.50 | 0.000066 | 0.10 |
| USA Spr1 Age 7 | 0.00108 | 0.000539 | 0.50 | 0.000099 | 0.09 |
| USA Spr1 Age 8 | 0.00131 | 0.000611 | 0.47 | 0.000113 | 0.09 |
| USA Spr2 Age 1 | 0.00005 | 0.000012 | 0.24 | 0.000002 | 0.03 |
| USA Spr2 Age 2 | 0.00022 | 0.000043 | 0.20 | 0.000002 | 0.01 |
| USA Spr2 Age 3 | 0.00041 | 0.000086 | 0.21 | 0.000004 | 0.01 |
| USA Spr2 Age 4 | 0.00059 | 0.000123 | 0.21 | 0.000012 | 0.02 |
| USA Spr2 Age 5 | 0.00076 | 0.000166 | 0.22 | 0.000023 | 0.03 |
| USA Spr2 Age 6 | 0.00074 | 0.000164 | 0.22 | 0.000014 | 0.02 |
| USA Spr2 Age 7 | 0.00096 | 0.000211 | 0.22 | 0.000034 | 0.04 |
| USA Spr2 Age 8 | 0.00111 | 0.000251 | 0.23 | 0.000026 | 0.02 |

Table 13. Yield per recruit analysis

a. Input parameters

| Age | Mean Weight | Partial Recruitment |
|-----|-------------|---------------------|
| 1   | 0.885       | 0.000               |
| 2   | 1.502       | 0.130               |
| 3   | 2.368       | 0.520               |
| 4   | 3.398       | 1.000               |
| 5   | 4.746       | 1.000               |
| 6   | 6.126       | 1.000               |
| 7   | 8.252       | 1.000               |
| 8   | 8.800       | 1.000               |
| 9   | 9.716       | 1.000               |
| 10  | 11.077      | 1.000               |
| 11  | 12.431      | 1.000               |
| 12  | 13.768      | 1.000               |
| 13  | 15.076      | 1.000               |
| 14  | 16.347      | 1.000               |
| 15  | 17.575      | 1.000               |

b. Results

```
NATURAL MORTALITY RATE :  0.2
F0.1   COMPUTED AS  0.1998  AT  Y/R  OF  1.6094
FMAX   COMPUTED AS  0.3916  AT  Y/R  OF  1.7432
```

| | FISHING MORTALITY | CATCH (NUMBER) | YIELD (KG) | AVG. WEIGHT (KG) | YIELD PER UNIT EFFORT |
|---|---|---|---|---|---|
|          | 0.1000 | 0.207 | 1.221 | 5.904 | 1.516 |
| F0.1---  | 0.1998 | 0.316 | 1.609 | 5.086 | 1.000 |
|          | 0.2000 | 0.317 | 1.610 | 5.085 | 0.999 |
|          | 0.3000 | 0.383 | 1.724 | 4.497 | 0.713 |
| FMAX---  | 0.3916 | 0.425 | 1.743 | 4.102 | 0.553 |
|          | 0.4000 | 0.428 | 1.743 | 4.071 | 0.541 |
|          | 0.5000 | 0.461 | 1.730 | 3.753 | 0.430 |
|          | 0.6000 | 0.486 | 1.705 | 3.511 | 0.353 |
|          | 0.7000 | 0.506 | 1.679 | 3.320 | 0.298 |
|          | 0.8000 | 0.522 | 1.653 | 3.166 | 0.257 |
|          | 0.9000 | 0.536 | 1.629 | 3.040 | 0.225 |
|          | 1.0000 | 0.548 | 1.607 | 2.934 | 0.199 |
|          | 1.1000 | 0.558 | 1.587 | 2.844 | 0.179 |
|          | 1.2000 | 0.567 | 1.569 | 2.767 | 0.162 |
|          | 1.3000 | 0.575 | 1.552 | 2.700 | 0.148 |
|          | 1.4000 | 0.582 | 1.537 | 2.641 | 0.136 |
|          | 1.5000 | 0.589 | 1.524 | 2.588 | 0.126 |

## Table 14. Input for Catch Projection.

| Age in 1999 | Population Numbers (000's) in 1999 | Partial Recruitment in 1999 (1995-98 average from F) | Natural Mortality in 1999 | Mean Weight kg Beg. Of Year (1996-99 average) | Mean Weight kg Fishery (1995-98 average) |
|---|---|---|---|---|---|
| 1 | 137 | 0.00 | 0.20 | 0.11 | 0.89 |
| 2 | 674 | 0.13 | 0.20 | 0.77 | 1.50 |
| 3 | 2021 | 0.52 | 0.20 | 1.55 | 2.37 |
| 4 | 2406 | 1.00 | 0.20 | 2.43 | 3.40 |
| 5 | 471 | 1.00 | 0.20 | 3.54 | 4.75 |
| 6 | 595 | 1.00 | 0.20 | 5.52 | 6.13 |
| 7 | 629 | 1.00 | 0.20 | 6.49 | 8.25 |
| 8 | 118 | 1.00 | 0.20 | 9.78 | 8.80 |

## Table 15. Catch projection results using bootstrap bias adjusted point estimates for a target of $F_{0.1}=0.2$

| | Year | Age | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population Numbers (000's) | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | | |
| | 1999 | 137 | 674 | 2021 | 2406 | 471 | 595 | 629 | 118 | | | | |
| | 2000 | 2000 | 112 | 538 | 1492 | 1613 | 315 | 399 | 422 | | | | |
| Fishing Mortality | | | | | | | | | | | | | |
| | 1999 | 0 | 0.026 | 0.104 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | | | | |
| Natural. Mortality | | | | | | | | | | | | | |
| | 1999 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | | | | |
| Partial Recruitment | | | | | | | | | | | | | |
| | 1999 | 0 | 0.13 | 0.52 | 1 | 1 | 1 | 1 | 1 | | | | |
| January Weight kg | | | | | | | | | | | | | |
| | 1999 | 0.11 | 0.77 | 1.55 | 2.43 | 3.54 | 5.52 | 6.49 | 9.78 | | | | |
| | 2000 | 0.11 | 0.77 | 1.55 | 2.43 | 3.54 | 5.52 | 6.49 | 9.78 | | | | |
| Projected Biomass (t) | | | | | | | | | | | 1+ | 2+ | 3+ | 4+ |
| | 1999 | 15 | 522 | 3129 | 5851 | 1668 | 3287 | 4084 | 1150 | 19706 | 19691 | 19169 | 16040 |
| | 2000 | 220 | 87 | 833 | 3628 | 5716 | 1742 | 2589 | 4125 | 18939 | 18719 | 18632 | 17799 |
| Projected Catch Numbers (000's) | | | | | | | | | | | | | |
| | 1999 | 0 | 16 | 181 | 397 | 78 | 98 | 104 | 19 | | | | |
| Fishery Weight kg | | | | | | | | | | | | | |
| | 1999 | 0.89 | 1.5 | 2.37 | 3.4 | 4.75 | 6.13 | 8.25 | 8.8 | | | | |
| Projected Catch Biomass (t) | | | | | | | | | | | | | |
| | 1999 | 0 | 24 | 429 | 1347 | 368 | 601 | 856 | 171 | 3796 | 3796 | 3773 | 3344 |

Figure 1. Map of area. Shaded area indicates USA closed area II.
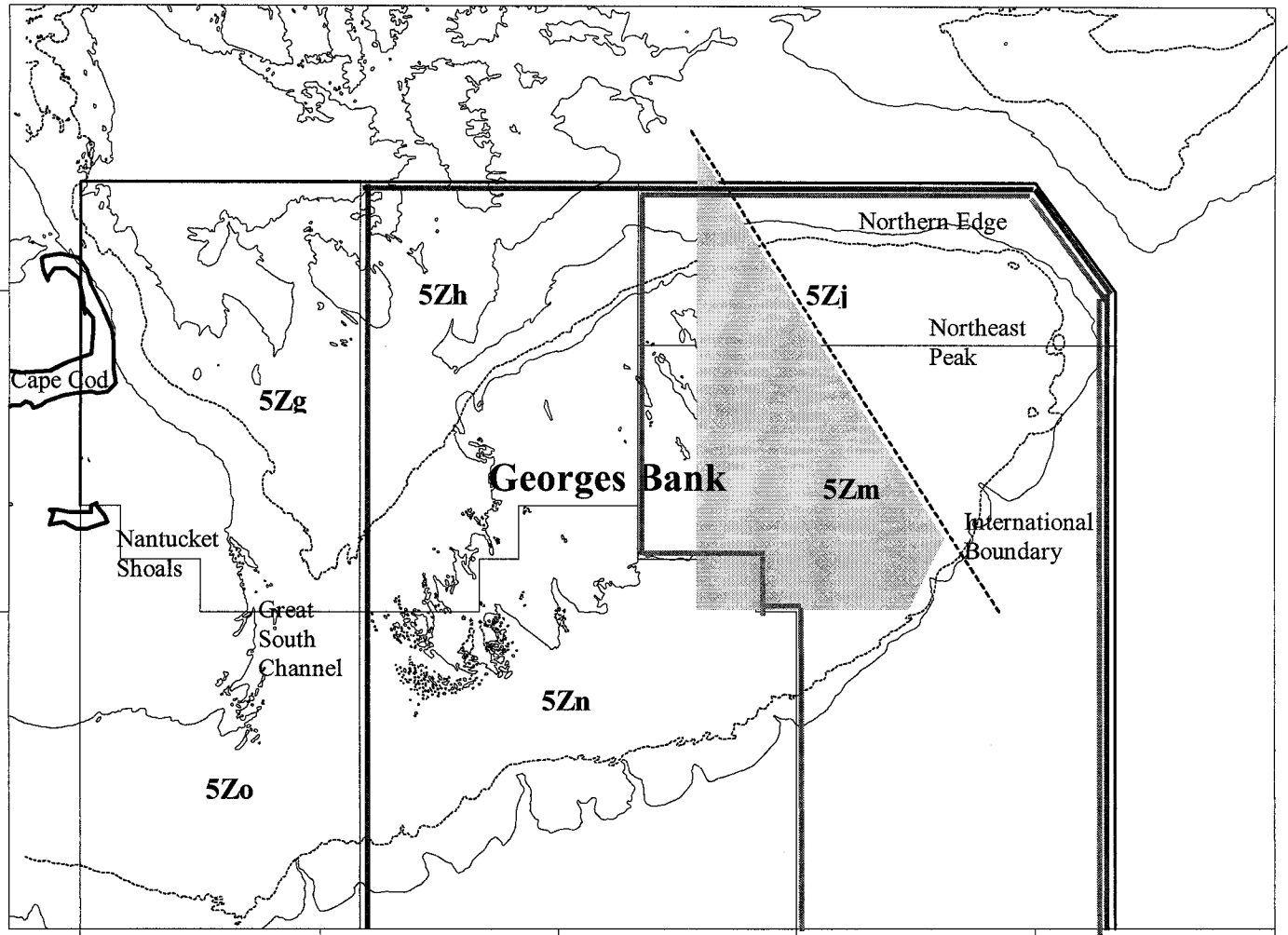
Figure 2. Landings of 5Zj,m cod by gear type for Canadian fisheries.
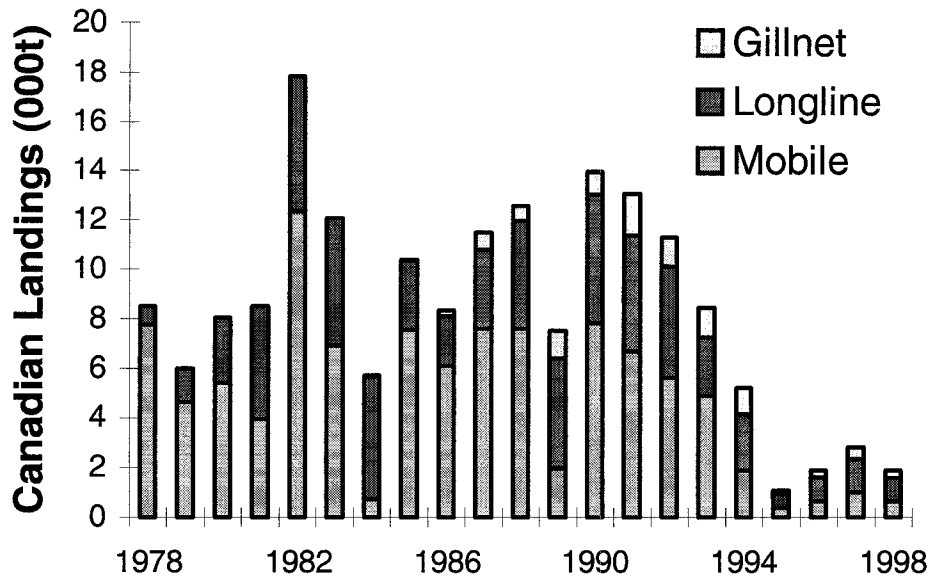


Figure 3. Landings of 5Zj,m cod by Canada and the USA
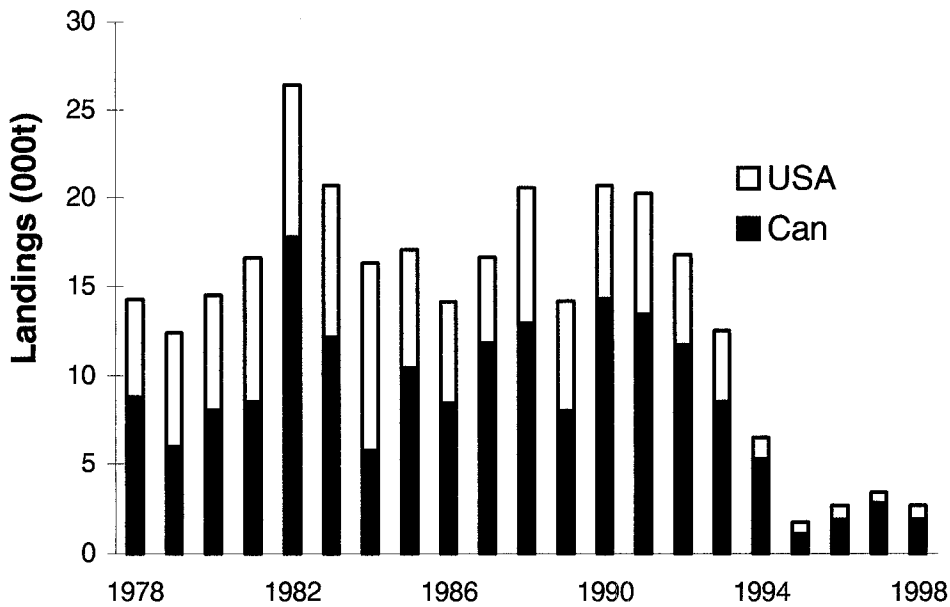
Figure 4. Percent catch at age for the 1998 Canadian and USA 5Zj,m cod fishery.
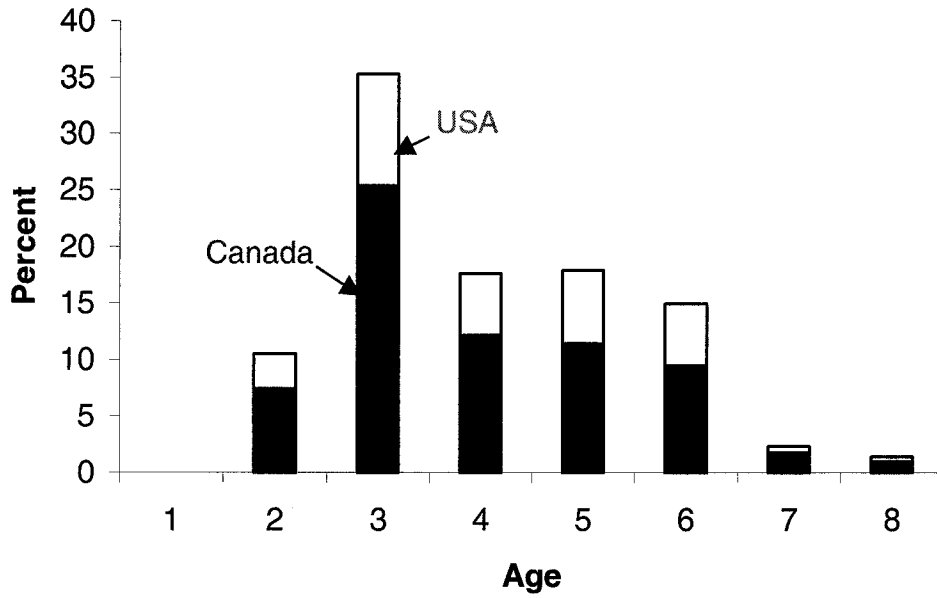


Figure 5. Length and age composition for the 1998 Canadian 5Zj,m cod fishery
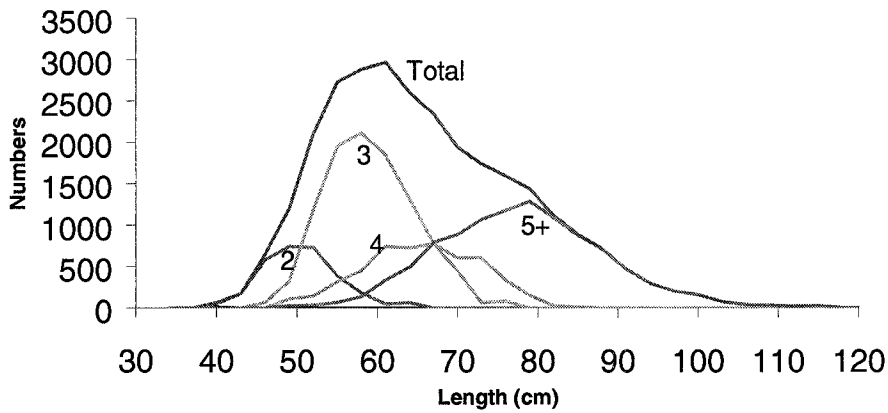
Figure 6. Comparison of observed percent catch at age in 1998 with the predicted percent catch at age from the 1998 assessment
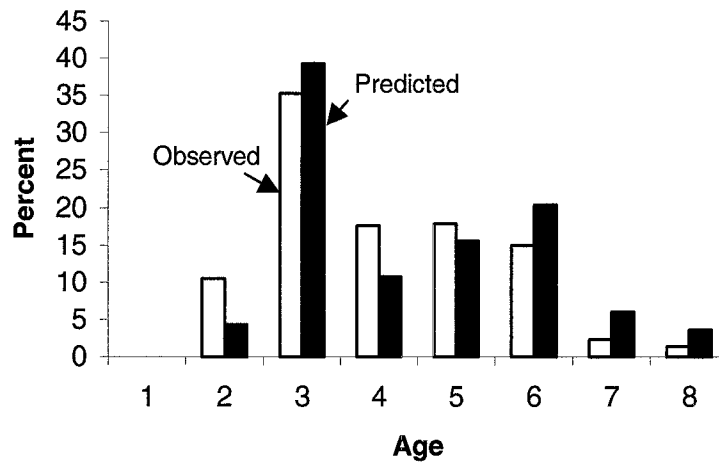


Figure 7. Beginning of year mean weight (kg) and length (cm) at age for cod calculated from Canadian Surveys, and beginning of year weights (kg) backcalculated from the fishery.
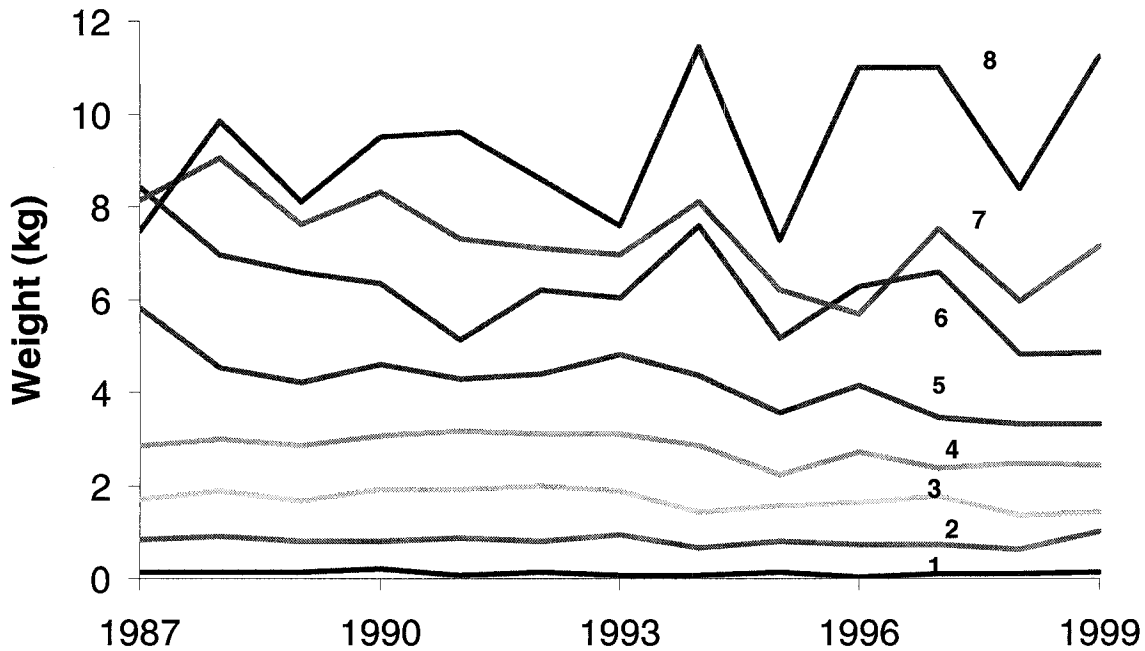
Figure 8. Comparison of cod catch per standard tow in numbers from the 1999 Canadian
research survey (open boxes) with average density distribution for 1994-98
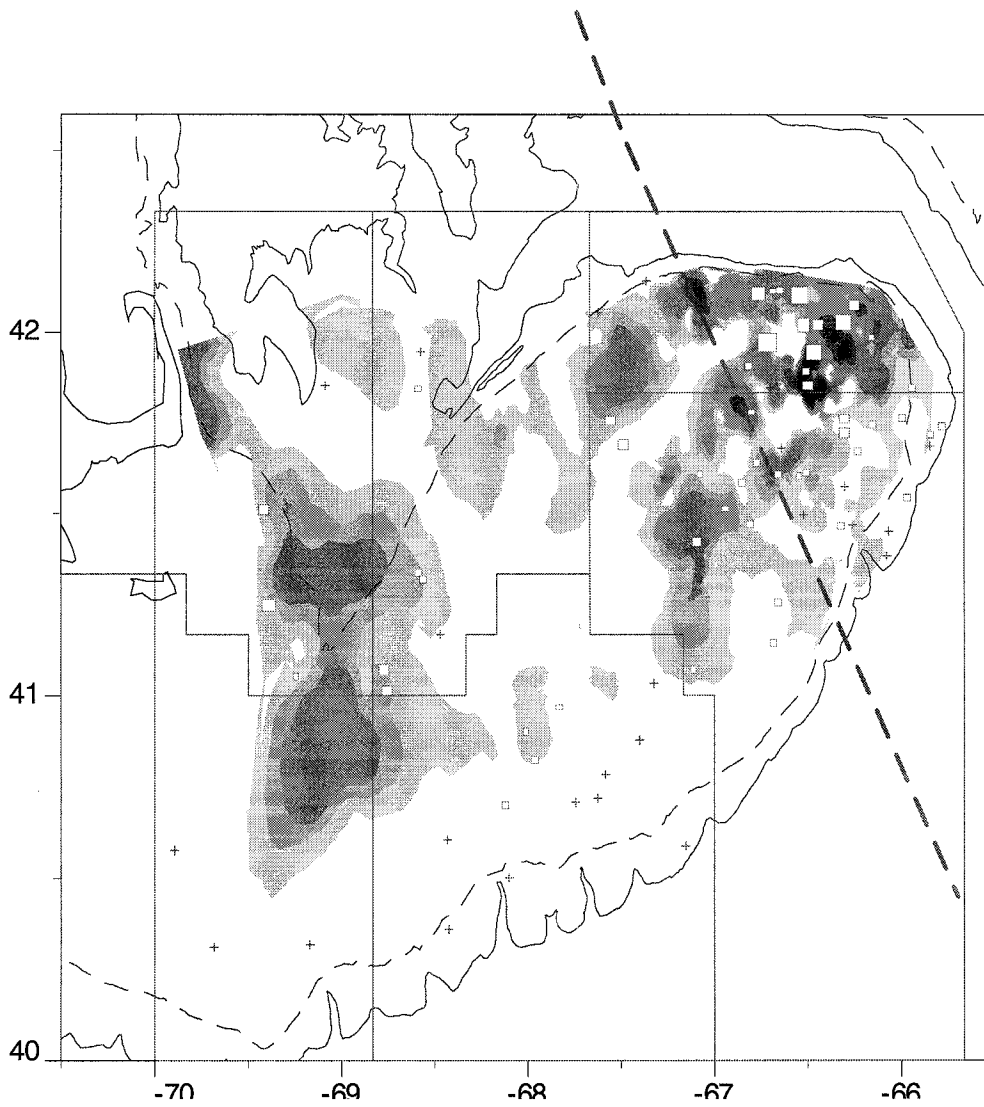
Figure 9. Estimates of adult biomass (t) and stratified mean numbers per tow indices of abundance at age 1 for 5Zj,m cod from the Canadian spring and USA spring and fall surveys in 5Zj,m
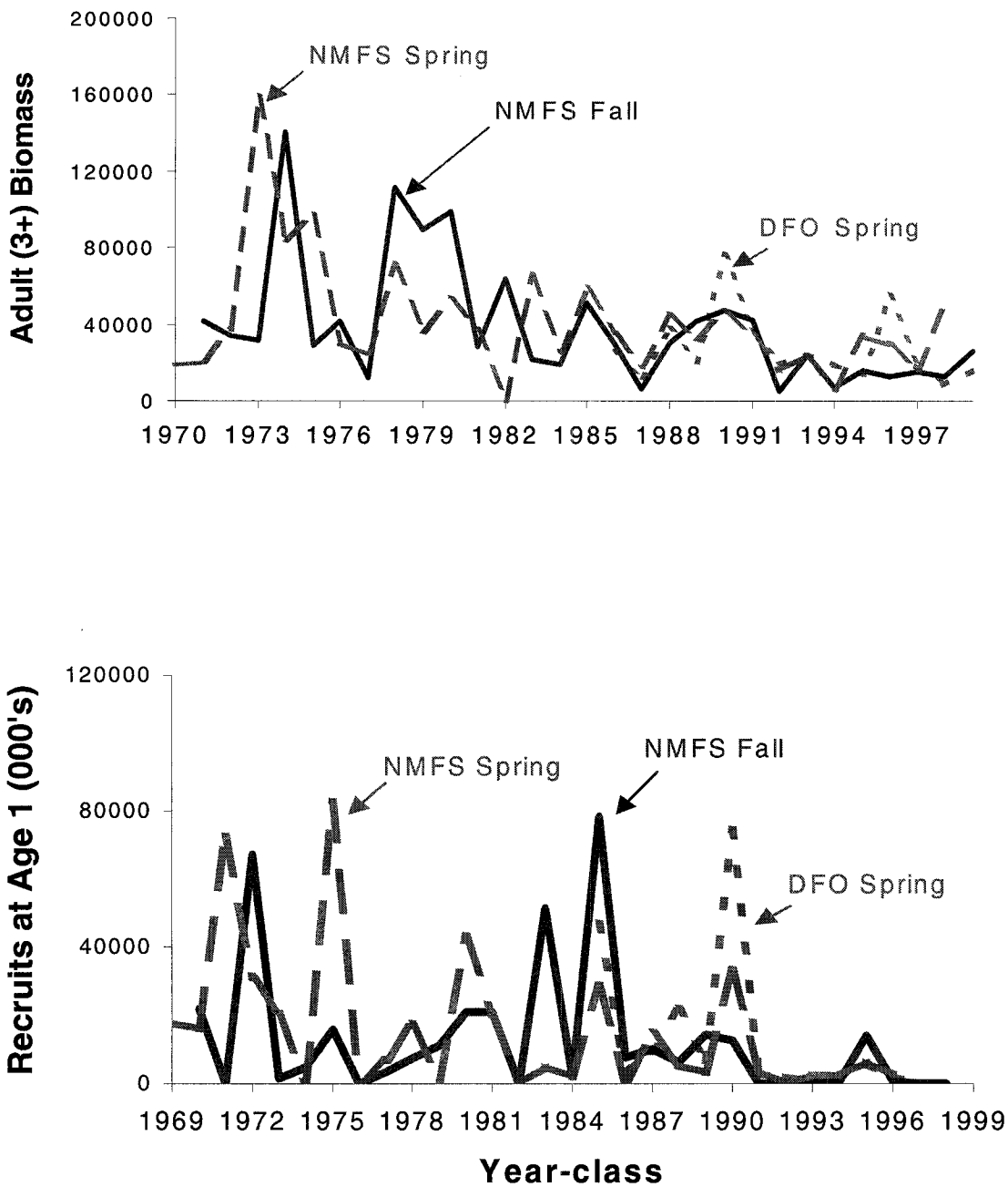
Figure 10. Number of Canadian vessels and landings per day for trips with >500kg cod landings



**Catch(t) per Day Fished**
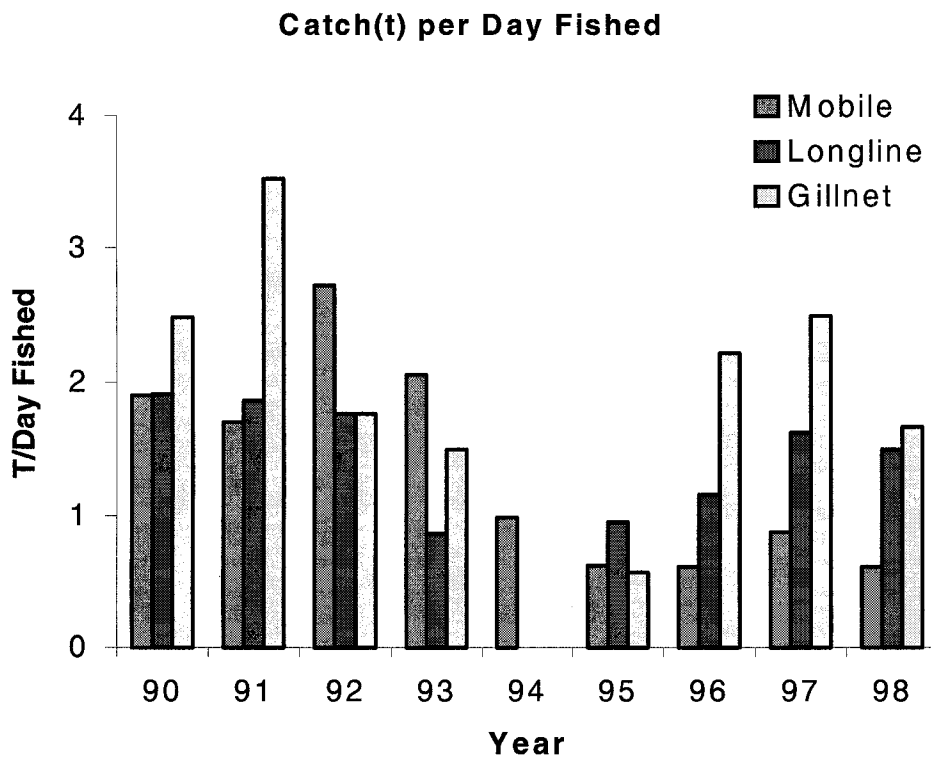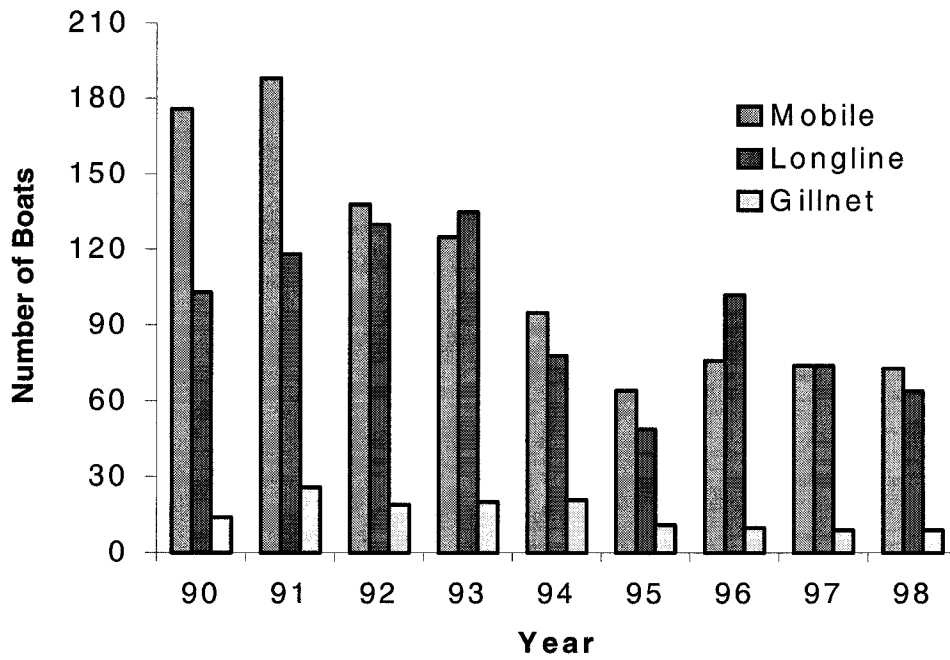
Figure 11. Average partial recruitment for 1988-94 and 1995-98 by gear and for the fishery
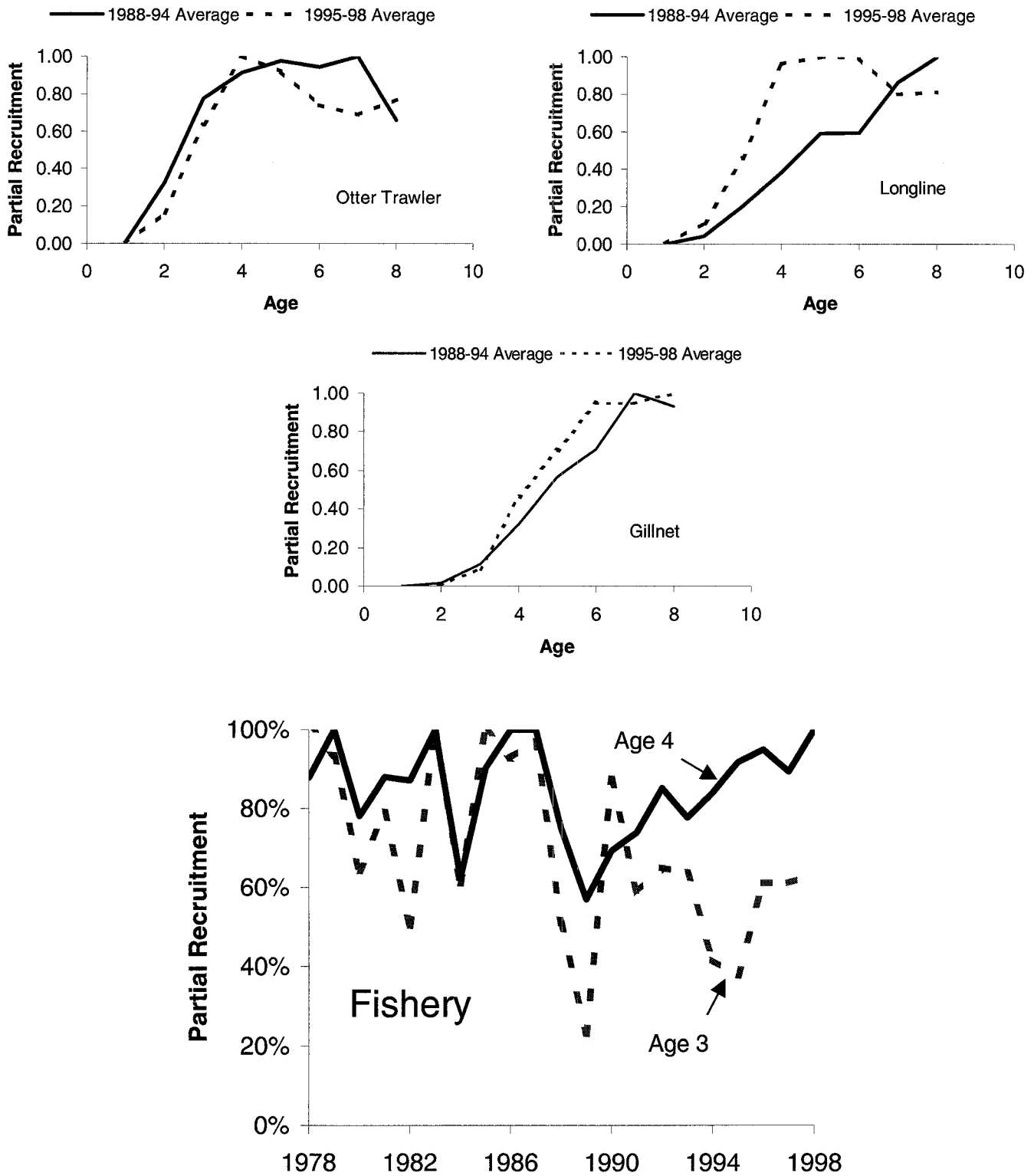
Figure 12. Standardized residuals at age from ADAPT for the Canadian spring, USA fall, USA spring (78-81) and USA spring (82-98) research surveys
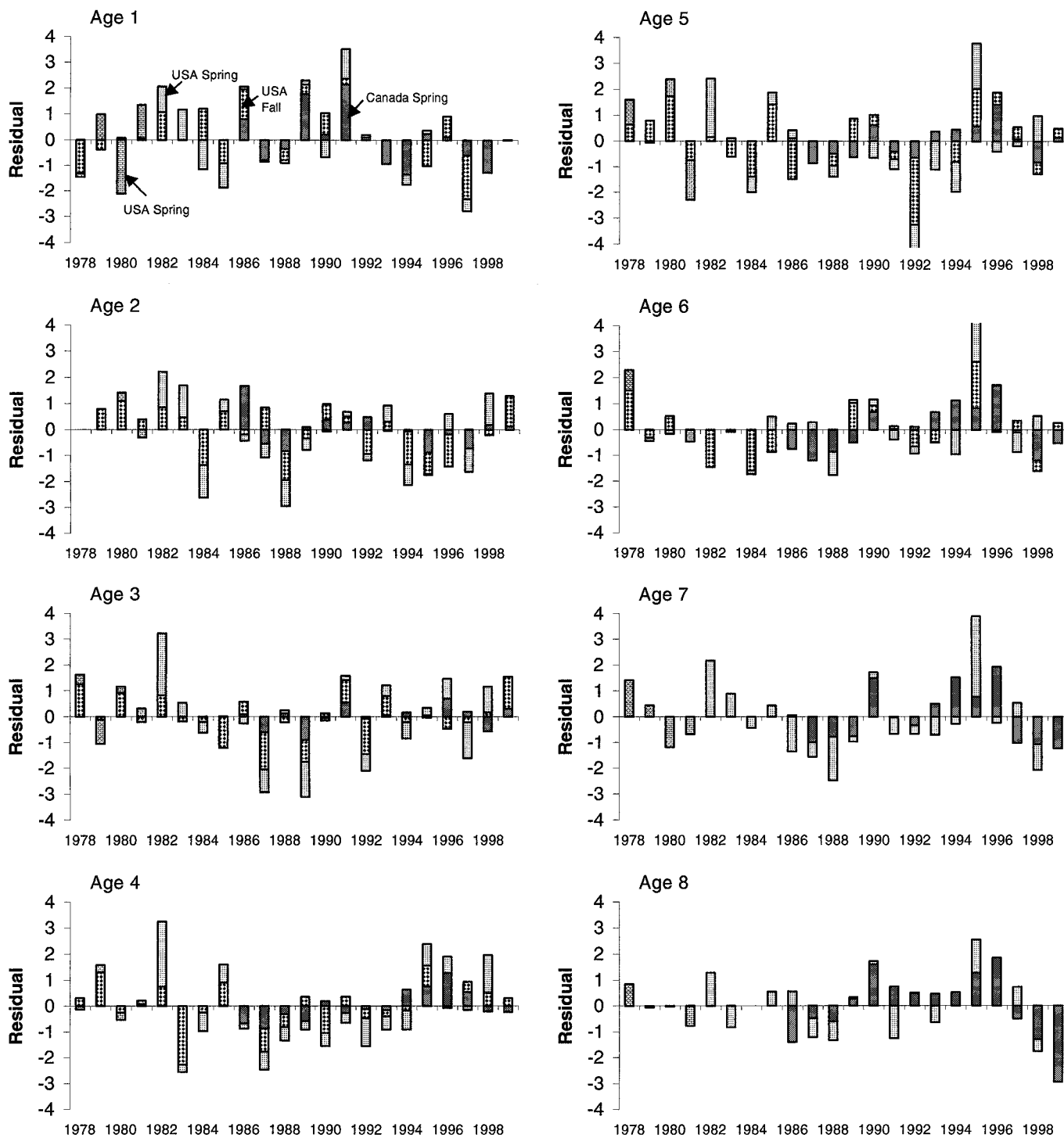
Figure 13. Adult (3+) biomass and recruits at age 1 from ADAPT for 5Zj,m cod.
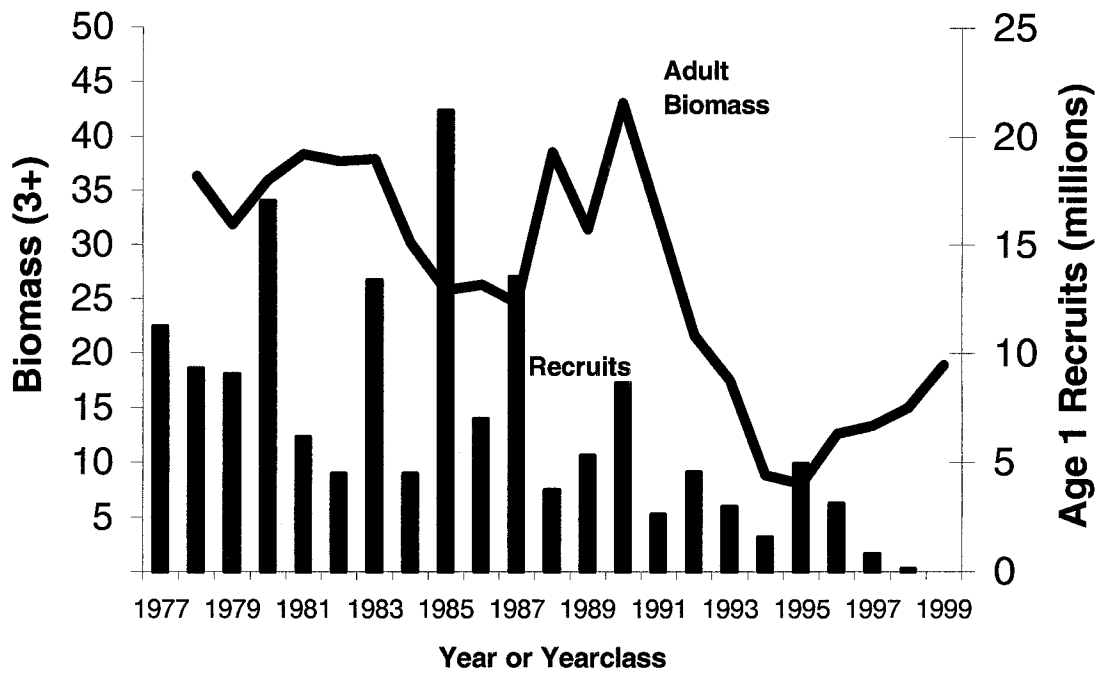


Figure 14. Percent exploitation rate from ADAPT for 5Zj,m cod
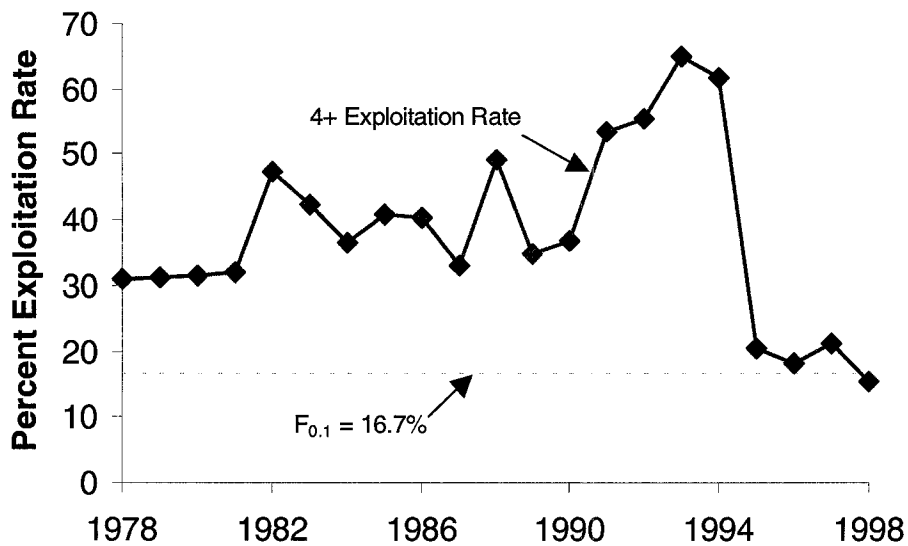
Figure 15. Probability of exceeding $F_{0.1}$ and of the 2000 beginning of year biomass being less than in 1999 at various levels of 1999 catch
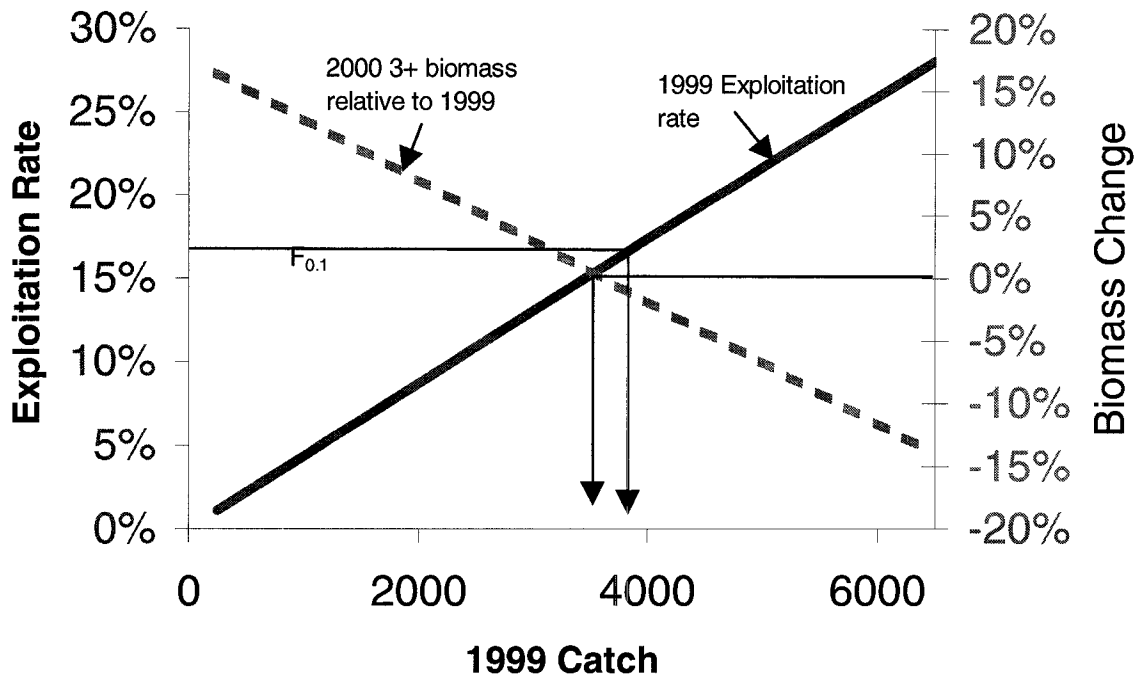


Figure 16. Projected change in 5Zj,m cod biomass from 1999 to 2000 at various exploitation rates.
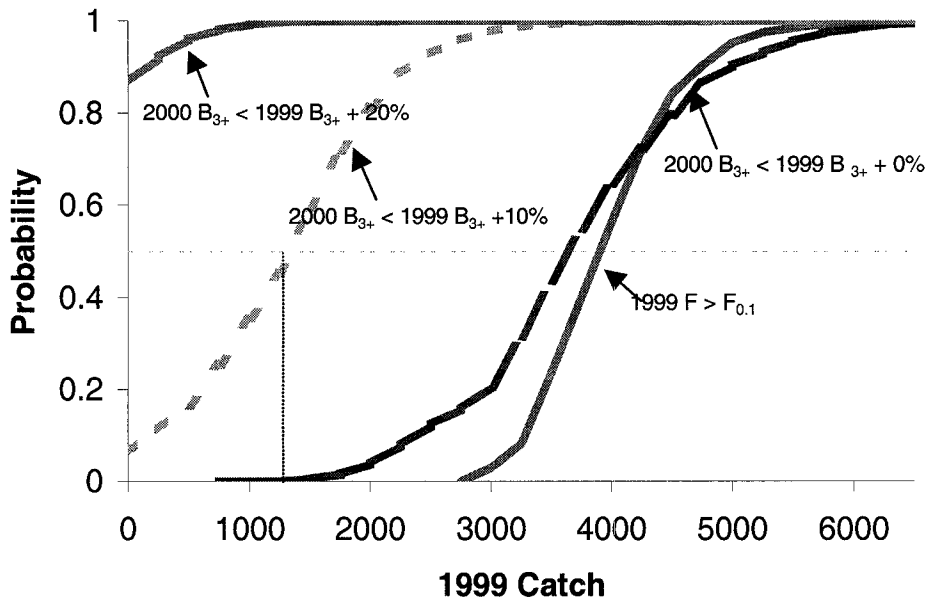
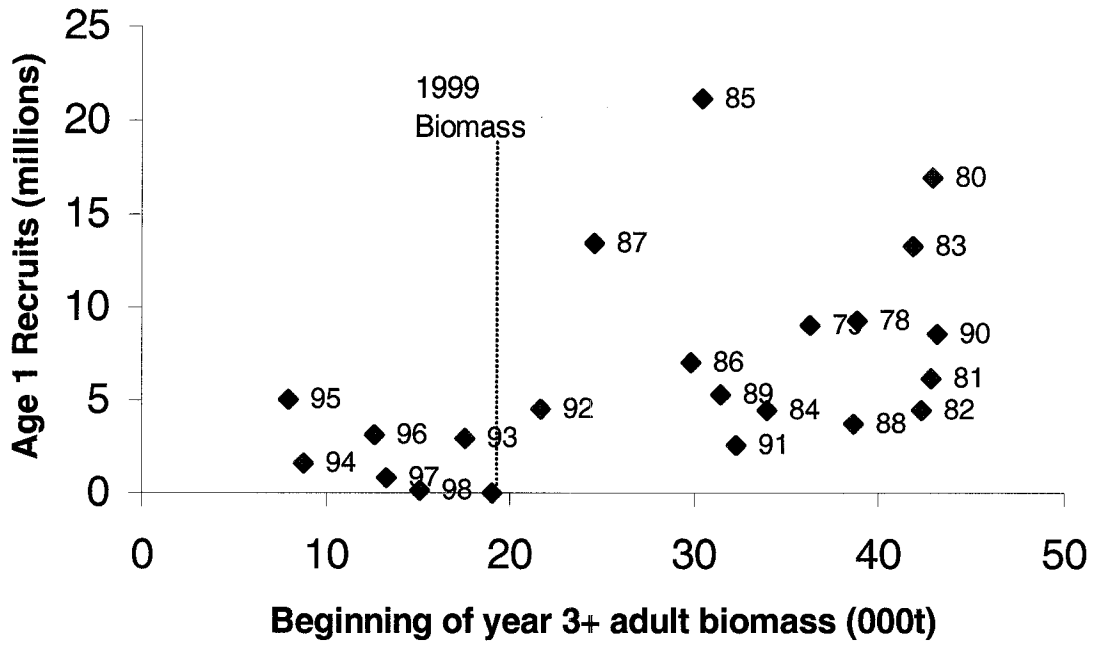Figure 17. Comparison of recruits at age 1 and adult biomass for 5Zj,m cod



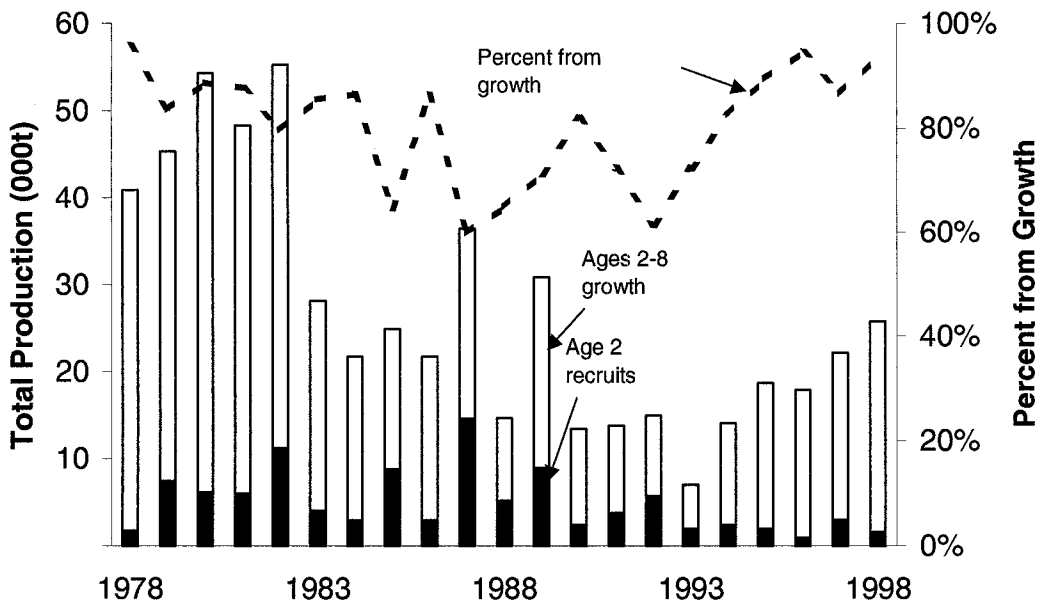Figure18. Comparison of population production from growth and from recruitment

Figure 19. Compariosn of surplus production (net production after accounting for growth, recruits and death) and yield for Georges Bank cod.