Northeast Fisheries Science Center Reference Document 99-03

Assessment of the Georges Bank Atlantic Cod Stock for 1998

by

Loretta O'Brien
and Steven X. Cadrin

February 1999

Northeast Fisheries Science Center Reference Document 99-03

A Report of the 27th Northeast Regional Stock Assessment Workshop

Assessment of the Georges Bank Atlantic Cod Stock for 1998

by

Loretta O'Brien and Steven X. Cadrin

National Marine Fisheries Serv., Woods Hole, MA 02543-1026

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
Northeast Fisheries Science Center
Woods Hole, Massachusetts

February 1999

Northeast Fisheries Science Center Reference Documents

This series is an informal report series designed to assure the long-term documentation and to enable the timely transmission of research results emanating from various Center laboratories. The reports in this series receive internal scientific review but no technical or copy editing. The National Marine Fisheries Service does not endorse any proprietary material, process, or product mentioned in these reports. To obtain additional copies of reports in this series, contact the senior Center author of the desired report. Refer to the title page of the desired report for the senior Center author's name and mailing address.

This report's publication history is as follows: manuscript submitted for review--July 7, 1998; manuscript accepted through technical review--July 31, 1998; manuscript accepted through policy review--February 12, 1999; and camera-ready copy submitted for publication-- February 16, 1999. This report may be cited as:

O'Brien, L.; Cadrin, S.X. 1999. Assessment of the Georges Bank Atlantic cod stock for 1998. *Northeast Fish. Sci. Cent. Ref. Doc.* 99-03; 138 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

ABSTRACT

This report presents an updated analytical assessment of the status of the Georges Bank cod (*Gadus morhua*) stock (NAFO Division 5Z and subarea 6) for the period 1978-1997 based on analysis of USA and Canadian commercial landings and effort data and research vessel survey data through 1997. Estimates of 1997 fishing mortality and spawning stock biomass, 1998 stock size, and the precision of the fishing mortality and spawning stock biomass estimates are presented. Short-term forecasts of landings in 1999 and the resulting spawning stock biomass in 2000 are given based on relevant 1999 fishing mortalities.

Total commercial landings of Georges Bank cod in 1997 were estimated at 10,435 mt, a 17% increase from the 8,900 mt landed in 1996. The USA fleet landed 72% of the total, a 7% increase from 1996. Commercial landings per unit of standardized effort declined steadily from 1982 to 1987, gradually increased until 1990, declined steadily to the lowest estimated values in 1995, and increased from 1996 to 1997. Fishery-independent surveys, conducted by the Northeast Fisheries Science Center, show a similar decline in both biomass and numbers of cod since 1982. The 1997 indices remain near or at record-low values. Recent recruitment indices of age 1 cod remain among the lowest in the time series.

Spawning stock biomass generally declined from about 90,000 mt in the early 1980s to a record low of 25,000 mt in 1994 and has increased to 36,000 mt in 1997. Fishing mortality doubled between 1979 and 1985, increased to a record high of 1.17 in 1994, an exploitation rate of about 64%, and has declined to 0.26 in 1997, an exploitation rate of about 21%. At the current level of exploitation, landings are expected to decrease in 1999 to about 9,800 mt and spawning stock biomass is projected to be about 35,000 mt in 2000.

INTRODUCTION

This report presents an updated and revised analytical assessment of the Georges Bank cod stock (NAFO Division 5Z and Subarea 6) for the period 1978-1997 based on analysis of commercial landings and effort data and research vessel survey data through 1997. The life history of Georges Bank cod and the commercial fishery are described in the previous assessment (O'Brien 1997, NEFSC 1997).

THE FISHERY

Commercial Landings

The methodology for proration of the commercial fishery landings data since 1994 is described in Wigley *et al.* 1998. The 1997 data were prorated using the same methodology, however, the criteria for matching the data was changed and resulted in a larger data set from which to prorate.

Total commercial landings of Georges Bank cod in 1997 were estimated at 10, 435mt, 17% higher than in 1996 (Table 1, Figure 1). The USA fleet landed 72% (7,500 mt) of the total, and the Canadian fleet landed the remaining 28% (2,900 mt).

Otter trawl landings from the USA and Canada accounted for about 54% of the total 1997. Otter trawls accounted for the majority (61%) of the USA landings (Table 2). In the Canadian fishery, the otter trawls and longlines accounted for 36% and 43%, respectively, of the cod landings (Hunt and Buzeta 1998). During 1978-1997, otter trawls accounted for 83% of the USA landings and 57% of the Canadian landings. The USA cod landings from Georges Bank continue to be dominated by 'market' cod in both weight (55%) and number (51%) in 1997 (Table 3). Historically, 'market' cod have accounted for 40-60% of the landings.

Commercial Discards

Preliminary estimates of discards on otter trawl and gillnet trips were derived for 1989-1997 using the Sea Sampling data base. Discard ratios were estimated as the amount of cod discarded to the amount kept. Discard ratios are presented in Table 4 for each quarter for catch taken in the western part (Statistical Areas 521, 522, 525, 526) and the eastern part (Statistical Areas 561, 562) of Georges Bank. In the otter trawl fishery, ratios ranged from 0 to 0.10, with less discarding occurring in the eastern part. In the gillnet fishery, discard ratios ranged from 0 to 0.19, but were predominantly less than 0.10. Discard estimates were not included in the assessment, however,

due primarily to the lack of data for 1978-1988.

Recreational Catches

The total cod caught during 1979-1997 by recreational fisherman ranged from 500 to 9,000 mt, accounting for 1-19% of the total landings (Table 5). Recreational landings increased by 28% in 1997 to an estimated 770 mt which represents 6.9% of the total cod landings.

In the previous assessment (O'Brien 1996), an analysis that incorporated recreational catches resulted in slightly elevated stock sizes with little change in the fishing mortality or the spawning stock biomass. Recreational catches have not been included in this assessment analysis, however, since a number of problems exist in estimating the quantity and size/age composition of the recreational catch by stock (Recreational Fisheries Statistics Working Group 1992). Among these are: (1) lack of recreational catch estimates in January and February when some party boats in Massachusetts, Rhode Island, and New York land cod; (2) inability to properly categorize catches of long-range trips (e.g., to Georges Bank) that are being made in increasing numbers by party boats from Maine to New York; (3) catch estimates for the Georges Bank stock are imprecise [i.e., relatively large CVs]; and (4) length frequency sampling intensity, particularly for the Georges Bank stock, is low and is probably insufficient to accurately characterize the size composition of the catch. Moreover, length frequency sampling is opportunistic and samples are not distributed in proportion to the catch by time, fishing mode, or state of landing.

Sampling Intensity

Commercial Landings

The numbers of samples taken for the length and age composition of the USA and Canadian commercial cod fishery for the Georges Bank region are summarized in Table 6. The average number of fish in each length sample is about 80 for the USA and about 270 for Canada. Sampling intensity was high in 1997 with 1 sample per 94 mt for the US (Table 7) and 1 sample per 24 mt for the Canadian fishery. The spatial and temporal pattern of sampling for landings from the eastern part of Georges Bank for the US was minimal in 1997. There were only 2 samples taken in the 'market' category for quarters 2 and 3 in Statistical Areas 561 and 562. The distribution of sampling by market category (scrod: 34%, market: 49%, large: 18%) approximates the distribution of the 1997 landings in number by market category (Table 3).

Recreational Catch

Recreational landings are only sampled for length frequency. Since 1981, the number of fish sampled represent less than 0.1% of the total number landed. During 1981-1997, the number of fish measured ranged from 0.01 to 0.06% of the total number landed. In 1997, 0.01% of the fish landed were sampled.

Commercial Catch at Age

The age composition of the 1978-1993 USA landings was estimated, by market category, from monthly length frequency and age samples and pooled by calendar quarter. Landed mean weights were estimated by applying the cod length-weight equation:

$$\ln \text{Weight}_{(\text{kg.live})} = -11.7231 + 3.0521 \ln \text{Length}_{(\text{cm})},$$

to the quarterly length frequency samples, by market category. Numbers landed, by quarter, were estimated by dividing the mean weight values into the quarterly landings, by market category, and prorating the total numbers by the corresponding market category sample length frequency. Quarterly age-length keys were then applied to the numbers at length to estimate numbers at age. Annual estimates of catch at age were obtained by summing values over market category and quarter (Table 8). Derivation of catch by quarter, rather than by month, was performed since not all months had at least two length frequency samples per market category (i.e., minimum desired for monthly catch estimates).

The age composition of the 1994-1996 USA landings was also estimated, by market category, from monthly length frequency and age samples, but was pooled semi-annually due to insufficient samples within quarters. The consistency in the estimation of the catch at age from 1978-1993 was maintained by dis-aggregating the landings into eastern (SA 561-562) and western components (SA 521, 522, 525, 526). The age composition of the USA landings from the eastern component was estimated by applying USA length frequencies and combined USA and Canadian age samples, while the age composition of the USA landings from the western component was estimated by only applying USA length frequencies and age samples.

The age composition of the 1997 USA landings was estimated in a similar manner, however, due to the lack of length samples in the eastern component, the assumption was made that eastern and western length frequencies would be similar, therefore western length frequencies were used to characterize eastern component landings. The 1997 catch at age was then derived as described above for the 1978-1993 landings. The eastern and western components were pooled to obtain the age composition for USA Georges Bank cod landings for 1997. The USA eastern component was used in the Canadian assessment of cod in area 5Zj,m (Hunt and Buzeta 1998).

Canadian landings-at-age data (Table 9) from the eastern component (5Zj,m) for 1997 were provided by Hunt (pers. comm.). Canadian and USA data were combined to produce a total landings-at-age matrix for 1978-1997 (Table 10). The proportions of the total landings accounted for by the USA and Canada are also indicated in Table 10. Total commercial landings in 1997 were dominated by age 4 and 5 fish from the 1992 and 1993 year classes, respectively (Table 11). These two cohorts combined accounted for 55% of the 1997 landings by number and 61% by weight.

Commercial Mean Weights at Age

Mean weights at age for ages 1-10+ are summarized for USA, Canadian, and total landings in Tables 8-10. There does not appear to be any consistent trend in the mean weight by age during the 20-year time series. Anomalous weights in the older fish in recent years may be due to poorer sampling in these years. Beginning year stock mean weights at age, derived from catch mean weights at age (Rivard 1980), are presented in Table 12.

STOCK ABUNDANCE AND BIOMASS INDICES

Commercial Catch Rates

USA commercial landings per unit effort (LPUE) and standardized fishing effort and LPUE were derived for all interviewed otter trawl trips landing cod from Georges Bank and South as described in O'Brien (1997) and Mayo *et al.* (1994) (Table 13). Total standardized (raised) effort was then derived by dividing total USA landings by the standardized LPUE (Table 14).

Nominal LPUE and standardized LPUE exhibit similar trends and, since 1985, are almost equivalent (Table 14, Figure 2). Standardized LPUE peaked in 1980 at 2.9 mt/day fished and declined steadily from 1982 to 1986. LPUE then remained stable, increasing slightly, until 1990 when another sharp decline occurred until 1995. LPUE increased in 1996 and 1997 and is estimated to be about 0.6 mt/day fished in 1997. Standardized or raised effort and nominal effort have similar trends in general, although effort trends did diverge in both 1991 and 1995 (Figure 3). Raised effort more than doubled from 1978 to 1985, declined in 1986, and then increased to historic high levels until 1993. Standardized effort in 1997 has declined to about 45% of the 1996 estimate.

Under the current management restrictions of days at sea (DAS), greater mesh sizes, and closed areas, imposed in December of 1994, and the use of mandatory logbooks to collect effort data , implemented in May 1994, and other management measures, the 1994-1996 effort data may no longer be equivalent to the historic 1978-1993 effort series. Additionally, the effort estimates for 1994-1997 were derived from unaudited data. The LPUE series was, therefore, not used as an index of abundance in the subsequent calibration of the VPA.

Research Vessel Survey Indices

USA Surveys

NEFSC spring and autumn research bottom trawl surveys have been conducted off the Northeast coast of the USA since 1968 and 1963, respectively (Azarovitz 1981). Indices of abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) were estimated from both the spring and autumn surveys for Georges Bank cod during 1963-1997 (Table 15). Unstandardized and standardized catch per tow at age in number for NEFSC spring and autumn surveys are presented in Appendix 1: Tables 1-2.

NEFSC spring and autumn catch per tow biomass and abundance indices show similar trends throughout the time series (Table 15, Figures 4-5). Survey biomass indices were stable between 1963 and 1971 and then increased to a record high in 1973. Biomass generally declined over the next two decades, reaching record low levels between 1991 and 1994, increasing in 1995, but declining in both 1996 and 1997. The autumn estimate of stratified number per tow in 1997 was the lowest in the time series. Survey abundance indices for ages 1 and 2 indicate above-average recruitment for the 1966, 1971, 1975, 1980, 1983, 1985, 1988, and 1993 year classes (Figure 6). The magnitude of an above-average year class, however, has been declining over time, particularly noticeable in the recruits at age 1.

Canadian Surveys

Canadian research bottom trawl surveys have been conducted on Georges Bank during the spring since 1986. Indices of abundance for Canadian surveys are summarized as stratified mean number per tow during 1986-1998 (Appendix 1: Table 3). In 1993 and 1994, the Canadian survey did not sample the western part of Georges Bank (Canadian strata 5Z5 - 5Z7) and, therefore, was not used in the calibration of the VPA. Survey abundance indices indicated a steady decline in total numbers of cod from 1990 to 1995, followed by an increase in 1996 dominated by the 1994 year class at age 4. The 1998 index increased slightly and is dominated by the 1995 year class.

MORTALITY

Total Mortality

Pooled estimates of instantaneous total mortality (Z) were estimated for eight time periods from both spring and autumn survey catch per tow indices (Table 16, Appendix 2: Table 2). Estimates in the spring are less than in the autumn in all time periods except 1973-1976.

Total mortality decreased from a high of 0.73 during 1964-1967 to a record low of 0.34 during 1968-1972, then increased and remained stable between 0.56-68 during 1973-1984. Total mortality reached 1.10 during 1985-1987, declined to 0.6 during 1988-1990, increased to 1.45 during 1991-1993 and declined to 0.87 during 1994-1996.

ESTIMATES OF STOCK SIZE AND FISHING MORTALITY

Virtual Population Analysis Calibration

The ADAPT calibration method (Parrack 1986, Gavaris 1988, Conser and Powers 1990) was used to derive estimates of fishing mortality in 1997 and beginning-year stock sizes in 1998. The catch at age used in the VPA consisted of combined USA and Canadian commercial landings from 1978-1997 for ages 1-9 with a 10+ age group. The indices of abundance used to calibrate the VPA included the NEFSC 1978-1997 spring survey indices for ages 1-8, the Canadian 1986-1998 spring survey indices for ages 1-8, and the NEFSC 1977-1997 autumn survey indices for ages 0-6. The NEFSC spring survey was dis-aggregated into two series based on the use of the Yankee 36 or 41 trawls. The NEFSC employed the 41 trawl during 1973 to 1981. The spring indices were split into a index series for 1978-1981 for the 41 trawl and a series for 1982-1997 for the 36 trawl. The autumn survey indices were lagged forward one age and one year to match cohorts in the subsequent year.

Several trial ADAPT calibrations were performed and the results are presented in Table 17. The final ADAPT formulation provided stock size estimates for ages 1-8 in 1998 and corresponding F estimates for ages 1-7 in 1997. Assuming full recruitment at age 4, the F on ages 8 and 9 in the terminal year was estimated as the average of the F on ages 4-8. The F on age 9 in all years prior to the terminal year was derived from weighted estimates of Z for ages 4-9. For all years, the F on age 9 was applied to the 10+ age group. Spawning stock estimates were derived by applying pooled maturity ogives for 1978-1981, 1982-1985, 1986-1989, 1990-1993, and 1994-1997 (Table 18) derived from NEFSC spring research survey data using methodology described in O'Brien (1990). The new pooled ogives, estimated with current data, are more representative of the current population than the previous 1986-1996 pooled ogive (NEFSC 1997).

The final ADAPT calibration results are presented in Appendix 2 for estimates of F, stock size, and SSB at age and are summarized in Table 18. Estimates of stock size were more precise for ages 2-8, with CVs ranging from 0.26 to 0.33, than for age 1 (CV=0.51). The residual patterns of the indices did not show any strong trends for the four surveys (Figure 7). The natural logs of the observed survey indices, standardized to the mean, are presented in Figure 8.

Average fishing mortality (ages 4-8) in 1997 was estimated at 0.26, an increase of 30% from 1997 (Table 18, Figure 9). The 1997 estimate of SSB was 36,000 mt, only a 5% increase from 1996 (Table 18, Figure 10).

Since 1978, recruitment has ranged from 4 million (1994 year class) to 43 million (1985 year class), and in 1998, the 1997 year class is estimated to be less than a million fish (424,000). With

the exception of the slightly above-average 1990 year class, recruitment since 1989 has been at record low values. The 1994 and 1997 year classes are the poorest of the 20-year time series (Table 18, Figure 10).

Precision Estimates of F and SSB

A conditional non-parametric bootstrap procedure (Efron 1982) was used to evaluate the uncertainty associated with the estimates of fishing mortality and spawning stock biomass from the final VPA. One thousand bootstrap iterations were performed to estimate standard errors, coefficients of variation (CVs), and bias for age 1-8 stock size estimates at the start of 1998, the catchability estimates (q) for each index of abundance used in calibrating the VPA, and the F at ages 1-7 in 1997 (Appendix 3).

The bootstrap results indicate that stock sizes were well estimated for ages 1-8 with coefficients of variation (CVs) varying between 0.19 and 0.43. The CVs for the catchability coefficients for all indices ranged between 0.11 and 0.28. The fully recruited F for ages 4+ was well estimated with a CV=0.11 . The bootstrap estimate of 0.27 was only slightly higher than the NLLS estimate (Appendix 3). The distribution of the 1997 F estimates, derived from the 1,000 bootstrap iterations, ranged from 0.20 to 0.46 (Figure 11). There is an 80% probability that the F in 1997 is between 0.25 and 0.31 (Figure 11).

The spawning stock biomass was reasonably well estimated (CV=0.08) and slightly higher than the NLLS estimate of 36,600 mt (Appendix 3). The distribution of the 1997 spawning stock biomass estimates, derived from the 1000 bootstrap iterations, ranged from 28,000 to 50,000 mt (Figure 12). There is an 80% probability that the 1997 SSB is between 33,000 and 39,000 mt (Figure 12). There is 100% probability that SSB in 1997 is less than 70,000 mt, the SSB threshold for re-building specified in Amendment 7 of the New England Fishery Management Council (NEFMC) Multispecies Fishery Management Plan (NEFMC 1996).

Retrospective Analysis

A retrospective analysis was performed to evaluate how well the current ADAPT calibration would estimate spawning stock biomass, fishing mortality, and recruits at age 1 for the five years prior to the current assessment, 1992-1996. Convergence of the estimates generally occurs after about three years (Figures 13-15). With the exception of 1996, the retrospective analysis indicates a pattern of closely estimating or underestimating the recruits at age 1 (Figure 13) . Estimates of SSB appear to be overestimated, but then converge after about 3 years (Figure 14). Estimates of fishing mortality (F) do not show a consistent trend over the 5 year period (Figure 15). Fishing mortality was underestimated in 1996, 1995, and 1994 and was over estimated in 1993 and 1992. The very high overestimation of F in 1993 and the underestimation of F in 1994 is most likely due

to the lack of 1993 and 1994 Canadian survey indices in the current calibration. The actual ADAPT formulation employed for the 1994 assessment had Canadian survey (5Z j,m) indices for all years derived only for the eastern portion of the survey (Serchuk *et al.* 1994). The fishing mortality in the 1994 assessment was estimated to be 0.91 for 1994 (Serchuk *et al.* 1994).

BIOLOGICAL REFERENCE POINTS

Yield and Spawning Stock Biomass per Recruit

Yield, total stock biomass, and spawning stock biomass per recruit were estimated using methodology of Thompson and Bell (1934). The estimates were derived based on arithmetic means of the 1995-1997 catch mean weight at age and stock mean weight at age (Tables 10 and 12) and the 1994-1997 maturity ogive. A partial recruitment (PR) vector was calculated as the geometric mean of the 1994-1997 F estimates from the final VPA (Table 18), based on the change in mesh regulations in 1994. The final exploitation pattern was derived by dividing the PR by the geometric mean of the unweighted F for ages 4-8 and smoothed by applying full exploitation at ages 4 and older. The exploitation pattern of:

Age 1: 0.0000, Age 2: 0.17, Age 3: 0.66, Ages 4+: 1.000

reflects an increase in the exploitation at ages 2 and 3 compared to the previous assessment (NEFSC 1997). Input values for the yield-per-recruit analysis are provided in Table 19, and results of the analysis are provided in Table 19 and Figure 16. The resulting biological reference points were $F_{0.1}$= 0.18 and $F_{20\%}$= 0.41. The yield and spawning stock biomass per recruit was re-estimated to account for the updated maturity ogive. The values remained very near the previous analysis ($F_{0.1}$= 0.17, $F_{20\%}$= 0.43).

Stock Production Model - ASPIC

The ASPIC model (Prager 1994, 1995), a nonequilibrium stock production model incorporating covariates, was employed to estimate F_{msy} and B_{msy} for the Georges Bank cod stock. Results of a bootstrapped analysis are presented in Appendix 4. The NEFSC autumn indices were employed as a series of observed effort, and the NEFSC spring survey, split by gear type, and the Canadian spring survey were used as independent biomass indices.

The model fit the NEFSC autumn and spring 36 trawl well (R^2= 0.44 and 0.45), but fit the Canadian spring and NEFSC 41 trawl surveys poorly (R^2= -0.06 and -0.18). The residuals showed no pattern or trend, however, there was a large negative residual for NEFSC spring 1994 (Appendix 4).

The estimated average biomass was estimated with a similar trend, but higher than the VPA estimates from 1978-1988, and was estimated less than the VPA until 1996 (Figure 17). The model estimated an MSY of 33,000 mt and a B_{MSY} of 136,000 mt (Appendix 4). F_{MSY} was

estimated as 0.24, which is about equivalent to a fully recruited $F_{4-8} = 0.36$. The MSY was well estimated (IQ range=0.13), but B_{MSY} and F_{MSY} were not as well estimated (IQ range= 0.62 and 0.67, respectively).

A similar analysis has also recently been conducted for several groundfish species, including cod, by Cadrin *et al.* (1998). Comparison of the ASPIC analysis in this assessment with the ASPIC analysis conducted by Cadrin *et al.* (1998), which employed a constrained model, indicates that the latter analysis provides more precise estimates. Based on the results of Cadrin *et al.* (1998) and the control rule for the Sustainable Fisheries Act (SFA) requirements, proposed by the NEFMC Overfishing Definition Review Panel (NEFMC 1998), the target F_{SFA} should be 0.14, given the current biomass levels.

Stock-Recruitment Analysis

A Beverton-Holt stock-recruitment relationship was employed as an alternative model to estimate the biological reference points, B_{MSY} and F_{MSY}. Yield per recruit and the Beverton-Holt stock-recruitment curve were both used to estimate equilibrium yield, spawning stock biomass, and recruitment (Sissenwine and Shepherd 1987, Sinclair 1997). Beverton-Holt spawner-recruit parameters were estimated using non-linear regression (Hilborn and Walters 1992) and fitted with a Gauss-Newton iterative search algorithm (SAS 1990) using the 1978-1997 spawner and recruit data from this assessment. B_{MSY} was estimated to be about 257,000 mt with an MSY of 37,000 mt and an F_{MSY} of 0.15 (Figure 18). On the recommendation of the TRAC (Transboundary Assessment Review Committee), additional analyzes were performed that backcasted spawning stock biomass and recruits during 1963-1977, and these results are presented in Appendix 5.

PROJECTIONS

Short-term, three year stochastic projections were performed to estimate landings and SSB during 1998-2000 under the F scenarios of *status quo* $F_{98} = 0.26$, $F_{0.1} = 0.18$ and $F_{SFA} = 0.14$. Data input are the same as described in the yield-per-recruit analysis (Table 20). In addition, recruitment in 1998 was set at 424,000 fish, as estimated by the ADAPT formulation, and the recruitment for 1999 and 2000 was estimated by a random draw from the observed 1992-1998 recruitment at age 1 (Table 18). These most recent years of recruitment were chosen based on having been produced from similar levels of SSB.

Under a *status quo* F of 0.26, landings are projected to be about 9,800 mt in 1999, and then decline to 9,000 mt in 2000 (Table 20, Figure 19). SSB increases to about 39,400 in 1999 but declines to 35,300 mt in 2000. Fishing at $F_{0.1\%} = 0.18$, landings will decline to 7,050 mt in 1999 and remain about 6,900 mt in 2000. SSB will remain relatively stable, increasing in 1999 (39,900 mt) and declining in 2000 (38,500 mt). If fishing mortality is reduced to $F_{SFA} = 0.14$, landings will decline in 1999 to 5,600 mt and then increase in 2000 to 5,700 mt. SSB will increase in 1999 (40,200) mt and remain stable in 2000.

CONCLUSIONS

The Georges Bank cod stock is at a low biomass level and is over-exploited relative to the Amendment 7 rebuilding target (NEFMC 1996). Biomass indices derived from research surveys indicate that the stock remains near the 30-year record-low value. Fishing mortality declined from record-high levels in 1993 and 1994 (1.1,1.2) to an F in 1997 of 0.26, which is about 45% higher than $F_{0.1}$=0.18. Spawning stock biomass declined from about 90,000 mt in the early 1980's, reached a record-low (25,000 mt) in 1994, and remains near record-low size (36,000 mt) in 1997. Recruiting year classes continue to decline in size with the four most recent year classes (1994, 1995, 1996, 1997) being the lowest on record.

Accounting for the estimation uncertainty associated with the 1997 SSB (36,000 mt) and F (0.26) estimates, there is an 80% probability that the 1997 SSB is between 33,000 and 39,000 mt and that the F in 1997 is between 0.25 and 0.31. At the present level of exploitation (21%), given the probable level of recruitment, the SSB is expected to increase in 1999, but again decline just below the current value (36,000 mt) in 2000.

ACKNOWLEDGMENTS

I appreciate the constructive review of all of the members of the Transboundary Assessment Working Group: R. Brown, M. Buzeta, S. Cadrin, S. Gavaris, J.J. Hunt, P. Hurley, R.K. Mayo, J. Neilson, , K. Sosebee, M. Terceiro, L. Van Eeckhaute, S. Wigley. I also thank J.J Hunt and M. Buzeta for their continued cooperation in providing statistics for the Canadian fishery.

LITERATURE CITED

Azarovitz, T.R. 1981. A brief historical review of the Woods Hole Laboratory trawl survey time series. *In*: Doubleday, W.G. and D. Rivard (eds.), Bottom Trawl Surveys. Can. Spec. Publ. Fish. Aquat. Sci. 58: 62-67.

Cadrin, S., L. O'Brien, S. Wigley, R. Mayo. 1998. Conditioned surplus production analyses of several Northeast groundfish stocks. Working paper, NEFMC Overfishing Definition Review Panel.

Conser, R. J. and J. E. Powers. 1990. Extensions of the ADAPT VPA tuning method designed to facilitate assessment work on tuna and swordfish stocks. Int. Comm. Conserv. Atlantic Tunas, Coll. Vol. Sci. Pap. 32: 461-467.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. CAFSAC Res.Doc. 88/29: 12 p.

Hunt, J. J., and M.-I. Buzeta. 1998. Eastern Georges Bank Cod in 5Zj,m. Transboundary Asssessment Working Group, WP.

Mayo, R.K. T.E. Helser, L. O'Brien, K.A. Sosebee, B.F. Figuerido, and D. Hayes. 1994. Estimation of standardized otter trawl effort, landings per unit effort, and landings at age for Gulf of Maine and Georges Bank cod. NEFSC Ref. Doc. 94-12, 17 p.

NEFMC. 1996. Final Amendment #7 to the Northeast Multispecies Fishery Management Plan. New England Fisheries Management Council. 246 p.

NEFMC. 1998. Evaluation of existing overfishing definitions and recommendations for new overfishing definitions to comply with the Sustainable Fisheries Act. Overfishing Definition Review Panel. Final Report. 179 p

Northeast Fisheries Science Center. 1997. 24th Northeast Regional Stock Assessment Workshop (24th SAW). Stock assessment review committee (SARC) consensus summary of assessments.

O'Brien, L. 1990. Effects of fluctuations in stock abundance upon life history parameters of Atlantic cod, *Gadus morhua* L., for the 1970-1987 year classes from Georges Bank and the Gulf of Maine. Masters Thesis, University of Washington, Seattle. 95 p.

O'Brien, L. 1997. Assessment of the Georges Bank cod stock for 1997. SAW-24 SARC Working Paper B1.

O'Brien, L. and S. Cadrin 1997. Estimation of SFA requirements by applying a Beverton-Holt model derived from backcasted (1963-1977) and VPA (1978-1997) estimates of spawning stock biomass and recruitment. SAW 27/ SARC Working Paper A2.

Parrack, M.L. 1986. A method of analyzing catches and abundance indices from a fishery. Int Comm. Conserv. Atlantic Tunas, Coll. Vol. Sci. Pap. 24:209-221.

Prager, M.H. 1994. A suite of extensions to a nonequilibrium surplus-production model. Fish. Bull. 92: 374-389.

Prager, M.H. 1995. User's manual for ASPIC: a stock production model incorporating covariates, program version 3.6x. Miami Lab. Doc. MIA-92/93-55.

Rivard, D. 1980. APL programs for stock assessment. Can Tech. Rep. Fish. Aquat. Sci. 953: 103 p.

Serchuk, F.M., R.K. Mayo, and L. O'Brien. 1994. Assessment of the Georges Bank Cod Stock for 1994. NEFSC Ref. Doc. 94-25, 88 p.

Sinclair, A. 1997. Biological reference points relevant to a precautionary approach to fisheries management : and example for southern Gulf of St. Lawrence cod. NAFO SCR Doc 97/77 16 p.

Sissenwine, M.P. and J.G. Shepherd. 1987. An Alternative perspective on recruitment overfishng and biological reference points. Can. J. Fish. Aquat. Sci. 44: 913-918.

Thompson, W.F. and F.H. Bell. 1934. Biological statistics of the Pacific halibut fishery. 2.Effect of changes in intensity upon total yield and yield per unit of gear. Rep. Int. Fish. (Pacific Halibut) Comm. 8: 49 p.

Wigley, S.E., M. Terceiro, A. DeLong, and K. Sosebee. 1998. Proration of 1994-1996 USA commercial landings of Atlantic cod, haddock, and yellowtail flounder to unit stock areas. NEFSC Ref. Doc. 98-02. 32p.

Table 1. Commercial landings (metric tons, live) of Atlantic cod from Georges Bank and South (Division 5Z and Subarea 6), 1960 - 1997.

	Country						
Year	USA	Canada	USSR	Spain	Poland	Other	Total
1960	10834	19	-	-	-	-	10853
1961	14453	223	55	-	-	-	14731
1962	15637	2404	5302	-	143	-	23486
1963	14139	7832	5217	-	-	1	27189
1964	12325	7108	5428	18	48	238	25165
1965	11410	10598	14415	59	1851	-	38333
1966	11990	15601	16830	8375	269	69	53134
1967	13157	8232	511	14730	-	122	36752
1968	15279	9127	1459	14622	2611	38	43136
1969	16782	5997	646	13597	798	119	37939
1970	14899	2583	364	6874	784	148	25652
1971	16178	2979	1270	7460	256	36	28179
1972	13406	2545	1878	6704	271	255	25059
1973	16202	3220	2977	5980	430	114	28923
1974	18377	1374	476	6370	566	168	27331
1975	16017	1847	2403	4044	481	216	25008
1976	14906	2328	933	1633	90	36	19926
1977	21138	6173	54	2	-	-	27367
1978	26579	8778	-	-	-	-	35357
1979	32645	5978	-	-	-	-	38623
1980	40053	8063	-	-	-	-	48116
1981	33849	8499	-	-	-	-	42348
1982	39333	17824	-	-	-	-	57157
1983	36756	12130	-	-	-	-	48886
1984	32915	5763	-	-	-	-	38678
1985	26828	10443	-	-	-	-	37271
1986	17490	8411	-	-	-	-	25901
1987	19035	11845	-	-	-	-	30880
1988	26310	12932	-	-	-	-	39242
1989	25097	8001	-	-	-	-	33098
1990	28193	14310	-	-	-	-	42503
1991	24175	13455	-	-	-	-	37630
1992	16855	11712	-	-	-	-	28567
1993	14594	8519	-	-	-	-	23113
1994	9893	5276	-	-	-	-	15169
1995	6759	1100	-	-	-	-	7859
1996	7020	1885	-	-	-	-	8905
1997	7537	2898	-	-	-	-	10435

Table 2. Distribution of USA commercial landings (metric tons, live) of Atlantic cod from Georges Bank (Area 5Ze), by gear type, 1965 - 1997. The percentage of total USA commercial landings of Atlantic cod from Georges Bank, by gear type, is also presented for each year. Data only reflect Georges Bank cod landings that could be identified by gear type.

	Landings (metric tons, live)						Percentage of Annual Landings					
Year	Otter Trawl	Sink Gill Net	Line Trawl	Handline	Other Gear	Total	Otter Trawl	Sink Gill Net	Line Trawl	Handline	Other Gear	Total
1965	10251	0	582	505	9	11347	90.3	-	5.1	4.5	0.1	100.0
1966	10206	0	787	757	19	11769	86.7	-	6.7	6.4	0.2	100.0
1967	10915	0	894	704	9	12522	87.2	-	7.1	5.6	0.1	100.0
1968	12084	0	936	524	<1	13544	89.2	-	6.9	3.9	-	100.0
1969	13194	0	1371	387	<1	14952	88.2	-	9.2	2.6	-	100.0
1970	11270	0	1676	404	<1	13350	84.4	-	12.6	3.0	-	100.0
1971	12436	0	2334	230	2	15002	82.9	-	15.6	1.5	-	100.0
1972	10179	0	2071	217	10	12477	81.6	-	16.6	1.7	0.1	100.0
1973	12431	3	2185	206	21	14846	83.7	-	14.7	1.4	0.2	100.0
1974	14078	3	2548	11	9	16649	84.6	-	15.3	0.1	-	100.0
1975	12069	0	2435	84	4	14592	82.7	-	16.7	0.6	-	100.0
1976	12257	4	1519	153	5	13938	88.0	-	10.9	1.1	-	100.0
1977	18529	30	912	83	22	19576	94.7	0.2	4.7	0.4	0.1	100.0
1978	20862	81	1569	1180	59	23751	87.8	0.3	6.6	5.0	0.3	100.0
1979	26562	620	2707	860	159	30908	85.9	2.0	8.8	2.8	0.5	100.0
1980	32479	4491	1102	0	273	38345	84.7	11.7	2.9	-	0.7	100.0
1981	27694	3515	120	584	197	32110	86.2	10.9	0.4	1.8	0.6	100.0
1982	33371	2935	385	624	210	37525	88.9	7.8	1.0	1.7	0.6	100.0
1983	30981	1812	831	441	81	34146	90.7	5.3	2.4	1.3	0.3	100.0
1984	26161	2573	366	753	197	30050	87.1	8.6	1.2	2.5	0.6	100.0
1985	21444	2482	436	284	163	24809	86.4	10.0	1.8	1.1	0.7	100.0
1986	13576	1679	692	305	95	16347	83.0	10.3	4.2	1.9	0.6	100.0
1987	13711	1522	1636	222	71	17162	79.9	8.9	9.5	1.3	0.4	100.0
1988	20296	1864	1950	232	116	24458	83.0	7.6	8.0	0.9	0.5	100.0
1989	17946	3150	1583	119	91	22889	78.4	13.8	6.9	0.5	0.4	100.0
1990	21707[1]	2316	1252	395	133	25803	84.1	9.0	4.9	1.5	0.5	100.0
1991	17892[2]	2171	1919	286	180	22448	79.7	9.7	8.5	1.3	0.8	100.0
1992	11696[3]	1747	1709	186	114	15452	75.7	11.3	11.1	1.2	0.7	100.0
1993	10893[4]	1321	1316	62	78	13670	79.7	9.7	9.6	0.4	0.6	100.0
1994	7139	1318	1372	-[5]	21	9850	72.5	13.4	13.9	-	0.2	100.0
1995	3780	1300	1660	-[5]	18	6758	55.9	19.2	24.6	-	0.3	100.0
1996	4047	1552	1413	-[5]	6	7018	57.7	22.1	20.1	-	0.1	100.0
1997	4583	1595	1331	-[5]	28	7537	60.8	21.2	17.7	-	0.3	100.0

[1] Includes 849 tons taken by pair-trawl (Note: 1990 was the first year that pair-trawl landings exceeded a few tons)
[2] Includes 1068 tons taken by pair-trawl
[3] Includes 1149 tons taken by pair-trawl
[4] Includes 1352 tons taken by pair-trawl
[5] Handline included with line trawl

Table 3. Percentage, by weight and number of fish landed, of USA commercial Atlantic cod landings from Georges Bank and South (NAFO Division 5Z and Subarea 6), by market category, 1964 - 1997. Percent values, by number, are only available from 1978 onwards.

	Percentage by Weight				Percentage by Number			
Year	Large	Market	Scrod	Total [a]	Large	Market	Scrod	Total [a]
1964	45	47	8	100	-	-	-	-
1965	56	40	3	100	-	-	-	-
1966	53	37	10	100	-	-	-	-
1967	41	42	16	100	-	-	-	-
1968	34	46	19	100	-	-	-	-
1969	27	57	16	100	-	-	-	-
1970	30	62	8	100	-	-	-	-
1971	40	51	9	100	-	-	-	-
1972	37	53	10	100	-	-	-	-
1973	24	40	36	100	-	-	-	-
1974	24	59	17	100	-	-	-	-
1975	28	62	10	100	-	-	-	-
1976	34	48	18	100	-	-	-	-
1977	26	39	34	100	-	-	-	-
1978	29	60	11	100	14	64	22	100
1979	37	55	8	100	20	57	23	100
1980	42	47	11	100	20	53	27	100
1981	37	51	12	100	13	56	31	100
1982	31	47	22	100	10	42	48	100
1983	25	53	22	100	9	48	43	100
1984	32	56	12	100	13	60	27	100
1985	28	47	25	100	10	35	55	100
1986	31	48	21	100	11	46	43	100
1987	25	38	37	100	8	27	65	100
1988	24	48	28	100	9	43	48	100
1989	24	54	22	100	10	49	41	100
1990	23	45	32	100	9	36	55	100
1991	31	50	19	100	14	49	37	100
1992	31	42	27	100	12	37	51	100
1993	28	43	29	100	10	39	51	100
1994	27	52	21	100	11	49	40	100
1995	26	49	25	100	11	40	49	100
1996	23	57	20	100	12	54	34	100
1997	27	55	18	100	13	51	36	100

[a] Includes landings of 'mixed' cod.

Table 4. Estimates of the discard ratios of Georges Bank Atlantic cod in the otter trawl and gillnet fisheries, by quarter, in the western part (Statistical Area 521, 522, 525, 526) and the eastern part (Statistical Area 561, 562) of Georges Bank, 1989-1997. Number of tows in parentheses.

Otter trawl

Year	West	East	West	East	West	East	West	East
1989	0.029 (126)	0.018 (16)	0.054 (239)	0.027 (100)	0.073 (222)	0.043 (16)	0.057 (151)	0.030 (27)
1990	0.100 (175)	0.012 (63)	0.074 (130)	0.008 (20)	0.027 (116)	0.002 (14)	0.020 (172)	0.026 (35)
1991	0.005 (187)	0.016 (81)	0.032 (173)	0.027 (1)	0.020 (167)	-	0.075 (220)	-
1992	0.012 (121)	0.022 (120)	0.009 (108)	0.001 (21)	0.053 (67)	-	0.018 (90)	0.061 (31)
1993	0.053 (41)	0.017 (18)	0.023 (38)	0.018 (203)	0.088 (74)	-	0.030 (123)	0.015 (15)
1994	0.008 (172)	0.003 (114)	0.043 (36)	0.005 (172)	0.000 (13)	0.003 (43)	0.004 (49)	0.000 (10)
1995	0.004 (227)	0.002 (38)	0.032 (217)	0.001 (38)	0.010 (114)	0.000 (8)	0.012 (103)	0.001 (28)
1996	0.012 (99)	0.007 (30)	0.001 (165)	0.000 (124)	-	-	0.009 (58)	-
1997	0.008 (152)	-	0.000 (1)	-	0.004 (156)		0.022 (77)	

Gill Net

Year	West	East	West	East	West	East	West	East
1989	-	-	0.001 (3)	-	0.011 (58)	-	0.067 (36)	-
1990	0.017 (8)	-	0.017 (37)	-	0.072 (15)	-	0.142 (21)	-
1991	0.115 (4)	-	0.011 (220)	0.001 (14)	0.033 (508)	-	0.102 (128)	-
1992	0.033 (29)	-	0.046 (340)	0.030 (18)	0.028 (257)	-	0.040 (188)	-
1993	0.060 (83)	-	0.074 (140)	0.064 (5)	0.007 (9)	0.003 (5)	0.056 (197)	-
1994	0.124 (88)	-	-	-	0.043 (18)	-	0.070 (70)	-
1995	0.193 (32)	-	0.028 (40)	-	0.029 (35)	-	0.081 (44)	-
1996	0.017 (32)	-	0.080 (18)	-	0.146 (6)	-	0.050 (50)	-
1997	0.068 (28)	-	0.049 (23)	-	0.020 (22)		0.180 (6)	

Data entered as of 5/21/98

Table 5. Estimated number (000's) and weight (metric tons, live) of Atlantic cod caught by marine recreational fishermen from the Georges Bank stock in 1960, 1965, 1970, 1974, and 1979 - 1997.[1]

	Total Cod Caught		Total Cod Retained (excluding those caught and released)			
Year	No. of Cod (000's)	Wt. of Cod (mt)	No. of Cod (000's)	Wt. of Cod (mt)	Mean Weight (kg)	Percent of Total Landings
1960	Not Estimated		Not Estimated		-----	-----
1965	Not Estimated		Not Estimated		-----	-----
1970	Not Estimated		Not Estimated		-----	-----
1974	Not Estimated		Not Estimated		-----	-----
1979	393	580	393	580	1.476	1.5
1980	186	471	133	270	2.523	1.0
1981	1749	6265	1695	6074	3.161	12.5
1982	1650	4582	1600	4444	1.022	7.2
1983	1885	5994	1709	5435	2.860	10.0
1984	499	1385	464	1289	2.603	3.2
1985	2144	9075	2054	8693	3.619	18.9
1986	354	1060	291	872	2.311	3.3
1987	472	797	434	734	2.539	2.3
1988	1321	4368	1102	3643	3.096	8.5
1989	567	1979	404	1411	3.517	4.1
1990	586	989	463	782	2.728	1.8
1991	485	1908	333	1308	3.356	3.4
1992	265	556	193	405	2.046	1.4
1993	1106	2856	755	1948	1.864	7.8
1994	437	1458	303	1010	2.140	6.2
1995	742	2080	471	1320	2.272	14.4
1996	235	817	174	603	3.059	6.3
1997	392	1220	247	769	2.591	6.9

[1] From 1979-1993 Marine Recreational Fishery Statistics Survey expanded catch estimates, 1981 to present estimated from new MRFSS methodology (1 January 1997).

Table 6. USA and Canadian sampling of commercial Atlantic cod landings from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978 - 1997.

	USA[3]				Canada			
	Length Samples		Age Samples		Length Samples		Age Samples	
Year	No.	# Fish Measured	No.	# Fish Aged	No.	# Fish Measured	No.	# Fish Aged
1978	88	6841	76	1463	29	7684	29	1308
1979	80	6973	79	1647	13	3991	12	656
1980	69	4990	67	1119	10	2784	10	536
1981	57	4304	57	1231	17	4147	16	842
1982	151	11970	147	2579	17	4756	8	858
1983	146	12544	138	2945	15	3822	14	604
1984	100	8721	100	2431	7	1889	7	385
1985	100	8366	100	2321	29	7644	20	1062
1986	94	7515	94	2222	19	5745	19	888
1987	80	6395	79	1704	33	9477	33	1288
1988	76	6483	76	1576	40	11709	40	1984
1989	66	5547	66	1350	32	8716	32	1561
1990	83	7158	83	1700	40	9901	40	2012
1991	88	7708	88	1865	45	10873	45	1782
1992	77	6549	77	1631	48	10878	48	1906
1993	82	6636	82	1598	51	12158	51	2146
1994	58	4688	54	1064	104	25845	101	1268
1995	40	2879	40	778	36	11598	36	548
1996	55	4600	54	1080	129	26663	129	879
1997	80	6638	80	1581	118	31882	38	1244

Table 7. USA sampling of commercial Atlantic cod landings, by market category, for the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978 - 1997.

	Number of Samples, by Market Category & Quarter															Annual Sampling Intensity			
	Scrod					Market					Large					No. of Tons Landed/Sample			
Year	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Scrd	Mkt	Lge	Σ
1978	17	15	6	3	41	9	12	13	9	43	1	0	1	2	4	69	374	1922	302
1979	2	5	14	8	29	6	19	11	8	44	2	0	4	1	7	88	407	1742	408
1980	7	10	13	4	34	12	14	5	1	32	3	0	0	0	3	136	588	5546	580
1981	4	10	11	3	28	6	9	10	2	27	2	0	0	0	2	149	634	6283	594
1982	5	9	32	9	55	6	20	27	13	66	8	8	9	5	30	156	279	410	260
1983	4	12	17	10	43	12	19	22	14	67	2	15	16	3	36	185	291	259	252
1984	6	8	8	7	29	8	15	8	11	42	18	5	3	3	29	138	441	358	329
1985	6	7	16	5	34	11	11	12	8	42	4	8	7	5	24	201	299	310	268
1986	6	7	7	6	26	8	10	10	11	39	6	5	10	8	29	142	215	186	186
1987	7	8	6	8	29	6	8	9	10	33	6	6	4	2	18	240	220	267	238
1988	8	6	7	5	26	13	7	9	9	38	4	4	3	1	12	283	331	532	346
1989	2	7	9	9	27	7	8	8	7	30	3	4	1	1	9	210	450	660	380
1990	8	9	10	4	31	10	13	9	8	40	4	4	4	0	12	295	315	538	340
1991	6	11	7	5	29	12	13	8	8	41	4	6	3	5	18	158	293	423	275
1992	6	7	7	10	30	8	10	6	9	33	5	5	3	1	14	149	215	377	219
1993	5	16	7	6	34	10	10	7	9	36	6	1	3	2	12	126	173	339	178
1994	3	9	8	2	22	5	11	7	4	27	1	4	3	1	9	92	187	290	167
1995	2	3	13	2	20	2	4	10	2	18	0	1	0	1	2	83	181	880	167
1996	6	2	12	3	23	5	6	11	6	28	0	2	1	1	4	59	143	400	127
1997	3	11	3	10	27	5	16	9	9	39	3	6	0	5	14	50	105	148	94

Table 8. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of USA commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978 - 1997.

Year	Age 1	2	3	4	5	6	7	8	9	10+	Total
USA Commercial Landings in Numbers (000's) at Age											
1978	-	331	5731	1636	625	53	288	35	28	8	8735
1979	34	1618	572	4107	910	403	59	244	-	45	7992
1980	88	3002	4707	286	1888	951	413	76	153	-	11564
1981	25	3060	3613	1960	101	1026	330	72	109	46	10342
1982	325	7855	2466	1682	1258	117	452	116	50	57	14378
1983	81	3542	5557	1244	854	722	85	218	88	62	12453
1984	81	1281	3305	2961	500	393	386	25	153	82	9167
1985	130	4280	1539	985	1388	273	173	165	12	86	9031
1986	137	1091	3290	432	337	412	58	53	38	26	5874
1987	12	4878	804	1380	188	173	153	41	23	18	7670
1988	-	1345	5662	688	1076	175	100	86	21	18	9171
1989	-	1770	2638	3237	207	362	51	20	13	-	8298
1990	-	4603	3273	1265	1465	134	143	28	3	8	10922
1991	41	1032	2731	2040	873	572	52	23	8	3	7375
1992	-	2387	1268	746	936	217	133	9	12	3	5711
1993	-	781	3178	521	269	228	68	74	15	2	5136
1994	0.1	258	1186	1232	181	62	90	24	22	4	3059
1995	-	354	895	629	237	35	24	14	1	1	2190
1996	0.1	183	744	971	190	88	6	0.4	3	-	2185
1997	-	427	511	633	565	72	58	8	6	3	2283
USA Commercial Landings in Weight (Tons) at Age											
1978	-	430	14159	6041	2794	276	2168	274	356	81	26579
1979	30	2462	1411	17662	4525	2943	541	2507	-	564	32645
1980	74	4475	11663	1141	10937	6375	3504	657	1227	-	40053
1981	22	4592	8528	6644	524	7532	2773	716	1628	890	33849
1982	249	10960	7032	6465	6856	755	4281	1200	624	911	39333
1983	80	5303	13647	4271	4015	4628	679	2244	975	914	36756
1984	85	2099	8096	10650	2655	2655	3456	246	1739	1234	32915
1985	118	6094	3320	3930	7219	1746	1397	1707	148	1149	26828
1986	131	1586	7498	1475	1892	2964	528	537	507	372	17490
1987	10	6888	1953	5581	1063	1349	1306	392	242	251	19035
1988	-	2098	12981	2288	5677	1157	848	776	226	259	26310
1989	-	2958	5964	11861	1106	2403	439	209	157	-	25097
1990	-	7094	7411	4346	6902	817	1193	297	35	98	28193
1991	47	1615	6840	6943	4362	3526	406	285	96	55	24175
1992	-	3663	3040	2949	4470	1379	1070	93	137	54	16855
1993	-	1192	7081	1865	1417	1581	560	692	166	40	14594
1994	-	378	2491	4407	868	473	726	234	236	79	9893
1995	-	515	1810	2412	1314	267	253	161	9	20	6759
1996	-	275	1823	3303	915	593	64	3	45	-	7020
1997	-	678	1192	2301	2284	441	461	73	69	37	7537
USA Commercial Landings Mean Weight (kg) at Age											Mean
1978	-	1.298	2.470	3.692	4.473	5.199	7.522	7.924	12.794	10.125	3.043
1979	0.889	1.522	2.464	4.301	4.974	7.309	9.127	10.264	-	12.533	4.085
1980	0.839	1.490	2.478	3.992	5.792	6.703	8.489	8.648	8.046	-	3.464
1981	0.885	1.501	2.360	3.389	5.209	7.339	8.397	9.988	14.884	19.348	3.274
1982	0.767	1.395	2.852	3.845	5.449	6.457	9.473	10.297	12.434	15.982	2.736
1983	0.993	1.497	2.456	3.434	4.703	6.407	7.955	10.280	11.091	14.742	2.952
1984	1.053	1.638	2.450	3.597	5.308	6.751	8.960	9.710	11.361	15.049	3.590
1985	0.914	1.424	2.157	3.989	5.201	6.398	8.075	10.355	12.107	13.360	2.971
1986	0.957	1.454	2.279	3.414	5.608	7.198	9.066	10.135	13.339	14.308	2.978
1987	0.801	1.412	2.429	4.043	5.657	7.811	8.520	9.466	10.621	13.944	2.482
1988	-	1.559	2.293	3.326	5.278	6.629	8.487	9.067	10.606	14.389	2.869
1989	-	1.672	2.260	3.664	5.351	6.632	8.686	10.673	11.622	-	3.025
1990	-	1.541	2.264	3.436	4.712	6.103	8.366	10.482	10.246	12.250	2.581
1991	1.131	1.566	2.504	3.403	4.955	6.161	7.829	12.392	11.991	20.861	3.278
1992	-	1.535	2.397	3.951	4.775	6.359	8.035	10.457	11.107	17.418	2.951
1993	-	1.526	2.228	3.580	5.271	6.936	8.185	9.386	10.520	21.211	2.841
1994	0.900	1.463	2.101	3.577	4.804	7.591	8.089	9.786	10.980	19.055	3.234
1995	-	1.453	2.022	3.837	5.535	7.679	10.701	11.761	10.678	14.953	3.088
1996	-	1.503	2.451	3.400	4.825	6.727	10.497	8.346	13.836	-	3.212
1997	-	1.586	2.335	3.635	4.041	6.156	7.987	8.705	11.898	12.843	3.302

Table 8 continued. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of USA commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978 - 1997.

Year	Age 1	2	3	4	5	6	7	8	9	10+	Mean
					USA Commercial Landings Mean Length (cm) at Age						
1978	-	50.2	61.5	69.8	73.7	79.3	89.3	91.3	107.1	101.0	64.9
1979	44.7	52.9	61.0	73.9	77.5	88.2	95.3	99.4	-	106.1	70.9
1980	43.9	52.6	61.6	72.4	81.9	86.3	92.9	92.2	91.2	-	66.5
1981	44.6	52.3	60.4	68.5	78.4	88.7	93.1	98.2	112.8	123.2	64.6
1982	42.3	51.4	64.4	70.8	79.9	84.1	96.5	99.2	105.5	114.9	60.7
1983	46.3	52.7	61.5	68.1	75.9	84.5	90.7	99.1	101.5	111.7	63.3
1984	47.2	54.1	61.5	69.8	79.3	86.5	94.8	97.5	102.5	112.0	67.7
1985	45.1	51.8	58.6	72.4	79.0	84.5	91.4	99.4	104.7	107.9	62.5
1986	45.8	52.0	60.1	67.6	81.1	88.2	95.2	98.7	108.2	109.8	63.2
1987	43.3	51.7	61.3	72.7	81.6	90.9	93.2	96.6	100.1	110.1	59.4
1988	-	53.6	60.3	67.6	79.2	85.5	92.7	94.8	100.1	109.6	63.4
1989	-	54.7	60.1	70.0	79.3	85.3	94.2	100.4	103.6	-	64.8
1990	-	53.4	59.8	68.6	76.1	82.7	92.2	99.7	99.3	106.0	61.1
1991	48.4	53.5	62.1	68.0	77.5	82.8	90.0	106.1	105.7	125.8	66.3
1992	-	53.1	61.0	71.7	75.9	83.5	91.1	99.3	101.8	118.2	63.3
1993	-	53.1	59.8	69.4	78.4	87.0	91.7	96.1	99.8	126.0	63.0
1994	45.0	52.4	58.7	69.5	76.4	89.4	91.3	97.4	101.4	122.1	65.7
1995	-	52.4	57.8	71.0	81.0	89.9	100.9	104.3	100.9	113.0	64.6
1996	46.0	53.0	61.6	68.4	76.7	86.4	99.4	92.1	109.8	-	66.4
1997	-	53.8	60.6	69.9	71.9	83.5	91.1	93.7	104.4	107.0	66.5

Table 9. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of Canadian commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978 - 1997.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
				CAN Commercial Landings in Numbers (000's) at Age							
1978	2	62	2017	667	205	78	57	12	12	7	3119
1979	-	371	328	763	302	55	18	9	4	3	1853
1980	1	775	1121	214	420	125	32	11	14	10	2723
1981	2	145	608	504	134	380	87	51	21	16	1948
1982	6	1283	1358	1105	742	164	221	97	21	26	5023
1983	27	744	2506	1212	201	54	10	17	12	3	4786
1984	-	26	118	375	340	123	72	19	18	39	1130
1985	4	2146	904	383	497	139	45	38	9	11	4176
1986	19	235	1283	365	143	215	29	19	9	3	2320
1987	14	2595	602	741	91	79	117	22	15	6	4282
1988	10	232	2360	324	421	69	61	111	29	29	3646
1989	-	318	284	918	124	179	31	23	37	18	1932
1990	7	339	1769	617	799	95	102	8	14	30	3780
1991	11	493	512	1241	585	516	74	47	15	20	3514
1992	70	1790	902	292	546	187	176	25	21	7	4016
1993	4	252	1068	594	171	244	91	69	17	15	2525
1994	2	140	340	593	213	34	47	22	16	2	1409
1995	0.1	38	162	63	53	10	2	1	1	-	331
1996	0.6	24	159	262	51	35	9	2	1	0.2	545
1997	3	89	128	249	228	60	26	7	4	1	795
				CAN Commercial Landings in Weight (Tons) at Age							
1978	1	85	4913	1949	803	483	378	122	113	107	8778
1979	-	509	525	2842	1398	342	169	105	47	42	5978
1980	1	1041	2720	692	2099	809	228	133	177	157	8063
1981	2	197	1426	1772	699	2624	801	497	220	224	8499
1982	4	1853	3156	4217	3849	1074	2019	914	266	418	17824
1983	24	1084	5521	3854	876	335	80	176	147	37	12130
1984	-	38	292	1423	1615	743	622	202	195	620	5763
1985	3	3017	1775	1388	2370	895	368	369	94	160	10443
1986	14	369	3691	1442	800	1543	250	180	89	28	8411
1987	9	4183	1556	3302	557	596	1113	243	189	93	11845
1988	8	300	5942	1265	2406	462	564	1188	334	437	12932
1989	-	417	669	3812	678	1221	231	247	432	276	8011
1990	5	615	5001	2283	4173	631	876	85	187	454	14310
1991	12	866	1425	4278	2593	2885	527	451	127	291	13455
1992	80	2778	2308	1042	2501	1107	1252	241	265	138	11712
1993	3	393	2485	1852	767	1431	635	623	150	180	8519
1994	2	203	817	2266	1023	243	370	196	128	23	5272
1995	0.1	56	405	237	281	60	20	14	12	-	1085
1996	1	37	376	875	268	224	62	18	14	2	1877
1997	3	138	290	813	972	348	213	62	43	16	2898
				CAN Commercial Landings Mean Weight (kg) at Age							
1978	0.707	1.376	2.436	2.922	3.918	6.187	6.625	10.148	9.429	15.262	2.814
1979	-	1.371	1.601	3.725	4.630	6.222	9.365	11.638	11.699	14.064	3.226
1980	0.567	1.343	2.426	3.235	4.997	6.468	7.119	12.135	12.652	15.721	2.961
1981	0.839	1.362	2.345	3.516	5.216	6.905	9.204	9.747	10.465	13.993	4.363
1982	0.652	1.444	2.324	3.816	5.188	6.550	9.137	9.418	12.667	16.092	3.548
1983	0.904	1.457	2.203	3.180	4.357	6.203	8.042	10.368	12.222	12.270	2.534
1984	-	1.477	2.473	3.794	4.751	6.043	8.633	10.622	10.807	15.897	5.100
1985	0.686	1.406	1.964	3.625	4.768	6.440	8.181	9.718	10.499	14.537	2.501
1986	0.723	1.572	2.877	3.952	5.592	7.179	8.612	9.453	9.934	9.437	3.625
1987	0.661	1.612	2.584	4.456	6.125	7.540	9.510	11.031	12.629	15.444	2.766
1988	0.786	1.294	2.518	3.904	5.716	6.694	9.251	10.700	11.531	15.065	3.547
1989	-	1.310	2.356	4.153	5.471	6.820	7.459	10.757	11.680	15.356	4.141
1990	0.831	1.812	2.827	3.699	5.221	6.657	8.582	11.227	13.080	14.821	3.786
1991	1.051	1.756	2.783	3.447	4.432	5.591	7.116	9.604	8.457	14.550	3.829
1992	1.148	1.552	2.559	3.568	4.581	5.921	7.112	9.626	12.603	19.714	2.916
1993	0.872	1.557	2.327	3.116	4.489	5.858	7.006	9.035	8.974	12.173	3.374
1994	0.906	1.453	2.404	3.822	4.805	7.141	7.869	8.914	7.970	11.637	3.742
1995	0.906	1.472	2.495	3.759	5.298	6.313	10.903	10.181	10.175	-	3.284
1996	1.034	1.538	2.358	3.337	5.237	6.358	6.916	8.455	10.594	12.002	3.443
1997	0.954	1.536	2.264	3.269	4.257	5.855	8.190	8.546	11.825	12.688	3.644

Table 9 continued. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of Canadian commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978 - 1997.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total
					CAN Commercial Landings Mean Length (cm) at Age						
1978	39.5	48.9	59.0	63.3	69.6	81.2	82.5	98.3	94.7	112.8	61.8
1979	-	49.3	51.9	69.3	74.8	82.2	95.2	103.2	103.4	110.4	64.1
1980	36.6	48.9	59.5	66.2	76.4	83.6	86.6	104.7	105.7	114.6	61.7
1981	41.8	49.1	59.1	68.1	78.0	86.1	94.8	96.6	97.5	108.9	70.6
1982	38.3	50.1	58.9	70.0	77.8	84.4	94.9	95.2	106.4	115.3	65.5
1983	42.9	50.4	57.9	65.8	73.0	82.9	90.9	99.0	105.1	105.0	59.9
1984	-	50.7	60.4	70.0	75.7	82.3	92.3	100.1	100.8	114.5	75.6
1985	39.0	49.8	55.7	68.7	75.3	83.8	91.1	96.3	99.0	110.8	58.1
1986	39.6	51.7	63.5	71.0	79.6	86.8	92.8	95.9	96.3	96.1	67.2
1987	38.5	52.1	61.0	73.6	82.3	88.4	96.1	101.2	106.3	114.4	60.1
1988	40.8	48.3	60.5	70.4	80.2	84.8	95.2	99.9	102.5	112.2	65.8
1989	-	48.6	59.1	71.9	79.0	85.1	87.7	100.3	103.1	113.3	69.4
1990	41.7	54.3	63.1	69.0	77.6	84.0	92.0	102.0	107.4	112.1	68.2
1991	45.1	53.7	62.6	67.2	73.3	78.8	86.2	96.1	90.6	112.1	68.4
1992	46.2	51.4	60.6	67.7	73.8	80.6	85.4	94.8	105.8	115.1	61.1
1993	42.2	51.4	58.9	64.9	72.9	80.4	85.5	94.1	92.4	104.5	65.0
1994	43.0	50.3	59.6	69.8	75.3	85.9	89.4	93.0	88.6	102.6	67.9
1995	43.0	50.6	60.4	69.5	78.3	83.1	100.9	98.4	97.8	-	65.0
1996	44.9	51.3	59.3	66.6	77.7	83.3	84.7	90.8	99.9	104.6	66.4
1997	43.7	51.3	58.6	66.1	72.4	80.9	91.3	92.5	103.9	105.5	67.4

Table 10. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978 - 1997.

Year	Age 1	2	3	4	5	6	7	8	9	10+	Total	% of Total Landings USA	Canada
Total Commercial Landings in Numbers (000's) at Age													
1978	2	393	7748	2303	830	131	345	47	40	15	11854	73.7	26.3
1979	34	1989	900	4870	1212	458	77	253	4	48	9845	81.2	18.8
1980	89	3777	5828	500	2308	1076	445	87	167	10	14287	80.9	19.1
1981	27	3205	4221	2464	235	1406	417	123	130	62	12290	84.1	15.9
1982	331	9138	3824	2787	2000	281	673	213	71	83	19401	74.1	25.9
1983	108	4286	8063	2456	1055	776	95	235	100	65	17239	72.2	27.8
1984	81	1307	3423	3336	840	516	458	44	171	121	10297	89.0	11.0
1985	134	6426	2443	1368	1885	412	218	203	21	97	13207	68.4	31.6
1986	156	1326	4573	797	480	627	87	72	47	29	8194	71.7	28.3
1987	26	7473	1406	2121	279	252	270	63	38	24	11952	64.2	35.8
1988	10	1577	8022	1012	1497	244	161	197	50	47	12817	71.6	28.4
1989	-	2088	2922	4155	331	541	82	43	50	18	10230	81.1	18.9
1990	7	4942	5042	1882	2264	229	245	36	17	38	14702	74.3	25.7
1991	52	1525	3243	3281	1458	1088	126	70	23	23	10889	67.7	32.3
1992	70	4177	2170	1038	1482	404	309	34	33	10	9727	58.7	41.3
1993	4	1033	4246	1115	440	472	159	143	32	17	7661	67.0	33.0
1994	2	398	1526	1825	394	96	137	46	38	6	4468	68.5	31.5
1995	0.1	392	1058	692	290	44	26	15	2	1	2520	86.9	13.1
1996	0.7	207	903	1234	241	123	15	3	5	0.2	2731	80.0	20.0
1997	3	517	639	881	794	131	84	16	9	4	3078	74.2	25.8
Total Commercial Landings in Weight (Tons) at Age													
1978	1	515	18890	7990	3597	757	2549	395	465	198	35357	75.2	24.8
1979	30	2970	1936	20504	5923	3288	711	2611	44	606	38623	84.5	15.5
1980	75	5516	14382	1833	13036	7184	3735	793	1408	154	48116	83.2	16.8
1981	24	4789	9953	8416	1224	10156	3575	1212	1848	1151	42348	79.9	20.1
1982	253	12812	10187	10681	10705	1827	6303	2110	891	1388	57157	68.8	31.2
1983	105	6387	19167	8126	4891	4963	763	2418	1120	946	48886	75.2	24.8
1984	85	2137	8389	12074	4271	3401	4078	447	1938	1858	38678	85.1	14.9
1985	121	9111	5095	5319	9588	2644	1765	2073	246	1309	37271	72.0	28.0
1986	145	1955	11189	2917	2692	4505	776	717	596	409	25901	67.5	32.5
1987	19	11071	3509	8882	1619	1945	2416	633	426	360	30880	61.6	38.4
1988	8	2399	18923	3552	8085	1618	1412	1960	566	719	39242	67.0	33.0
1989	-	3375	6633	15673	1783	3625	669	455	588	298	33098	75.8	24.2
1990	5	7709	12412	6629	11075	1448	2069	382	222	552	42503	66.3	33.7
1991	59	2481	8265	11221	6955	6411	933	736	223	346	37630	64.2	35.8
1992	80	6441	5348	3991	6971	2486	2322	334	402	192	28567	59.0	41.0
1993	3	1585	9566	3717	2184	3012	1195	1315	316	220	23113	63.1	36.9
1994	2	581	3308	6673	1892	716	1095	430	364	103	15165	65.2	34.8
1995	0.1	577	2215	2649	1595	327	273	174	20	20	7851	86.1	13.9
1996	0.6	311	2199	4178	1183	817	127	21	59	2	8898	78.9	21.1
1997	3	816	1483	3114	3256	790	674	135	111	53	10435	72.2	27.8
Total Commercial Landings Mean Weight (kg) at Age											Mean		
1978	0.707	1.310	2.461	3.469	4.336	5.787	7.374	8.492	11.785	13.200	2.983		
1979	0.889	1.494	2.149	4.211	4.888	7.178	9.183	10.313	11.699	12.625	3.923		
1980	0.836	1.460	2.468	3.668	5.647	6.676	8.390	9.089	8.432	15.400	3.368		
1981	0.882	1.495	2.358	3.415	5.213	7.222	8.565	9.888	14.170	18.565	3.446		
1982	0.765	1.402	2.664	3.834	5.352	6.511	9.363	9.897	12.503	16.723	2.946		
1983	0.971	1.490	2.377	3.309	4.637	6.393	7.964	10.286	11.227	14.554	2.836		
1984	1.053	1.635	2.451	3.619	5.083	6.582	8.909	10.104	11.303	15.356	3.756		
1985	0.907	1.418	2.086	3.887	5.087	6.412	8.097	10.236	11.418	13.494	2.822		
1986	0.929	1.475	2.447	3.660	5.603	7.191	8.915	9.955	12.687	14.104	3.161		
1987	0.726	1.481	2.495	4.187	5.810	7.726	8.949	10.013	11.414	15.000	2.584		
1988	0.786	1.520	2.359	3.511	5.401	6.647	8.776	9.987	11.143	15.298	3.062		
1989	-	1.617	2.269	3.772	5.396	6.694	8.222	10.718	11.665	17.111	3.235		
1990	0.831	1.560	2.462	3.522	4.892	6.333	8.456	10.648	12.580	14.526	2.891		
1991	1.114	1.627	2.548	3.420	4.769	5.891	7.410	10.520	9.686	15.373	3.456		
1992	1.148	1.542	2.464	3.843	4.704	6.156	7.509	9.846	12.059	19.025	2.937		
1993	0.872	1.534	2.253	3.333	4.967	6.379	7.510	9.217	9.699	13.236	3.017		
1994	0.906	1.459	2.168	3.657	4.804	7.432	8.013	9.368	9.698	16.659	3.394		
1995	0.906	1.471	2.095	3.830	5.492	7.384	10.715	11.617	10.383	14.953	3.087		
1996	0.882	1.507	2.435	3.387	4.912	6.622	8.369	8.438	12.883	12.002	3.212		
1997	0.954	1.577	2.321	3.532	4.103	6.019	8.050	8.631	11.870	12.795	3.390		

Table 10 continued. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978 - 1997.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean
	Total Commercial Landings Mean Length (cm) at Age										
1978	39.5	50.0	60.8	67.9	72.7	80.4	80.2	93.1	103.4	106.5	64.1
1979	44.7	52.2	57.7	73.2	76.8	87.5	95.3	99.5	103.4	106.4	69.6
1980	43.8	51.8	61.2	69.7	80.9	86.0	92.4	93.8	92.4	114.6	65.6
1981	44.4	52.2	60.2	68.4	78.2	88.0	93.5	97.5	110.3	119.5	65.6
1982	42.2	51.2	62.4	70.5	79.1	84.3	96.0	97.4	105.8	115.0	61.9
1983	45.5	52.3	60.4	67.0	75.3	84.4	90.7	99.1	101.9	111.4	62.4
1984	47.2	54.0	61.5	69.8	77.8	85.5	94.4	98.6	102.3	112.8	68.6
1985	44.9	51.1	57.5	71.4	78.0	84.3	91.3	98.8	102.3	108.2	61.1
1986	45.0	51.9	61.1	69.2	80.7	87.7	94.4	98.0	105.9	108.4	64.3
1987	40.7	51.8	61.2	73.0	81.8	90.1	94.5	98.2	102.5	111.2	59.7
1988	40.8	52.8	60.4	68.5	79.5	85.3	93.6	97.7	101.5	111.2	64.1
1989	-	53.8	60.0	70.4	79.2	85.2	91.7	100.3	103.2	113.3	65.7
1990	41.7	53.5	61.0	68.7	76.6	83.2	92.1	100.2	106.0	110.8	62.9
1991	47.7	53.6	62.2	67.7	75.8	80.9	87.8	99.4	95.9	113.9	67.0
1992	46.2	52.4	60.8	70.6	75.1	82.2	87.9	96.0	104.3	116.0	62.4
1993	42.2	52.7	59.6	67.0	76.3	83.6	88.2	95.1	95.9	107.0	63.0
1994	43.1	51.7	58.9	69.6	75.8	88.2	90.7	95.3	95.9	115.8	65.8
1995	43.0	50.6	58.2	70.9	80.5	88.5	100.9	103.8	99.1	113.0	64.6
1996	45.1	52.7	61.2	68.0	76.9	85.5	90.7	91.0	106.9	104.6	66.4
1997	43.7	53.4	60.2	68.8	72.1	82.3	91.2	93.1	104.2	106.5	66.7

Table 11. Summary of USA and Canadian 1997 commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6).

	USA Catch at Age				Canadian Catch at Age				Total 1997 Catch at Age			
Age	Catch in Numbers (000's)	% of USA Total	Catch in Weight (mt)	% of USA Total	Catch in Numbers (000's)	% of CAN Total	Catch in Weight (mt)	% of CAN Total	Catch in Numbers (000's)	% of Total	Catch in Weight (mt)	% of Total
1	-	-	-	-	3	0.3	3	0.1	3	0.1	3	0.03
2	427	18.7	678	9.0	89	11.3	138	4.8	517	16.8	816	7.8
3	511	22.4	1192	15.8	128	16.1	390	10.0	639	20.8	1483	14.2
4	633	27.7	2301	30.5	249	31.3	813	28.0	881	28.6	3114	29.8
5	565	24.8	2284	30.3	228	28.7	972	33.6	794	25.8	3256	31.2
6	72	3.1	441	5.9	60	7.5	348	12.0	131	4.3	790	7.6
7	58	2.5	461	6.1	26	3.3	213	7.4	84	2.7	674	6.5
8	8	0.4	73	1.0	7	0.9	62	2.1	16	0.5	135	1.3
9	6	0.3	69	0.9	4	0.5	43	1.5	9	0.3	111	1.1
10+	3	0.1	37	0.5	1	0.2	16	0.6	4	0.1	53	0.5
Total	2283	100.0	7537	100.0	795	100.0	2898	100.0	3078	100.0	10435	100.0
	Mean Weight Per Fish (kg)		3.302		Mean Weight Per Fish (kg)		3.644		Mean Weight Per Fish (kg)		3.390	

Table 12. Mean weight at age (kg) at the beginning of the year (January 1) for Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978 - 1998. Values derived from landings mean weights-at-age using the procedures described by Rivard (1980).

	Year																				
Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.486	0.694	0.625	0.700	0.548	0.748	0.907	0.711	0.736	0.502	0.548	0.583	0.594	0.947	0.993	0.674	0.711	0.702	0.666	0.772	0.680
2	1.023	1.028	1.139	1.118	1.112	1.068	1.260	1.222	1.157	1.173	1.050	1.127	1.123	1.163	1.311	1.327	1.128	1.154	1.168	1.179	1.179
3	1.881	1.678	1.920	1.855	1.996	1.826	1.911	1.847	1.863	1.918	1.869	1.857	1.995	1.994	2.002	1.864	1.824	1.748	1.893	1.870	2.109
4	2.922	3.219	2.808	2.903	3.007	2.969	2.933	3.087	2.763	3.201	2.960	2.983	2.827	2.902	3.129	2.866	2.870	2.882	2.664	2.933	2.880
5	3.370	4.118	4.876	4.373	4.275	4.216	4.101	4.291	4.667	4.611	4.755	4.353	4.296	4.098	4.011	4.369	4.001	4.482	4.337	3.728	4.254
6	4.594	5.579	5.712	6.386	5.826	5.849	5.525	5.709	6.048	6.579	6.214	6.013	5.846	5.368	5.418	5.478	6.076	5.956	6.031	5.437	4.516
7	6.235	7.290	7.760	7.562	8.223	7.201	7.547	7.300	7.561	8.022	8.234	7.393	7.524	6.850	6.651	6.799	7.149	8.924	7.861	7.301	6.663
8	7.235	8.721	9.136	9.108	9.207	9.814	8.970	9.549	8.978	9.448	9.454	9.699	9.357	9.432	8.542	8.319	8.388	9.648	9.509	8.499	8.876
9	10.004	9.967	9.325	11.349	11.119	10.541	10.783	10.741	11.396	10.660	10.563	10.793	11.612	10.156	11.263	9.772	9.454	9.862	12.234	10.008	8.765
10+	13.200	12.625	15.400	18.565	16.723	14.554	15.356	13.494	14.104	15.000	15.298	17.111	14.526	15.373	19.025	13.236	16.659	14.953	12.002	12.795	12.795

Table 13. General linear model (GLM) analysis of LPUE of Georges Bank cod for interviewed trips landing cod during 1978-1993 as a function of year, area, quarter, tonnage class and depth with no interaction.

General Linear Models Procedure

Dependent Variable: LNCPUEDF

Source	DF	Sum of Squares	Mean Square	F Value	> F
Model	28	31732.79388553	1133.31406734	735.46	0.0001
Error	54356	83760.33125977	1.54095834		
Corrected Total	54384	115493.12514529			

R-Square	C.V.	Root MSE	LNCPUEDF Mean
0.274759	-549.0211	1.24135343	-0.22610303

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	15	12685.54117665	845.70274511	548.82	0.0001
AREA	5	5241.16957276	1048.23391455	680.25	0.0001
QTR	3	4097.78364005	1365.92788002	886.41	0.0001
TC2	3	6023.47684536	2007.82561512	1302.97	0.0001
DEPTH	2	3684.82265071	1842.41132535	1195.63	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	15	15953.77293165	1063.58486211	690.21	0.0001
AREA	5	7615.39757423	1523.07951485	988.40	0.0001
QTR	3	3159.27477519	1053.09159173	683.40	0.0001
TC2	3	6322.64153966	2107.54717989	1367.69	0.0001
DEPTH	2	3684.82265071	1842.41132535	1195.63	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate	Retransformed Estimate
INTERCEPT		0.760997649 B	26.75	0.0001	0.02844571	
AREA	522	-0.444577000 B	-29.48	0.0001	0.01507858	0.641168
	523	-0.010785910 B	-0.53	0.5968	0.02038704	0.989478
	524	-0.735978983 B	-41.37	0.0001	0.01778914	0.479112
	525	-0.843403568 B	-36.88	0.0001	0.02286656	0.430356
	526	-1.194326116 B	-60.80	0.0001	0.01964379	0.302966
	521	0.000000000 B	.	.	.	1.000000
QTR	1	-0.057274522 B	-3.86	0.0001	0.01482597	0.944439
	3	-0.621223632 B	-41.41	0.0001	0.01500215	0.537347
	4	-0.417172723 B	-26.54	0.0001	0.01571823	0.658989
	2	0.000000000 B	.	.	.	1.000000
Tonclass	31	-0.793757151 B	-32.66	0.0001	0.02430028	0.452276
	32	-0.540370836 B	-33.92	0.0001	0.01593153	0.582606
	41	0.433927651 B	33.67	0.0001	0.01288832	1.543435
	33	0.000000000 B	.	.	.	1.000000
DEPTHCD	1	0.731465629 B	48.11	0.0001	0.01520442	2.078364
	2	0.373888353 B	24.87	0.0001	0.01503558	1.453539
	3	0.000000000 B	.	.	.	1.000000

Table 14. Georges Bank cod landings (mt), nominal and standardized effort (days fished) and landings per day fished (LPUE), USA only.

Year	USA Landings Used in GLM (mt)	Nominal		Standardized		
		Effort	LPUE	Effort	LPUE	Raised Effort[1]
1978	15776	7980	1.977	5937	2.657	10003
1979	20584	9406	2.188	7720	2.666	12244
1980	25213	10080	2.501	8525	2.958	13543
1981	18339	9089	2.018	8130	2.256	15005
1982	23289	10045	2.319	8833	2.607	15087
1983	22072	11668	1.892	10561	2.090	17587
1984	19669	14641	1.343	12632	1.557	21140
1985	18012	16447	1.095	15045	1.197	22408
1986	11572	12520	0.924	11956	0.968	18072
1987	12731	14945	0.852	13942	0.913	20846
1988	19010	17769	1.070	17099	1.112	23666
1989	15557	15834	0.983	15581	0.998	25136
1990	18358	15882	1.156	15007	1.223	23047
1991	14173	14857	0.954	15085	0.940	25730
1992	8786	13606	0.646	12989	0.676	24919
1993	7749	12958	0.598	12883	0.602	24262
1994	3939	7397	0.532	6834	0.576	17166
1995	1951	6564	0.297	6166	0.316	21365
1996	2242	6200	0.362	5687	0.394	17806
1997	2683	5173	0.519	4782	0.561	13433

[1] Derived as total landings/ standardized LPUE.

Table 15. Standardized stratified mean catch per tow in numbers and weight (kg) for Atlantic cod in NEFSC offshore spring and autumn research vessel bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 1997. [a,b,c]

	Spring		Autumn	
Year	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	4.37	17.8
1964	-	-	2.98	11.6
1965	-	-	4.25	11.7
1966	-	-	4.81	8.1
1967	-	-	10.38	13.6
1968	4.72	12.6	3.30	8.6
1969	4.64	17.8	2.20	8.0
1970	4.34	15.6	5.07	12.5
1971	3.39	14.2	3.19	9.9
1972	8.97	19.0	13.09	23.0
1973	18.68 [d]	39.7 [d]	12.28	30.8
1974	14.75	36.4	3.49	8.2
1975	6.89	26.0	6.41	14.1
1976	7.06	18.6	10.44	17.7
1977	6.30	15.4	5.45	12.5
1978	12.31	31.2	8.59	23.3
1979	5.16	16.9	5.95	16.5
1980	6.12	16.7	2.91	6.7
1981	10.44	26.1	9.04	19.0
1982	8.20 [e]	15.4 [e]	3.71	6.9
1983	7.70	24.0	3.64	6.5
1984	4.08	15.4	4.75	10.3
1985	6.94	21.5	2.43	3.5
1986	5.04	16.7	3.12	4.7
1987	3.26	10.3	2.33	4.4
1988	5.86	13.5	3.11	5.8
1989	4.80	10.8	4.78	4.6
1990	4.74	11.6	3.62 [f]	7.1 [f]
1991	4.39	9.0	0.96	1.4
1992	2.67	7.5	1.84	3.1
1993	2.48	7.3	2.15	2.2
1994	0.94	1.2	1.82	3.3
1995	3.29	8.4	3.62	5.6
1996	2.70	7.5	1.10	2.7
1997	2.32	5.2	0.87	1.9

[a] During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFC 1991).

[b] Spring surveys during 1980-1982, 1989-1991 and 1994 and autumn surveys during 1977-1981, 1989-1991, and 1993 were accomplished with the *R/V Delaware II*; in all other years, the surveys were accomplished using the *R/V Albatross IV*. Adjustments have been made to the *R/V Delaware II* catch per tow data to standardize these to *R/V Albatross IV* equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFC 1991).

[c] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these gear differences.

[d] Excludes unusually high catch of 1894 cod (2558 kg) at Station 230 (Strata tow 20-4).
[e] Excludes unusually high catch of 1032 cod (4096 kg) at Station 323 (Strata tow 16-7).
[f] Excludes unusually high catch of 111 cod (504 kg) at Station 205 (Strata tow 23-4).

Table 16. Estimates of instantaneous total mortality (Z) and fishing mortality (F) for the Georges Bank cod stock for ten time-periods, 1964 - 1996, derived from NEFSC offshore spring and autumn bottom trawl survey data.[2]

Time Period	Spring Z	Spring F	Autumn Z	Autumn F	Geometric Mean Z	Geometric Mean F
1964-1967	-	-	0.73	0.53	0.73	0.53
1968-1972	0.34	0.14	0.35	0.15	0.34	0.14
1973-1976	0.70	0.50	0.56	0.36	0.63	0.43
1977-1981	0.47	0.27	0.67	0.47	0.56	0.36
1982-1984	0.42	0.22	1.12	0.92	0.68	0.48
1985-1987	0.84	0.64	1.45	1.25	1.10	0.90
1988-1990	0.60	0.40	0.60	0.40	0.60	0.40
1991-1993	1.04	0.84	2.02	1.82	1.45	1.25
1994-1996	0.54	0.34	1.39	1.19	0.87	0.67

[1]Instantaneous natural mortality (M) assumed to be 0.20.

[2]Estimates derived from:

Georges Bank spring: $\ln(\Sigma \text{ age } 4+ \text{ for years } i \text{ to } j / \Sigma \text{ age } 5+ \text{ for years } i+1 \text{ to } j+1)$.
Georges Bank autumn: $\ln(\Sigma \text{ age } 3+ \text{ for years } i-1 \text{ to } j-1 / \Sigma \text{ age } 4+ \text{ for years } i \text{ to } j)$.

Table 17. Parameter estimates of stock size, with CVs , fishing mortality and partial variance of the indices for three trial ADAPT calibrations for Georges Bank cod, 1997.

	BASE	Split 36 / 41	41 Trawl
Run #	6	9	10
# of surveys	3	4	3
N1	421	424	424
N2	5292	5283	5283
N3	3698	3718	3718
N4	1178	1202	1202
N5	2535	2841	2841
N6	1345	1516	1516
N7	420	479	479
N8	266	349	349
CV1	0.51	0.51	0.5
CV2	0.32	0.32	0.32
CV3	0.28	0.28	0.27
CV4	0.31	0.3	0.3
CV5	0.27	0.26	0.26
CV6	0.32	0.3	0.3
CV7	0.34	0.32	0.32
CV8	0.36	0.33	0.33
F4-8	0.3	0.26	0.26
pV usspr 1	1.12	0.955	0.961
pV usspr 2	0.14	0.144	0.145
pV usspr 3	0.132	0.109	0.11
pV usspr 4	0.172	0.197	0.199
pV usspr 5	0.334	0.368	0.371
pV usspr 6	0.704	0.873	0.879
pV usspr 7	0.52	0.541	0.545
pV usspr 8	0.603	0.398	0.401
pVcansp 1	0.53	0.526	0.532
pVcansp 2	0.238	0.241	0.243
pVcansp 3	0.079	0.072	0.073
pVcansp 4	0.209	0.194	0.196
pVcansp 5	0.276	0.142	0.144
pVcansp 6	0.47	0.363	0.367
pVcansp 7	1.018	0.939	0.949
pVcansp 8	0.991	0.632	0.638
pV autsp1	0.639	0.64	0.644
pV autsp2	0.251	0.25	0.251
pV autsp3	0.471	0.457	0.459
pV autsp4	0.419	0.41	0.412
pV autsp5	0.796	0.79	0.793
pV autsp6	0.477	0.472	0.474
pV 41sp1		2.475	
pV 41sp2		0.213	
pV 41sp3		0.195	
pV 41sp4		0.104	
pV 41sp5		0.202	
pV 41sp6		0.086	
pV 41sp7		0.456	
pV 41sp8		1.74	

Table 18. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F) and spawning stock biomass (mt) of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1978-1997.

Stock Numbers (Jan 1) in thousands

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	27714	23514	20105	41394	17471	9616	27397	8682	42813	16389	23486	15800	9355	19176	7957	10844	10116	3523	6246	6456	424
2	4268	22688	19221	16380	33867	14005	7775	22358	6987	34912	13395	19220	12936	7653	15653	6451	8874	8280	2884	5113	5283
3	25526	3139	16776	12319	10511	19459	7588	5183	12490	4521	21821	9540	13846	6120	4886	9036	4347	6906	6425	2174	3718
4	7947	13888	1756	8461	6267	5146	8636	3115	2033	6088	2429	10607	5166	6774	2076	2037	3556	2178	4696	4443	1202
5	2878	4422	6964	985	4698	2609	1991	4052	1313	943	3066	1073	4925	2527	2578	760	659	1260	1157	2729	2841
6	1124	1605	2524	3614	594	2037	1181	870	1612	640	520	1155	579	1984	750	769	224	183	769	730	1516
7	1434	802	900	1093	1686	232	965	500	339	752	296	205	456	267	640	248	203	97	110	519	479
8	67	862	587	334	518	772	104	376	212	199	372	97	94	152	104	244	59	42	56	76	349
9	146	12	477	402	162	231	419	45	124	109	106	126	40	44	61	55	70	7	21	43	48
10+	54	148	28	190	187	148	293	206	76	68	98	45	89	43	18	29	11	3	1	19	39
1 +	71158	71081	69337	85172	75960	54254	56350	45387	68000	64622	65589	57868	47488	44740	34723	30473	28120	22479	22365	22301	15898

Fishing Mortality

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2	0.11	0.10	0.24	0.24	0.35	0.41	0.21	0.38	0.24	0.27	0.14	0.13	0.55	0.25	0.35	0.19	0.05	0.05	0.08	0.12
3	0.41	0.38	0.48	0.48	0.51	0.61	0.69	0.74	0.52	0.42	0.52	0.41	0.51	0.88	0.67	0.73	0.49	0.19	0.17	0.39
4	0.39	0.49	0.38	0.39	0.68	0.75	0.56	0.66	0.57	0.49	0.62	0.57	0.52	0.77	0.80	0.93	0.84	0.43	0.34	0.25
5	0.38	0.36	0.46	0.31	0.64	0.59	0.63	0.72	0.52	0.40	0.78	0.42	0.71	1.02	1.01	1.02	1.08	0.29	0.26	0.39
6	0.14	0.38	0.64	0.56	0.74	0.55	0.66	0.74	0.56	0.57	0.73	0.73	0.57	0.93	0.91	1.13	0.64	0.31	0.19	0.22
7	0.31	0.11	0.79	0.55	0.58	0.60	0.74	0.66	0.33	0.51	0.92	0.58	0.90	0.74	0.76	1.23	1.37	0.35	0.16	0.20
8	1.48	0.39	0.18	0.52	0.61	0.41	0.63	0.91	0.47	0.43	0.88	0.67	0.55	0.71	0.45	1.04	1.94	0.50	0.06	0.26
9	0.36	0.44	0.49	0.44	0.66	0.65	0.60	0.72	0.54	0.49	0.74	0.58	0.62	0.86	0.91	1.04	0.91	0.38	0.31	0.26
10+	0.36	0.44	0.49	0.44	0.66	0.65	0.60	0.72	0.54	0.49	0.74	0.58	0.62	0.86	0.91	1.04	0.91	0.38	0.31	0.26
mn4-8,	0.54	0.35	0.49	0.47	0.65	0.58	0.64	0.74	0.49	0.48	0.79	0.59	0.65	0.83	0.79	1.07	1.17	0.38	0.20	0.26
mn3-6,	0.40	0.44	0.48	0.45	0.59	0.63	0.62	0.72	0.53	0.46	0.56	0.50	0.55	0.86	0.80	0.80	0.68	0.25	0.24	0.32

Table 18 continued. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F) and spawning stock biomass (mt) of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1978-1997.

SSB at the start of the spawning season - males and females (mt)

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	913	1104	850	1960	1200	903	3124	774	8525	2226	3485	2493	645	2106	916	848	278	96	159	193
2	1410	7539	6913	5782	16138	6345	4303	11653	5036	25369	8909	13745	6670	4294	9734	4168	4224	4032	1414	2516
3	33845	3729	22417	15929	15642	26060	10501	6879	18782	7116	32911	14555	22071	9170	7610	12976	6571	10529	10634	3425
4	20219	38256	4297	21379	15793	12649	21658	8076	4844	17034	6148	27285	12834	16565	5439	4787	8587	5649	11428	12094
5	8798	16585	30442	3958	17473	9639	7111	14910	5436	3939	12390	4214	18179	8458	8451	2710	2129	5202	4648	9222
6	4882	8130	12541	20323	2957	10520	5656	4244	8587	3706	2766	5950	2975	8817	3379	3374	1185	1000	4345	3698
7	8215	5550	5918	7296	12172	1460	6227	3166	2347	5367	2026	1329	2859	1563	3622	1330	1115	788	813	3544
8	367	6810	5034	2696	4165	6840	811	2986	1705	1693	2935	813	772	1231	801	1650	349	361	508	601
9	1331	112	3963	4097	1561	2113	3956	416	1251	1033	957	1196	410	374	572	435	553	63	235	398
10+	653	1681	388	3168	2710	1873	3940	2384	945	910	1285	675	1132	558	288	308	151	47	9	225
Total	80633	89496	92765	86590	89813	78403	67287	55488	57457	68393	73812	72255	68547	53137	40812	32587	25142	27767	34193	35915

Percent Mature (females)

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	7	7	7	7	13	13	13	13	28	28	28	28	12	12	12	12	4	4	4	4
2	34	34	34	34	47	47	47	47	67	67	67	67	52	52	52	52	44	44	44	44
3	78	78	78	78	84	84	84	84	91	91	91	91	90	90	90	90	93	93	93	93
4	96	96	96	96	97	97	97	97	98	98	98	98	99	99	99	99	100	100	100	100
5-10+	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 19. Yield and SSB per Recruit results for Georges Bank cod.

```
   The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
    PC Ver.1.2 [Method of Thompson and Bell (1934)] 1-Jan-1992
              ------------------------------------
              Run Date:  7- 4-1998;  Time: 17:28:09.47  Cod Georges Bank - 1998

Proportion of F before spawning:  .1667
Proportion of M before spawning:  .1667
Natural Mortality is Constant at:  .200
Initial age is:  1; Last age is: 10
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file: ==> GBYPR10P.DAT
```

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Stock
1	.0001	1.0000	.0400	.914	.711
2	.1700	1.0000	.4400	1.518	1.167
3	.6600	1.0000	.9300	2.283	1.837
4	1.0000	1.0000	1.0000	3.583	2.826
5	1.0000	1.0000	1.0000	4.835	4.182
6	1.0000	1.0000	1.0000	6.675	5.808
7	1.0000	1.0000	1.0000	9.044	8.028
8	1.0000	1.0000	1.0000	9.562	9.218
9	1.0000	1.0000	1.0000	11.712	10.700
10+	1.0000	1.0000	1.0000	13.250	13.250

Summary of Yield per Recruit Analysis for: Cod Georges Bank - 1998

```
 Slope of the Yield/Recruit Curve at F=0.00: -->   24.7823
   F level at slope=1/10 of the above slope (F0.1): ----->    .175
     Yield/Recruit corresponding to F0.1: ----->    1.6614
   F level to produce Maximum Yield/Recruit (Fmax): ----->    .340
     Yield/Recruit corresponding to Fmax: ----->    1.8051
   F level at 20 % of Max Spawning Potential (F20): ----->    .406
     SSB/Recruit corresponding to F20: -------->    5.0472
```

Listing of Yield per Recruit Results for:
Cod Georges Bank - 1998

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.000	.00000	.00000	5.5167	27.3986	3.9184	25.2391	100.00
	.050	.13115	.89059	4.8636	20.3778	3.2642	18.3023	72.52
	.100	.21908	1.34762	4.4265	16.0044	2.8262	13.9970	55.46
	.150	.28229	1.58847	4.1130	13.0878	2.5116	11.1361	44.12
F0.1	.175	.30759	1.66141	3.9877	11.9857	2.3858	10.0580	39.85
	.200	.33004	1.71408	3.8766	11.0438	2.2743	9.1382	36.21
	.250	.36748	1.77563	3.6918	9.5555	2.0886	7.6881	30.46
	.300	.39770	1.80069	3.5430	8.4381	1.9389	6.6026	26.16
Fmax	.340	.41785	1.80513	3.4440	7.7381	1.8392	5.9243	23.47
	.350	.42265	1.80475	3.4205	7.5772	1.8155	5.7687	22.86
	.400	.44364	1.79678	3.3176	6.8995	1.7119	5.1139	20.26
F20%	.406	.44587	1.79535	3.3068	6.8304	1.7009	5.0472	20.00
	.450	.46159	1.78208	3.2299	6.3559	1.6234	4.5898	18.19
	.500	.47715	1.76384	3.1542	5.9126	1.5469	4.1633	16.50
	.550	.49077	1.74397	3.0880	5.5458	1.4800	3.8111	15.10
	.600	.50284	1.72364	3.0296	5.2382	1.4209	3.5163	13.93
	.650	.51360	1.70352	2.9776	4.9774	1.3683	3.2667	12.94
	.700	.52329	1.68402	2.9310	4.7539	1.3210	3.0531	12.10
	.750	.53206	1.66535	2.8889	4.5605	1.2783	2.8684	11.36
	.800	.54006	1.64762	2.8506	4.3918	1.2395	2.7074	10.73
	.850	.54738	1.63085	2.8156	4.2433	1.2040	2.5660	10.17
	.900	.55412	1.61504	2.7835	4.1118	1.1713	2.4408	9.67
	.950	.56036	1.60016	2.7539	3.9945	1.1412	2.3292	9.23
	1.000	.56615	1.58616	2.7265	3.8892	1.1133	2.2291	8.83

Table 20. Summary of stochastic projections for Georges Bank cod for 1999-2000 fishing mortalities of $F_{0.1}$=0.18, F_{98}= 0.26, and F_{SFA}=0.14.

Input for Projections:

Number of Years: 3; Initial Year: 1998; Final Year: 2000
Number of Ages : 10; Age at Recruitment: 1; Last Age: 10
Natural Mortality is assumed Constant over time at: .20
Proportion of F before spawning: .1667
Proportion of M before spawning: .1667
Last age is a PLUS group.

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
1	.0001	1.0000	.0400	.914	.711
2	.1700	1.0000	.4400	1.518	1.167
3	.6600	1.0000	.9300	2.283	1.837
4	1.0000	1.0000	1.0000	3.583	2.826
5	1.0000	1.0000	1.0000	4.835	4.182
6	1.0000	1.0000	1.0000	6.675	5.808
7	1.0000	1.0000	1.0000	9.044	8.028
8	1.0000	1.0000	1.0000	9.562	9.218
9	1.0000	1.0000	1.0000	11.712	10.700
10+	1.0000	1.0000	1.0000	13.250	13.250

Projection results:

Year	Recruitment	F	Median Landings	Median SSB
1998	424	0.26	9390	39100
1999	6460	0.26	9830	39400
2000	6460	0.26	8990	35300
1998	424	0.26	9390	39100
1999	6460	0.18	7050	39900
2000	6460	0.18	6940	38500
1998	424	0.26	9390	39100
1999	6460	0.14	5580	40200
2000	6460	0.14	5710	40200

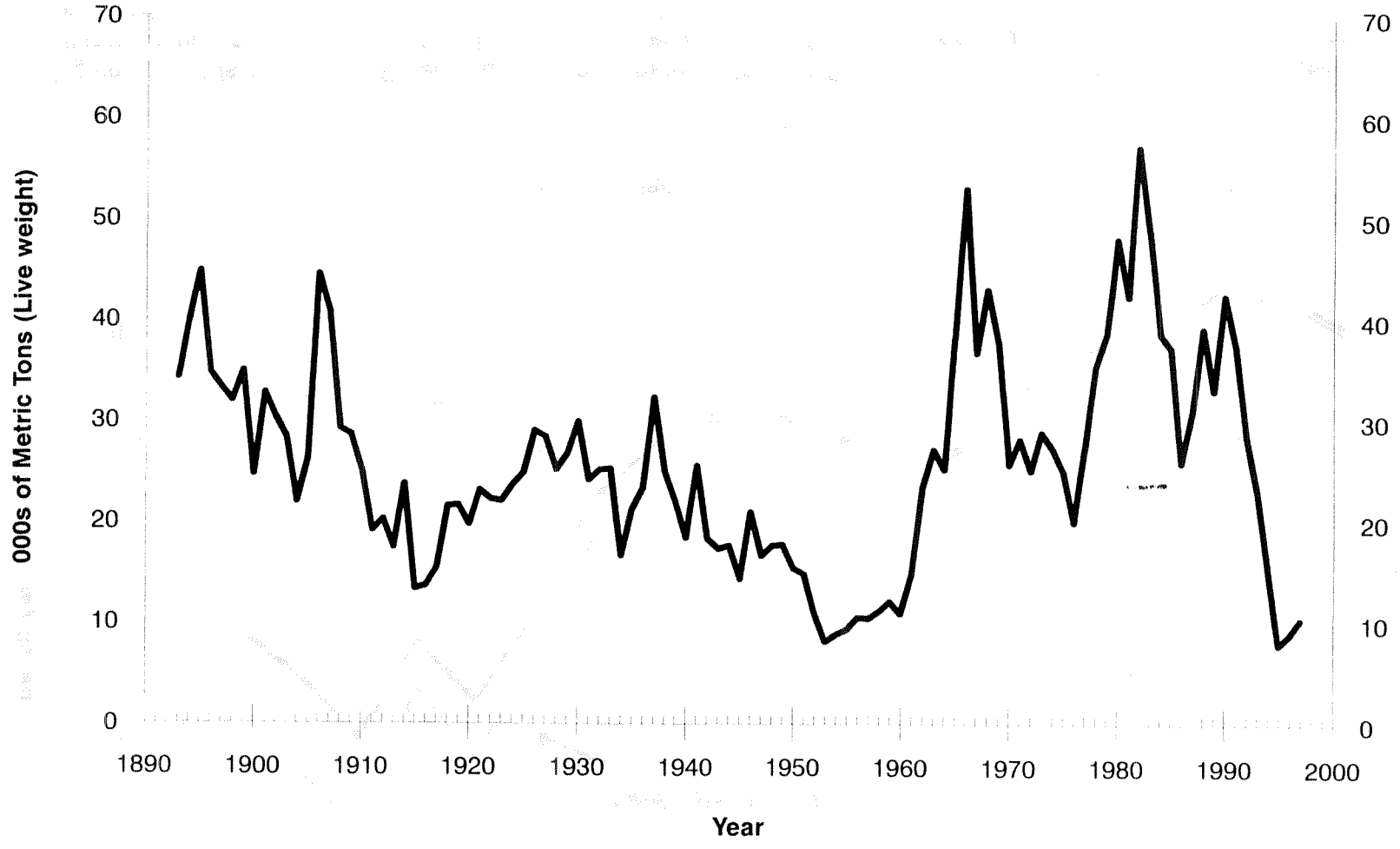


Figure 1. Total commercial landings of Georges Bank cod (Division 5Z and Subarea 6), 1893-1997.

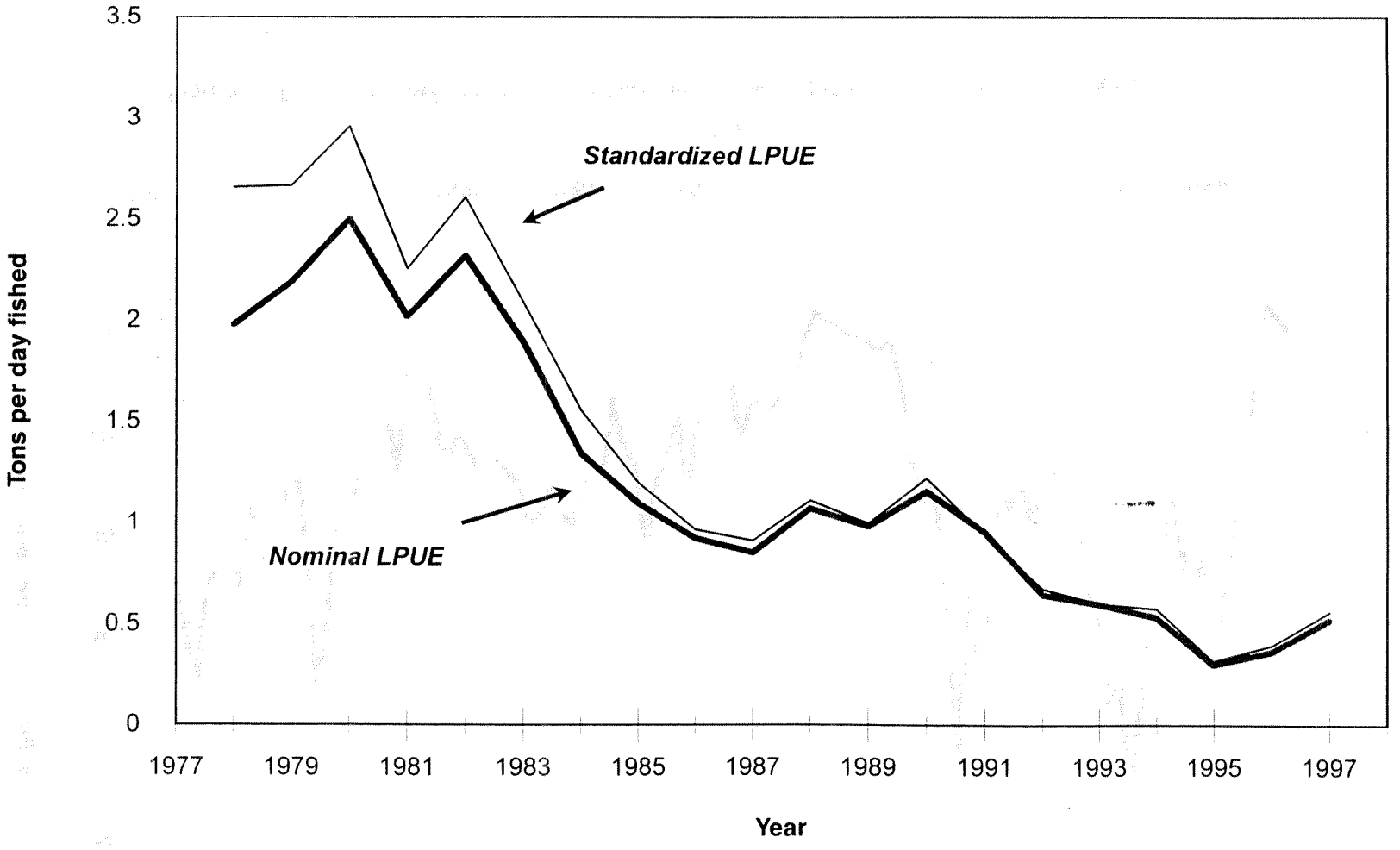


Figure 2. Trends in USA LPUE (landings per day fished) of Georges Bank cod, 1978-1997. Nominal LPUE is based on all otter trawl trips landing cod. Standardized LPUE is derived from a GLM incorporating year, tonnage class, area, quarter, and depth.

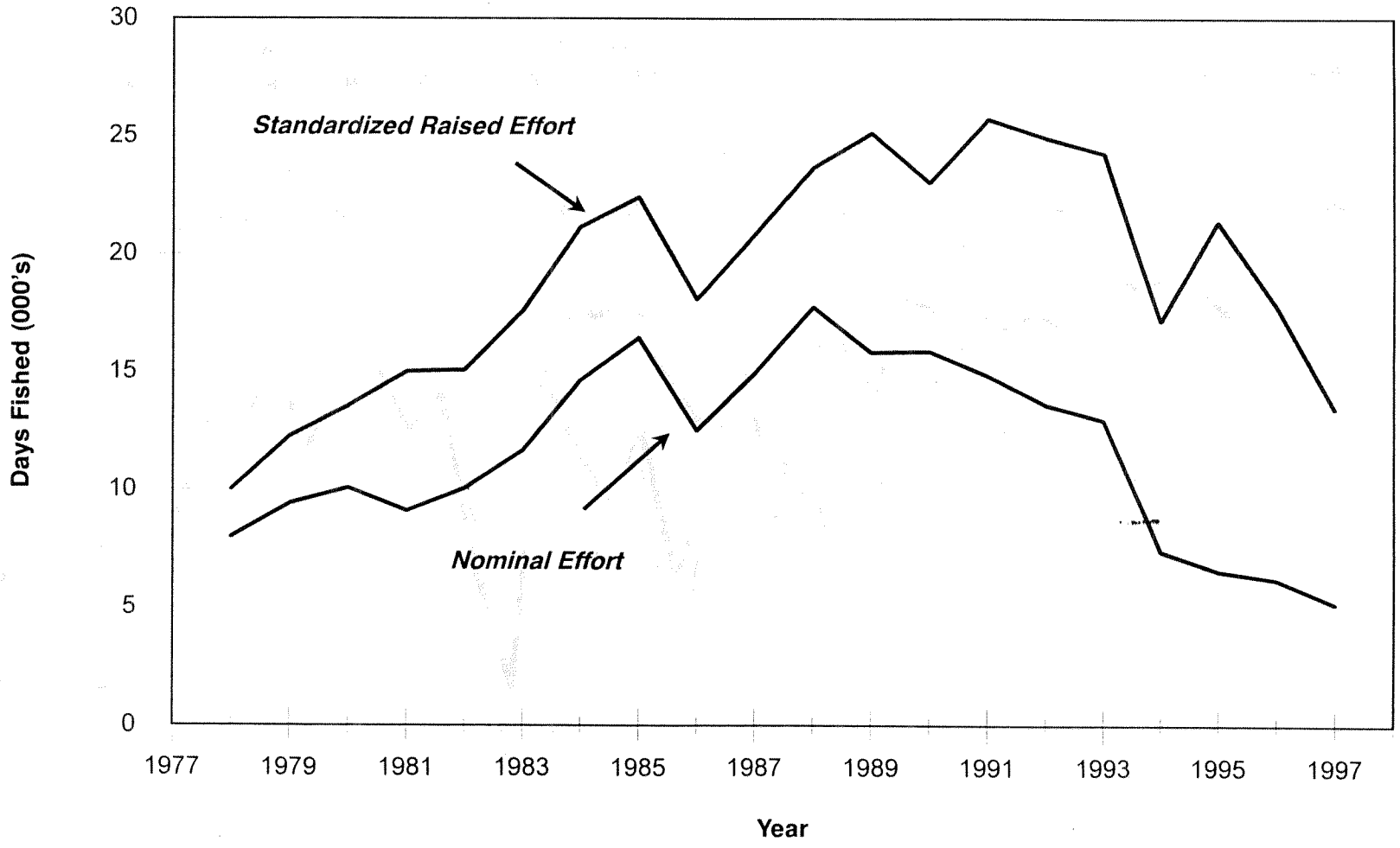


Figure 3. Trends in USA fishing effort (days fished) on Georges Bank, 1978-1997. Nominal effort based on all otter trawl trips landing cod. Standardized-raised effort derived from a GLM incorporating year, tonnage class, area, quarter, and depth.

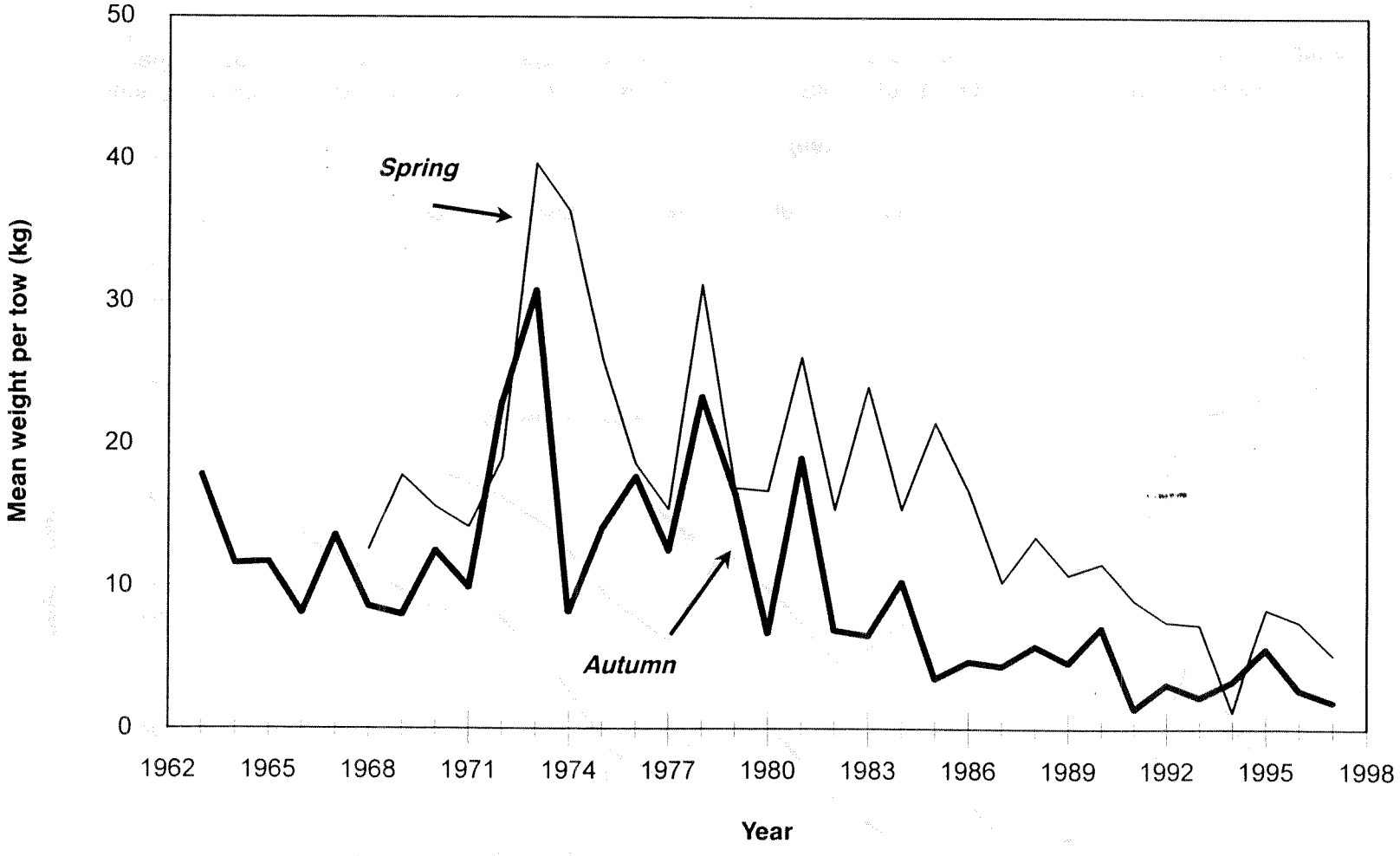


Figure 4. Standardized stratified mean catch per tow (kg) of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys on Georges Bank, 1963-1997.

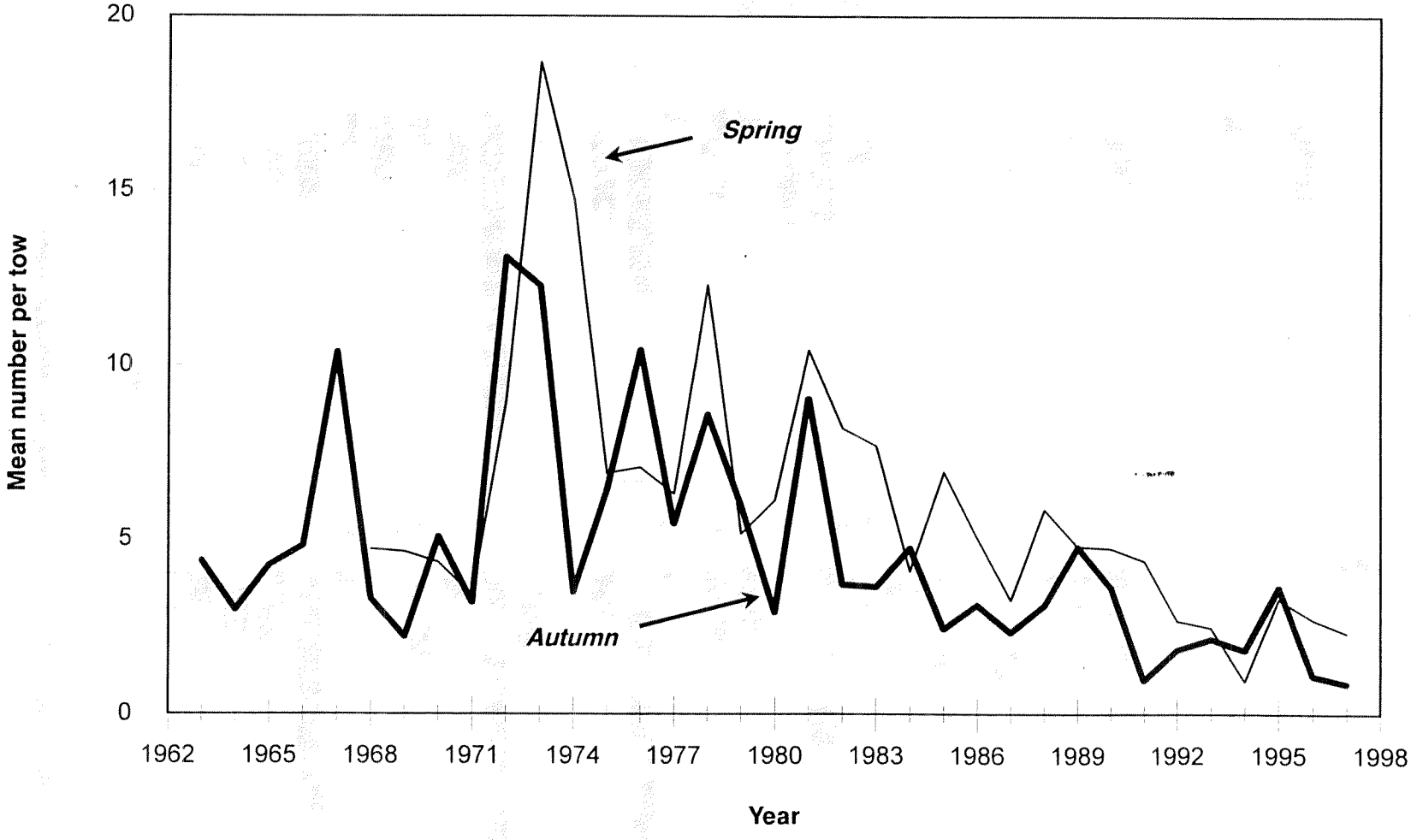


Figure 5. Standardized stratified mean number per tow of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys on Georges Bank, 1963 -1997.

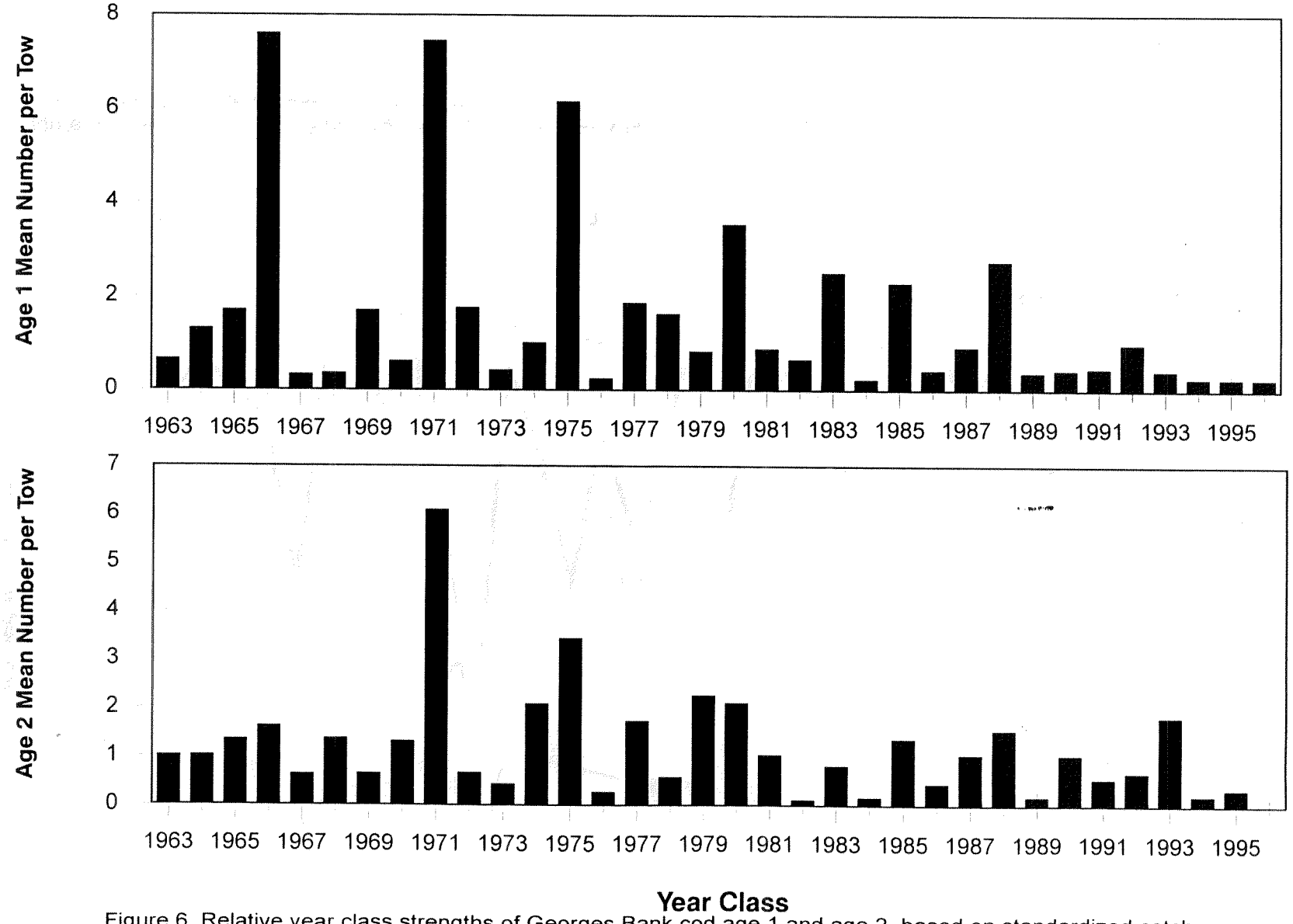


Figure 6. Relative year class strengths of Georges Bank cod age 1 and age 2 based on standardized catch (number) per tow indices from NEFSC autumn research vessel bottom trawl surveys, 1963-1997.

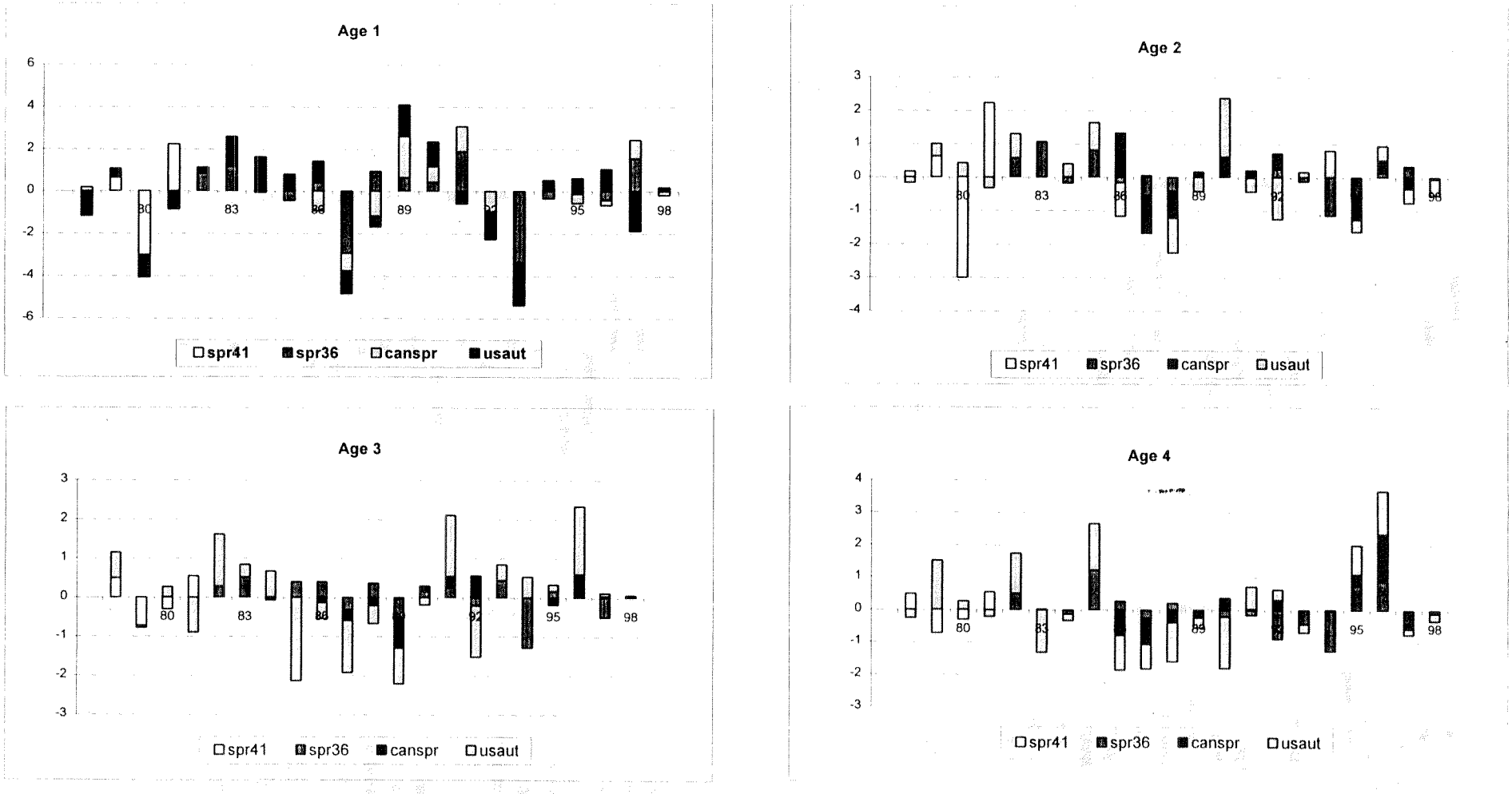
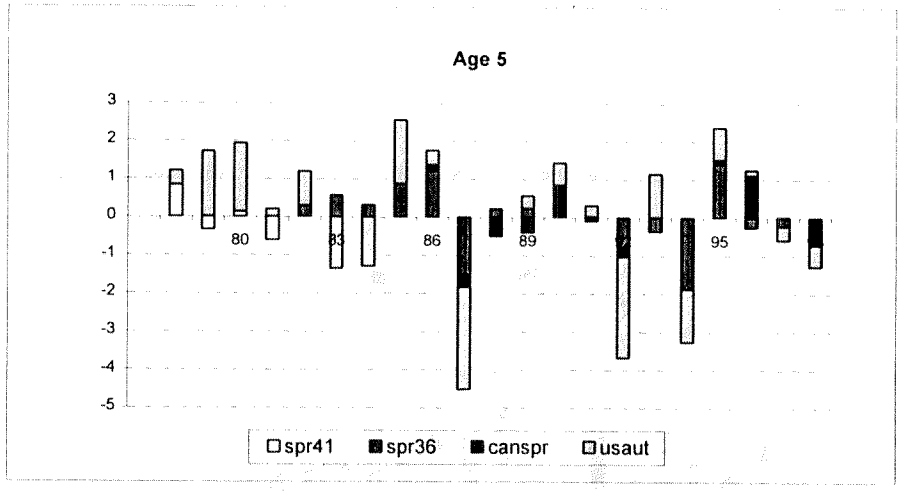
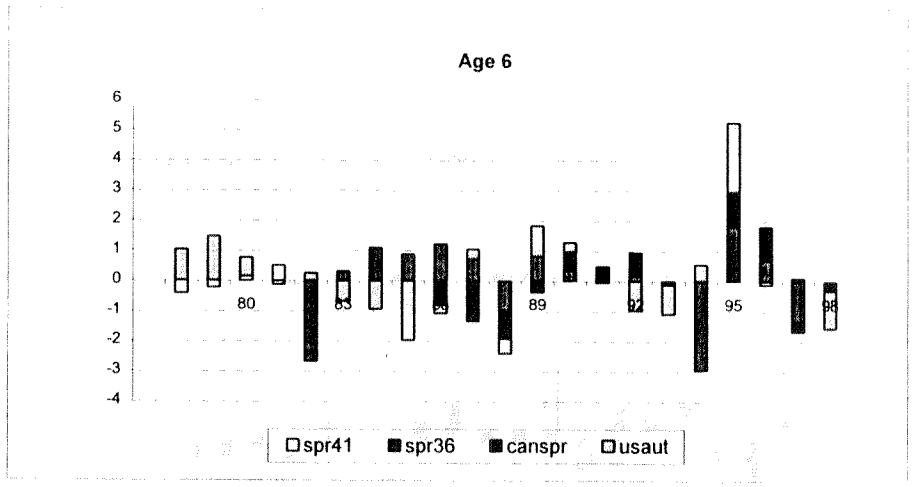
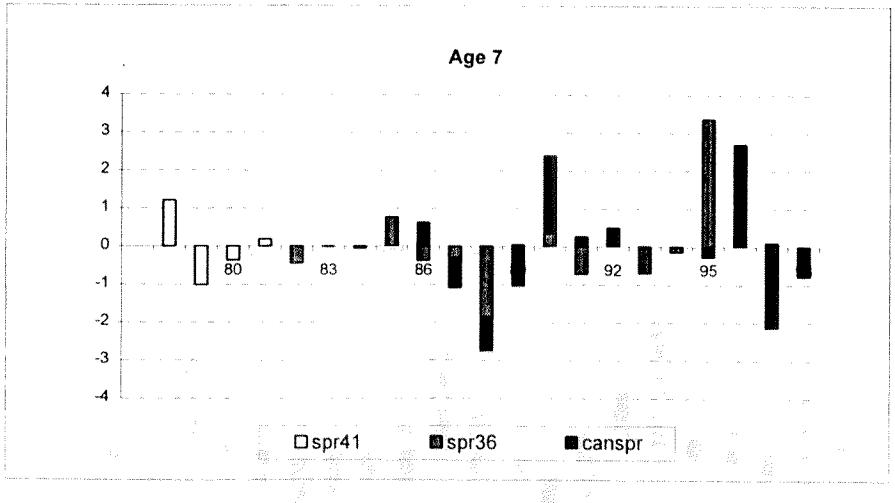


Figure 7. Residual plots (expected -observed) for ages 1-8 for the USA spring and Canadian spring abundance indicies, and ages 1-6 for the USA autumn research survey indices.







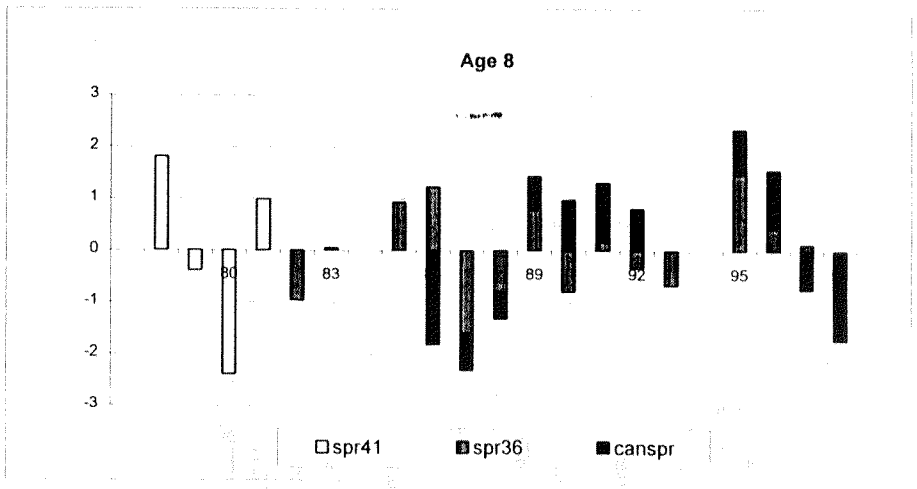


Figure 7 continued. Residual plots (expected -observed) for ages 1-8 for the USA spring and Canadian spring abundance indicies, and ages 1-6 for the USA autumn research survey indices.

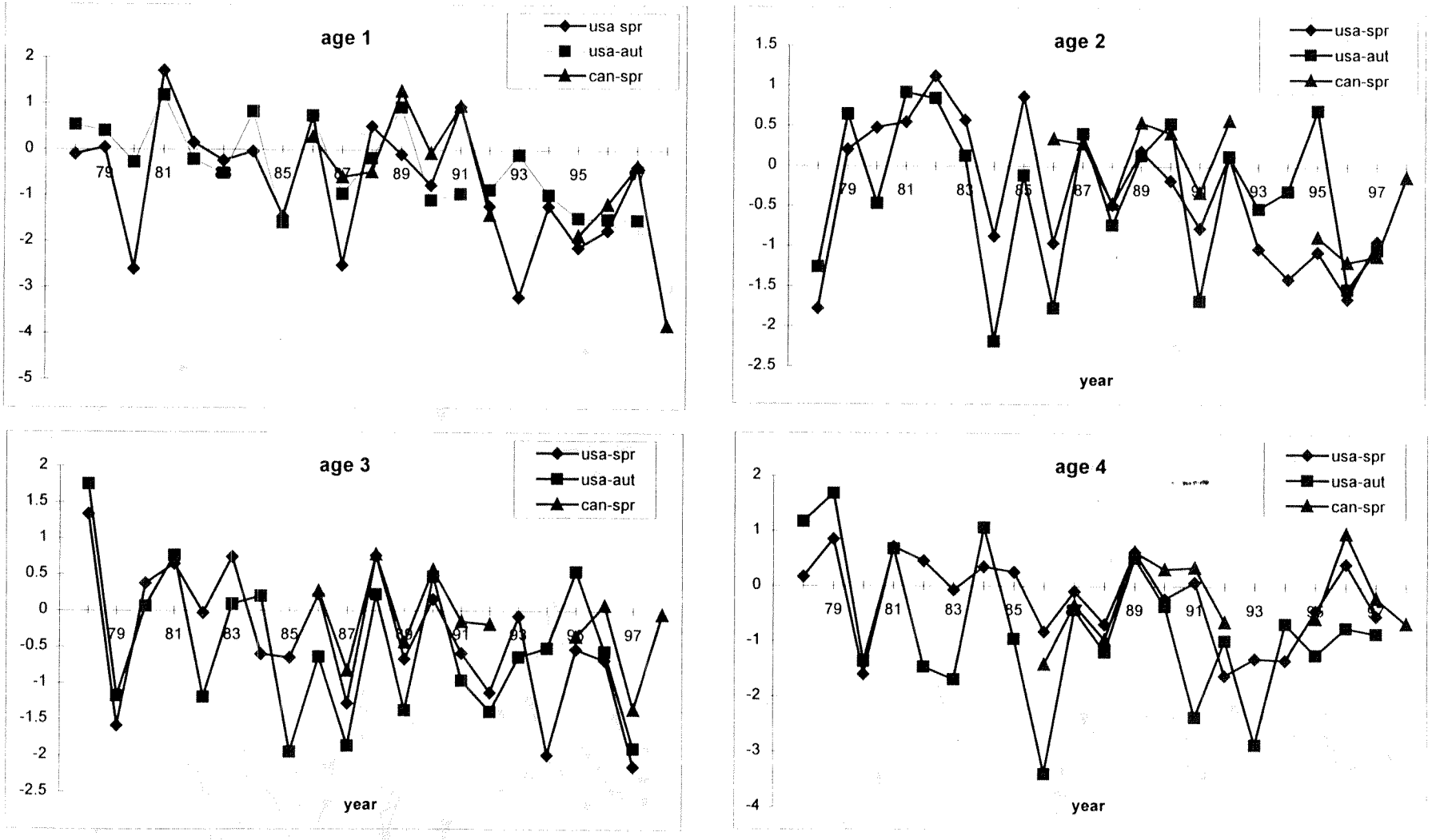
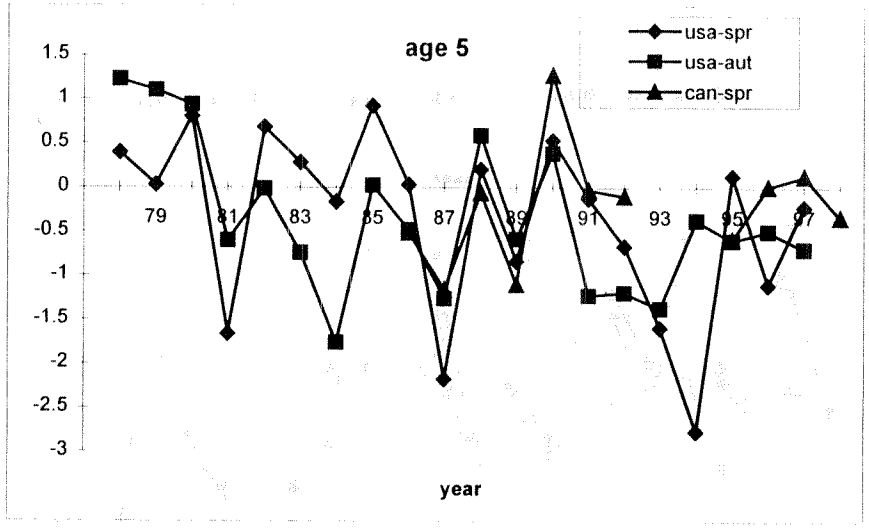
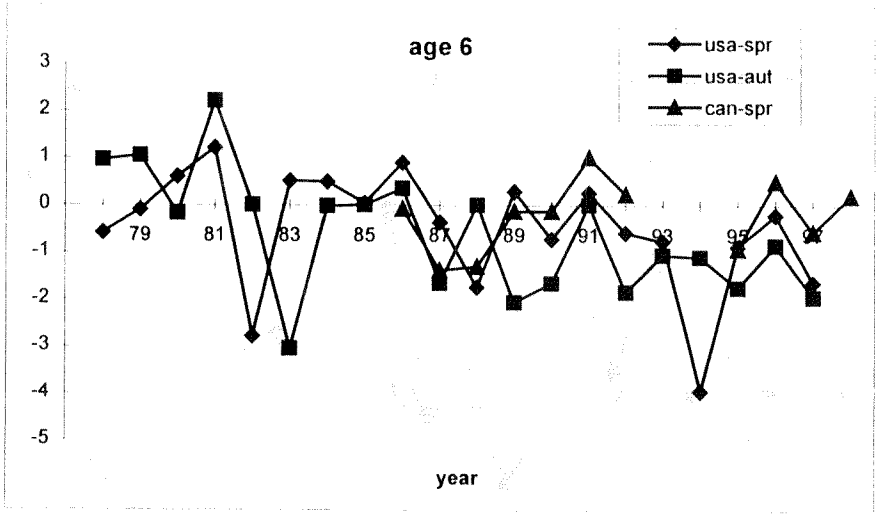
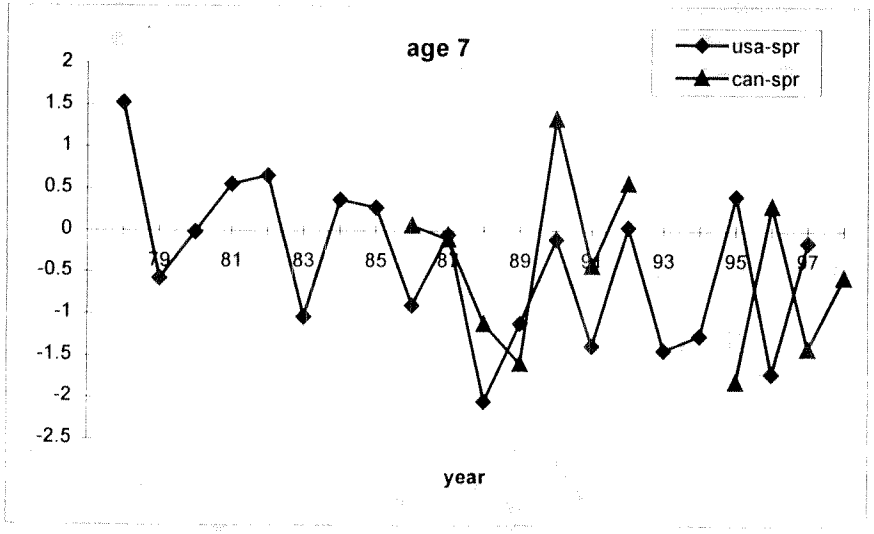


Figure 8. Natural log of the observed survey indices, standardized to the mean, for the USA spring and autumn survey and the Canadian spring survey.







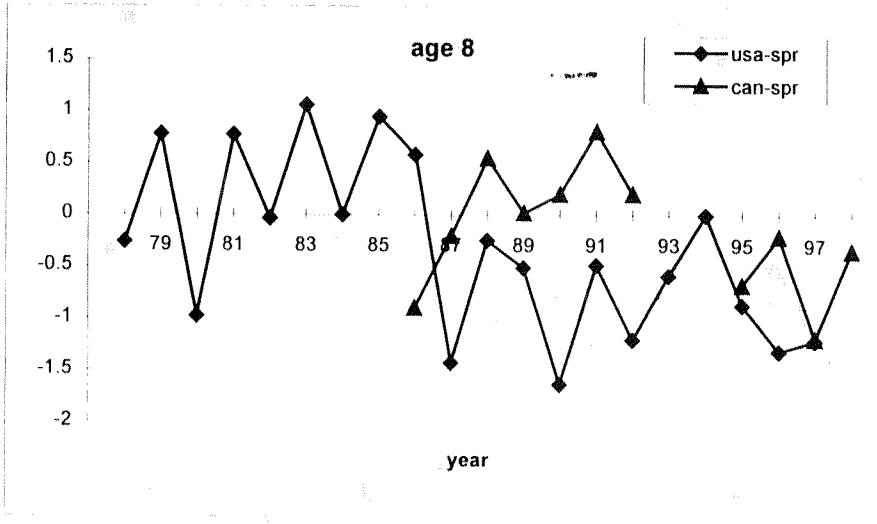


Figure 8 continued. Natural log of the observed survey indices, standardized to the mean, for the USA spring and autumn survey and the Canadian spring survey.

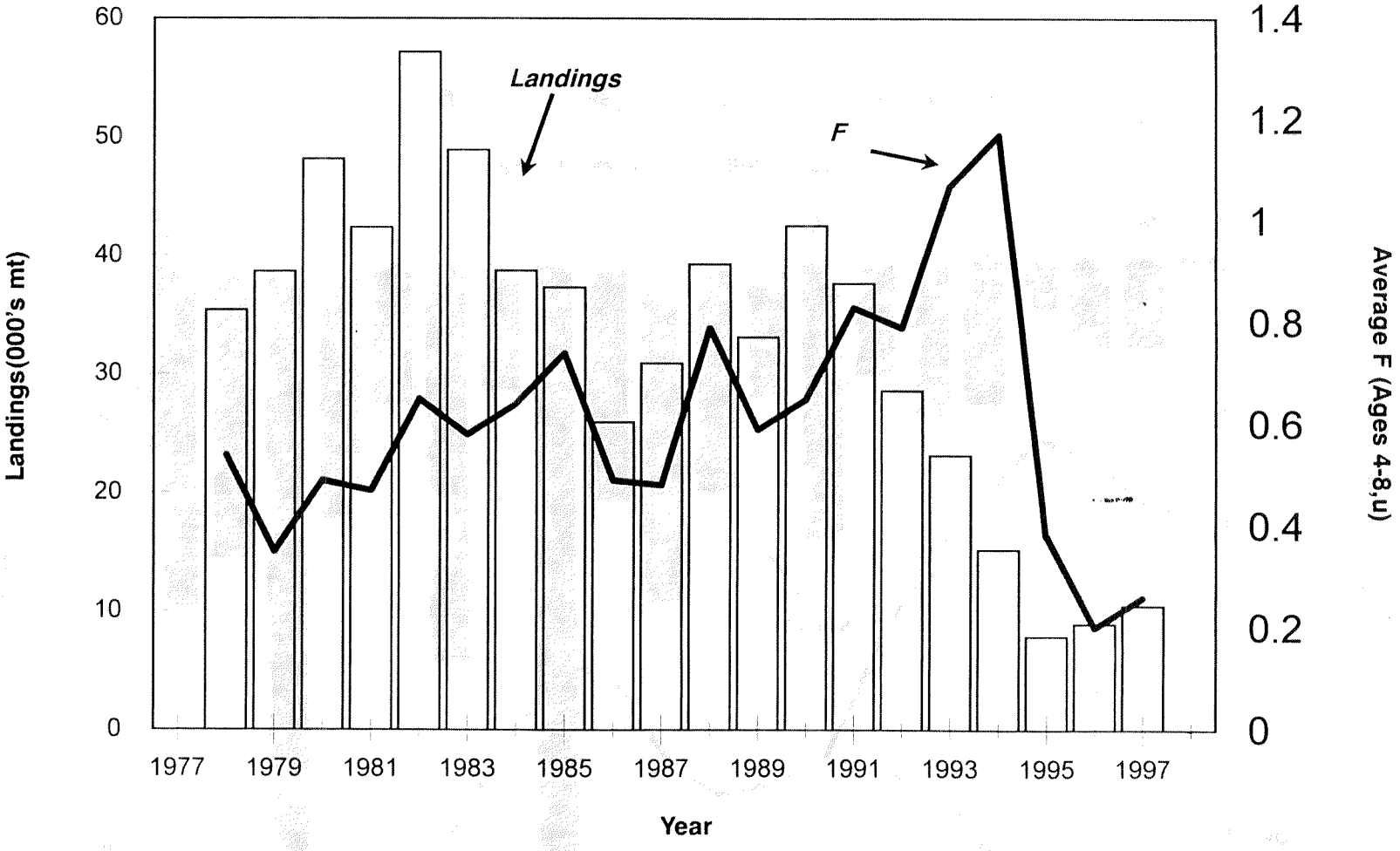


Figure 9. Trends in total commercial landings and fishing mortality for Georges Bank cod, 1978-1997.

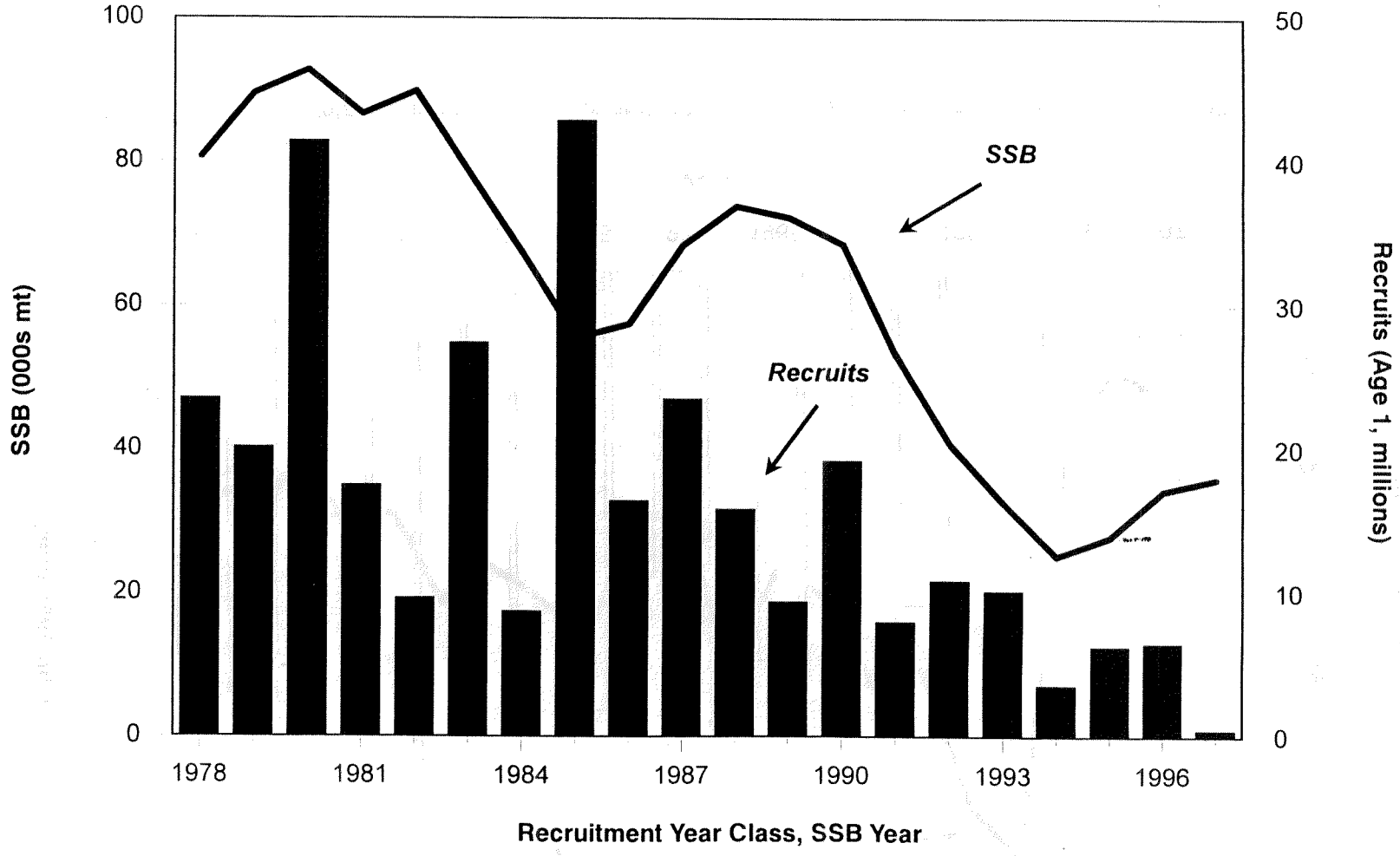


Figure 10. Trends in spawning stock biomass and recruitment for Georges Bank cod, 1978-1997.

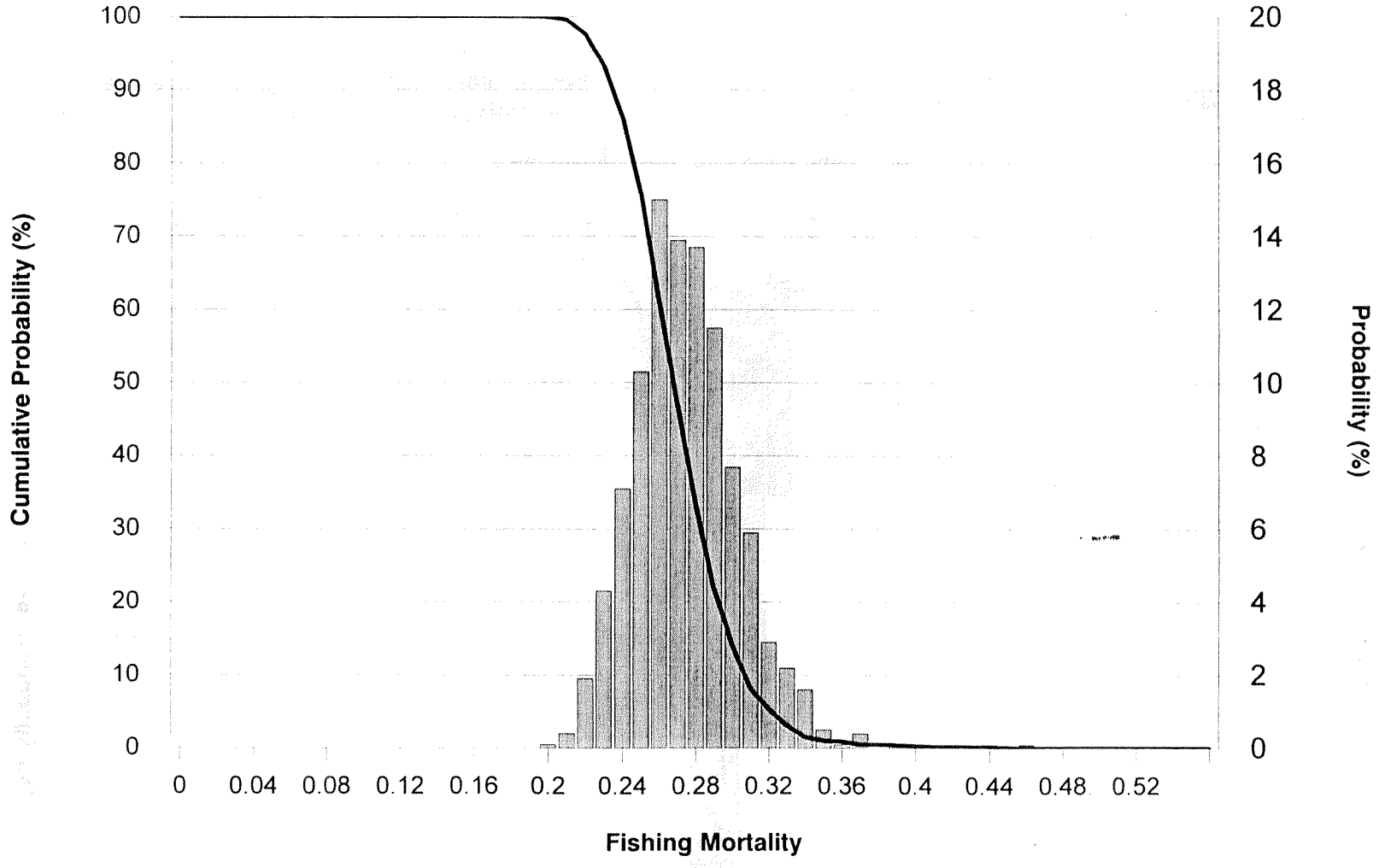


Figure 11. Precision of the estimates of the instantaneous rate of fishing (F) on the fully recruited ages (4+) in 1997 for Georges Bank cod. The bar height indicates the probability of values within that range. The solid line gives the probability that F is greater than any selected value on the X-axis.

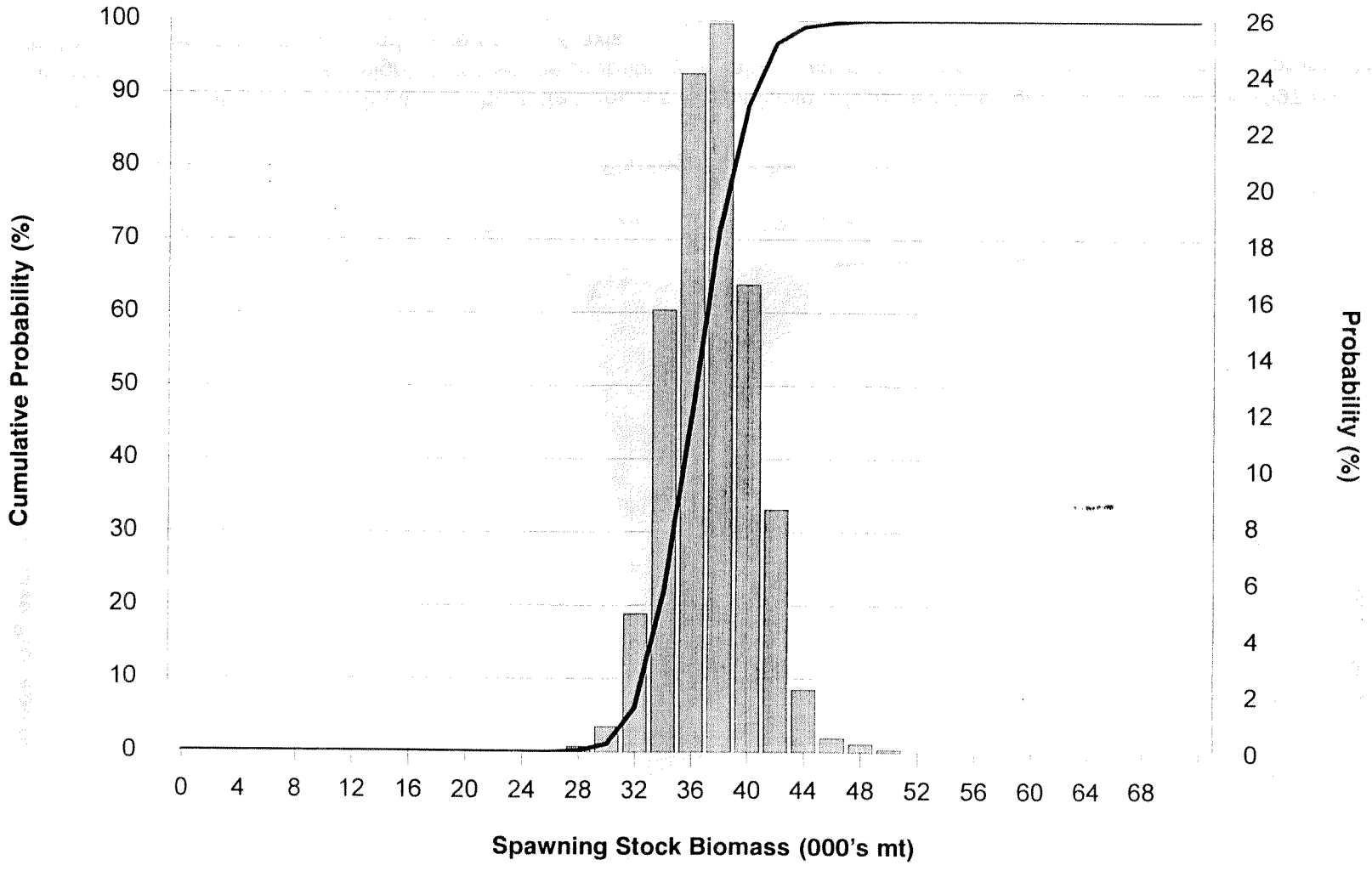


Figure 12. Precision of the estimates of spawning stock biomass (SSB) at the beginning of the spawning season for Georges Bank cod, 1997. The bar height indicates the probability of values within that range. The solid line gives the probability that SSB is less than any selected value on the X-axis.

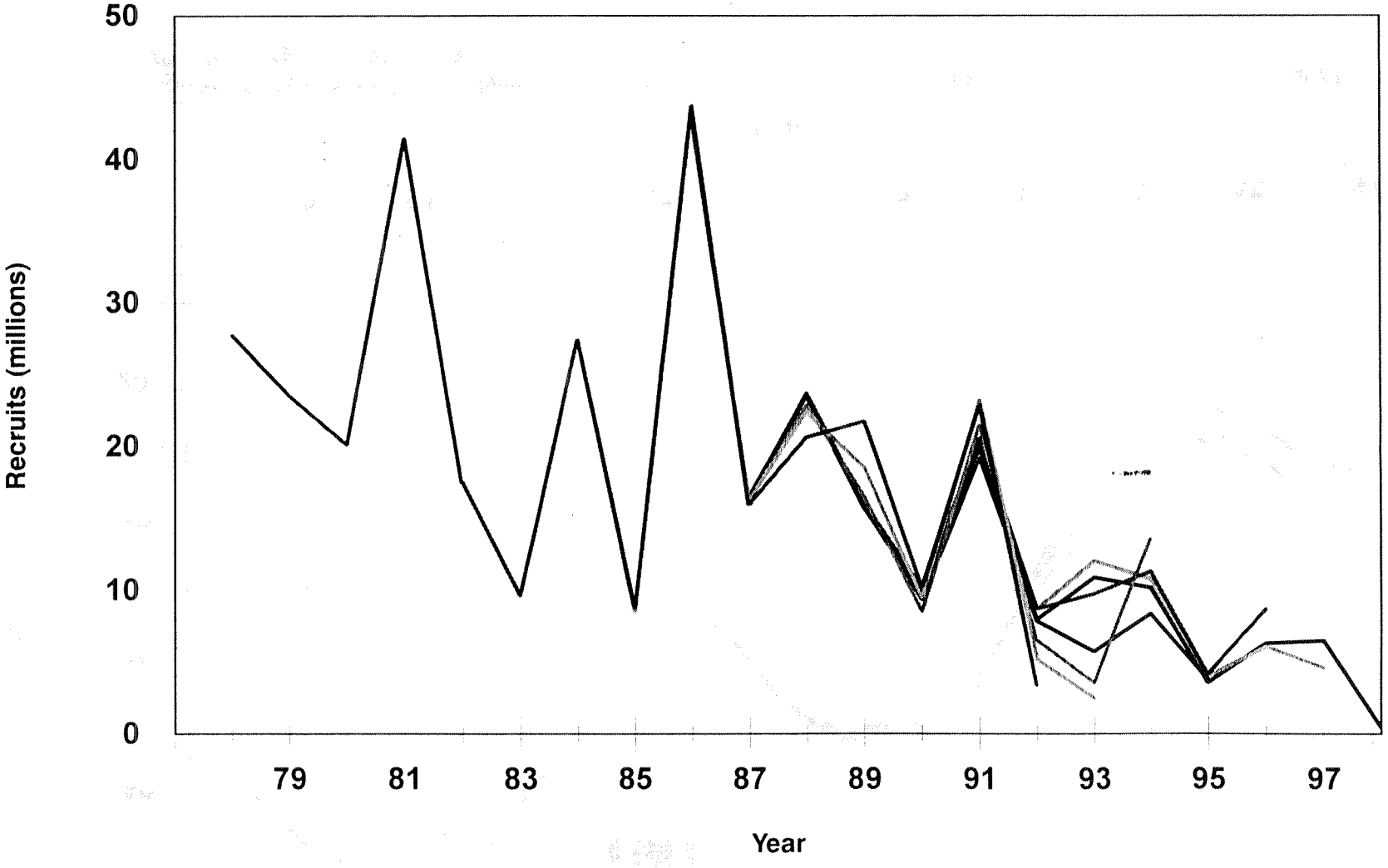


Figure 13.Retrospective analysis of Georges Bank cod recruits at age 1 based on the final ADAPT VPA formulation, 1997-1989.

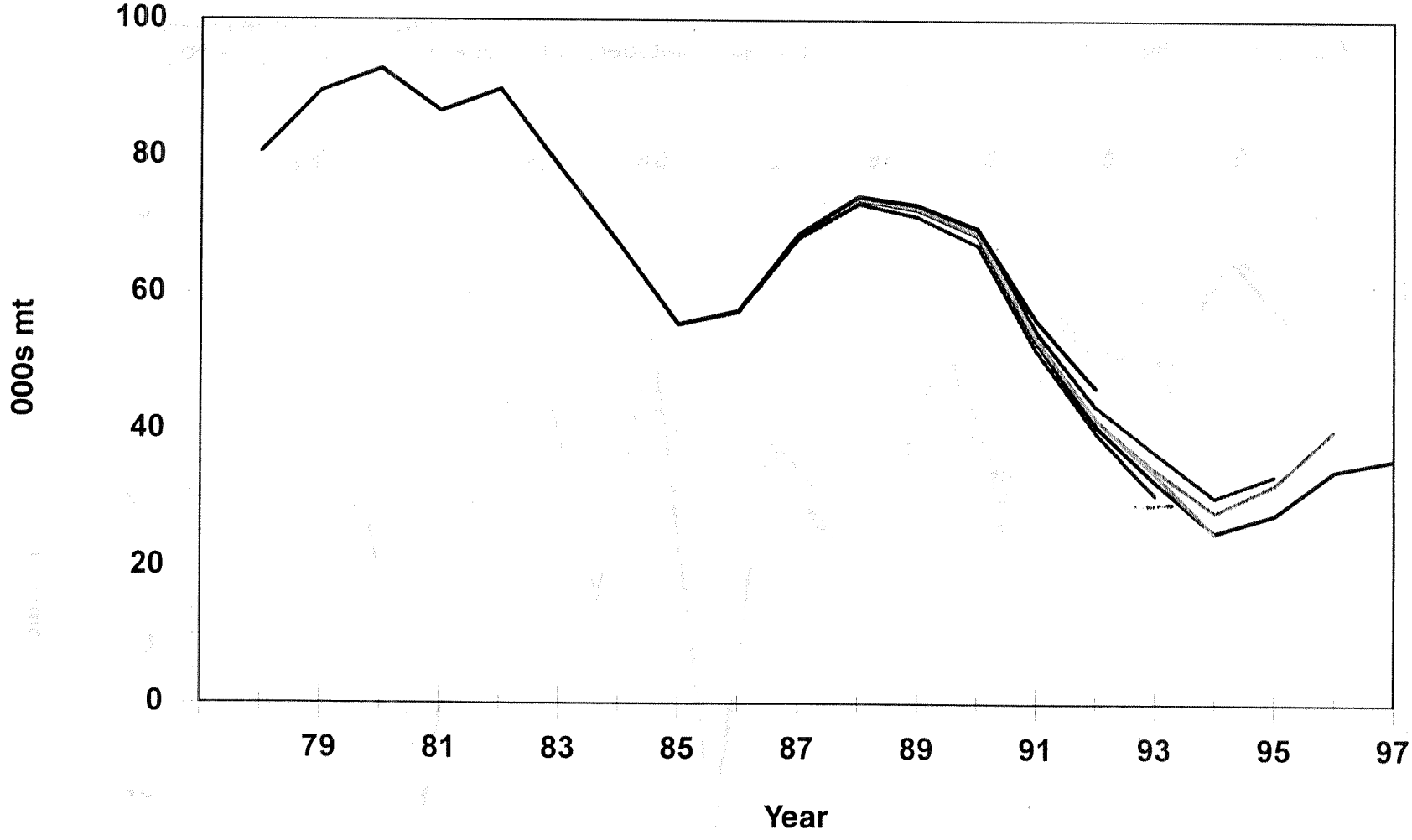


Figure 14.Retrospective analysis of Georges Bank cod spawning stock biomass based on the final ADAPT VPA formulation, 1997-1989.

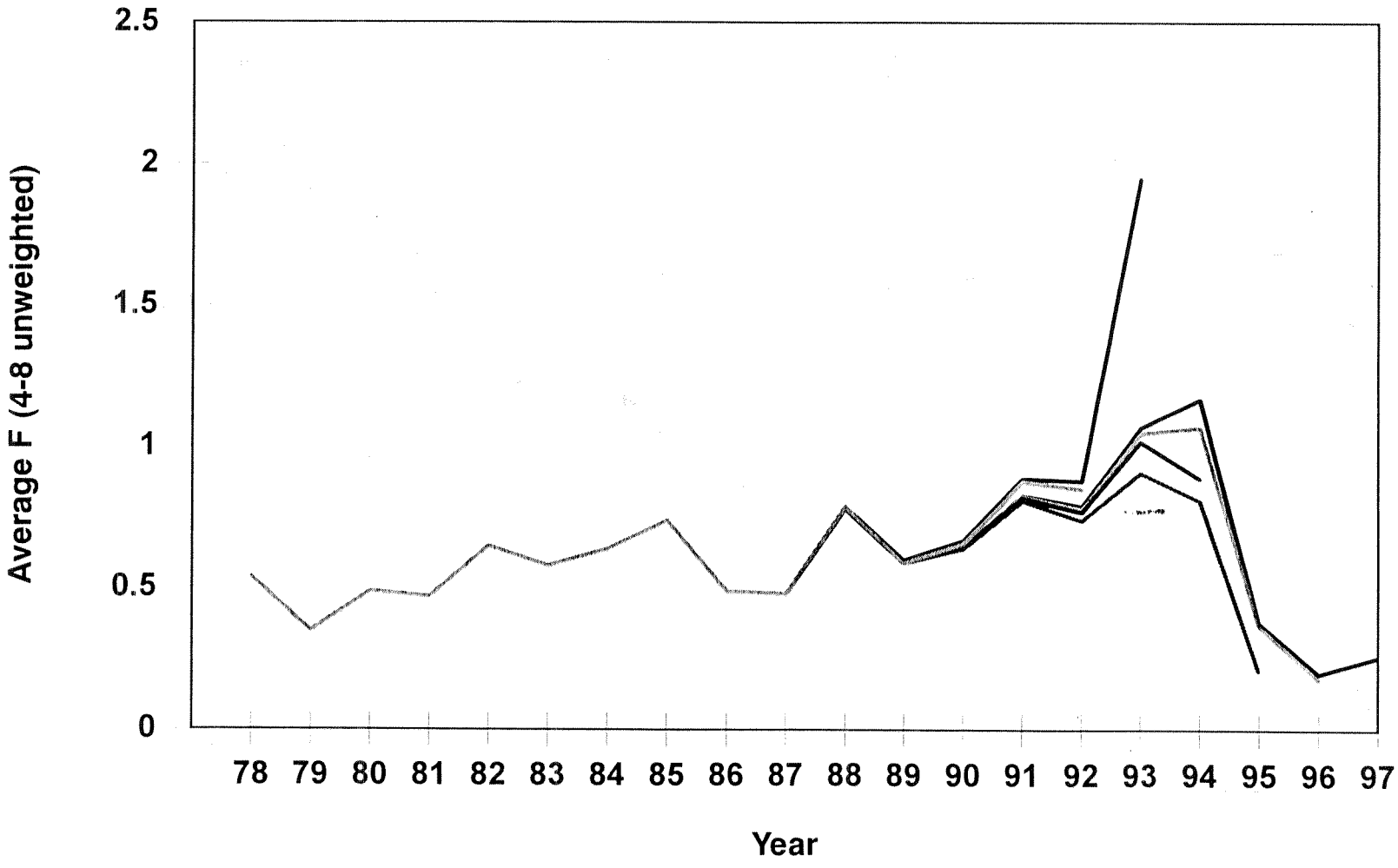


Figure 15. Retrospective analysis of Georges Bank cod fishing mortality (average F, ages 4-8, unweighted) based on the final ADAPT VPA formulation, 1997-1989.

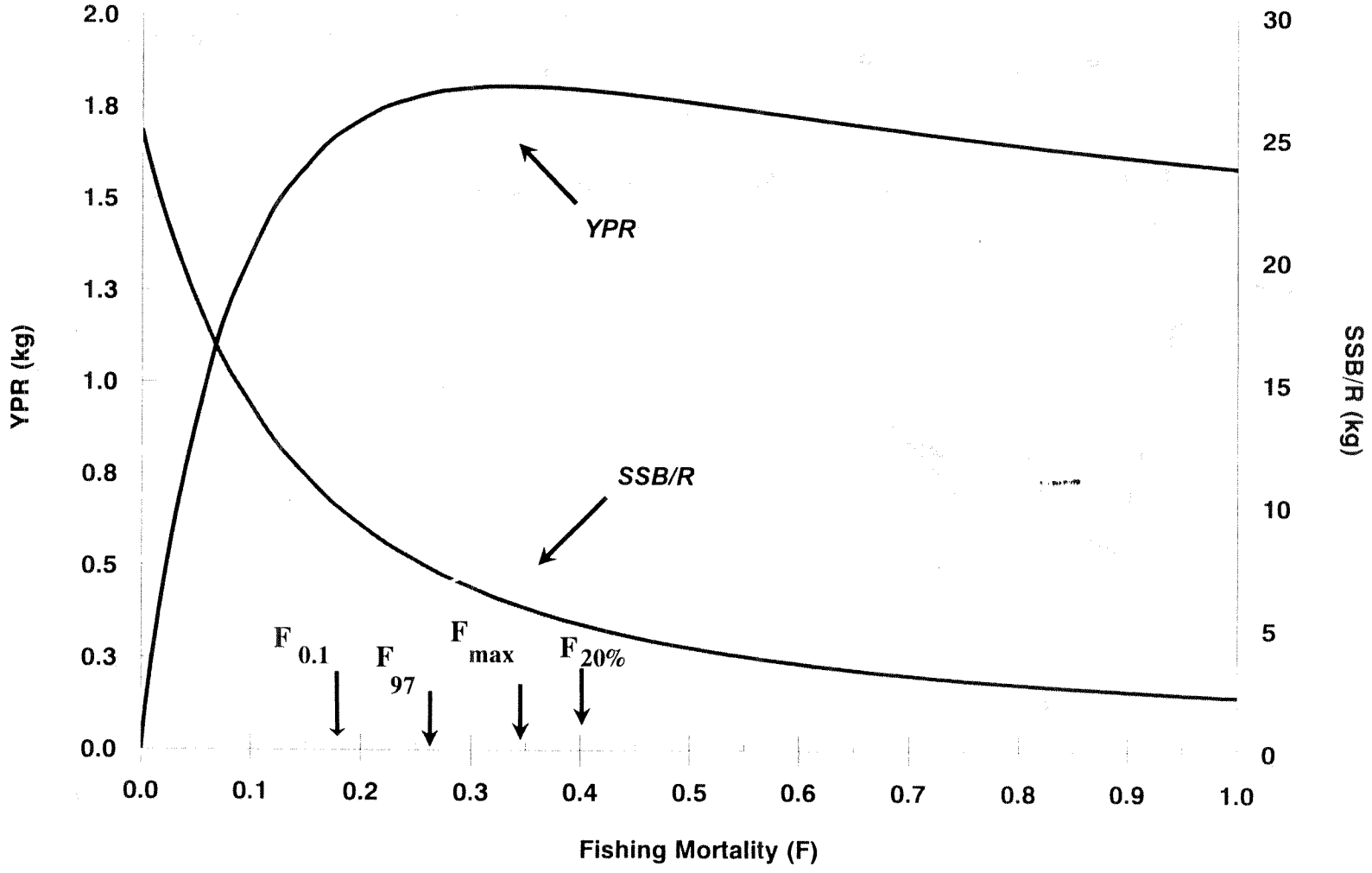


Figure 16. Yield per recruit (YPR) and spawning stock per recruit (SSB/R) for Georges Bank cod.

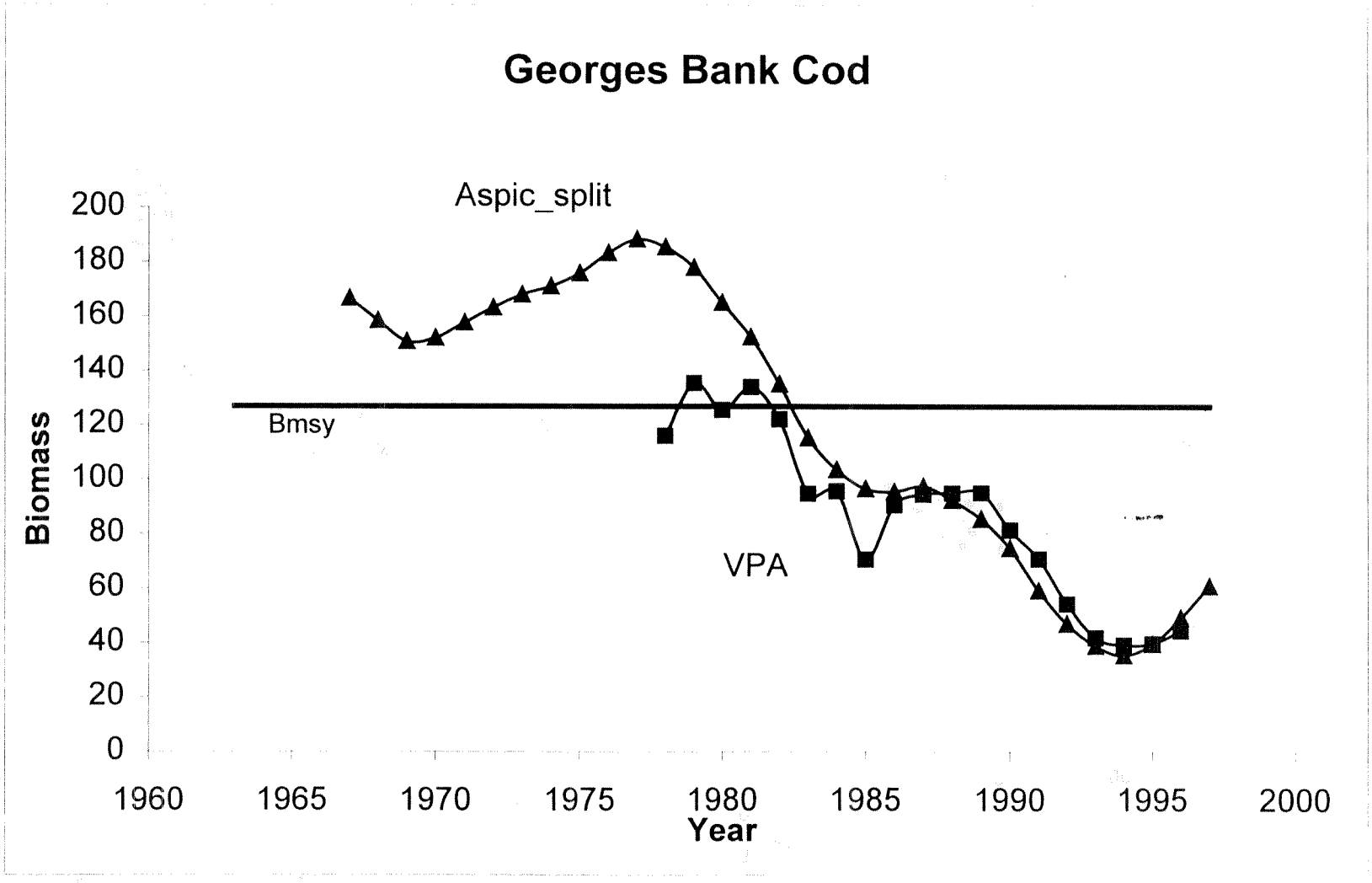


Figure 17. Mean biomass estimates from the ADAPT calibration and ASPIC using four indices.

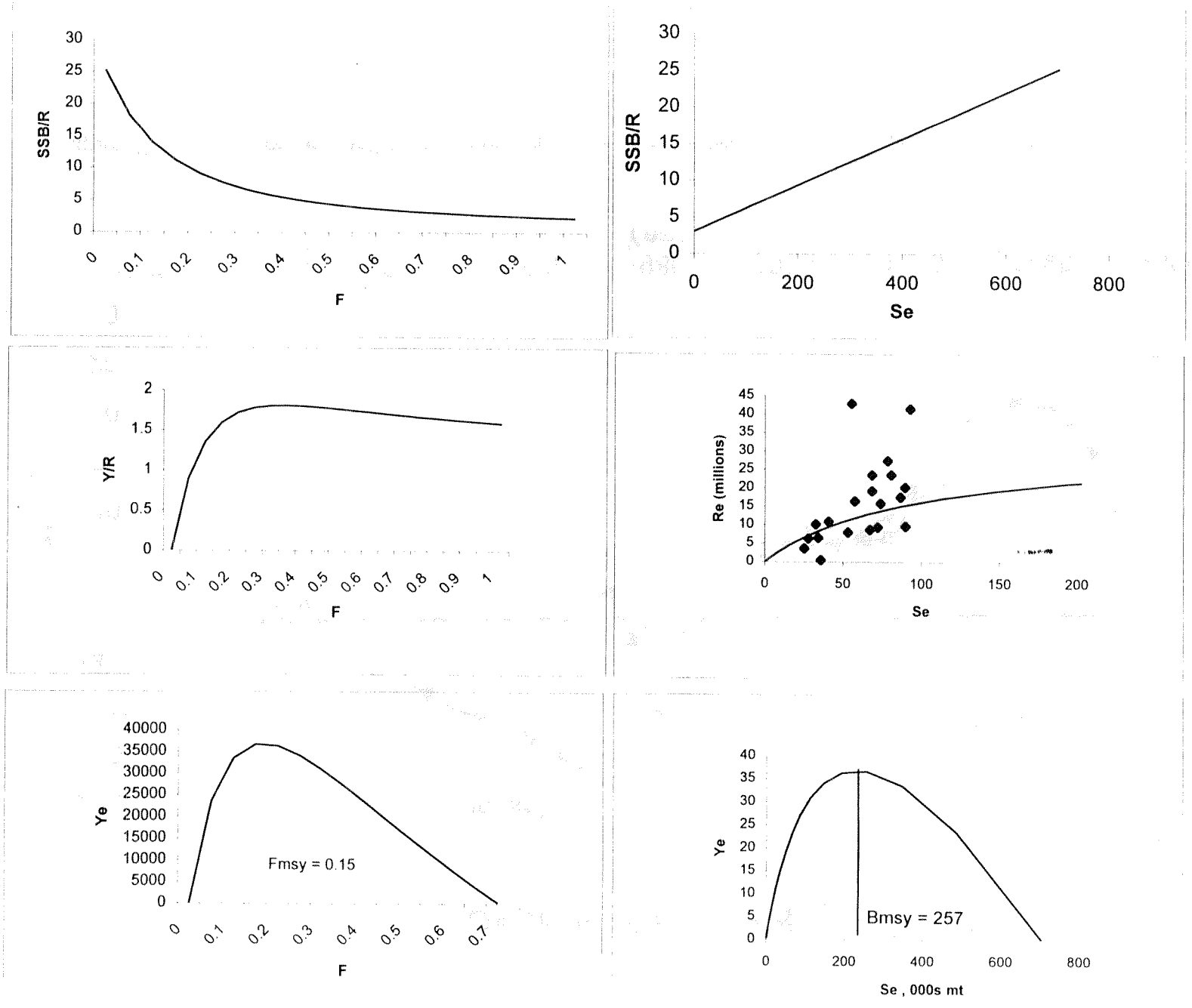


Figure 18. Equilibrium yield per recruit (Ye) and spawning stock biomass per recruit (Se) based on a Beverton-Holt model (estimated from 78-97 data) with estimates of Bmsy and Fmsy

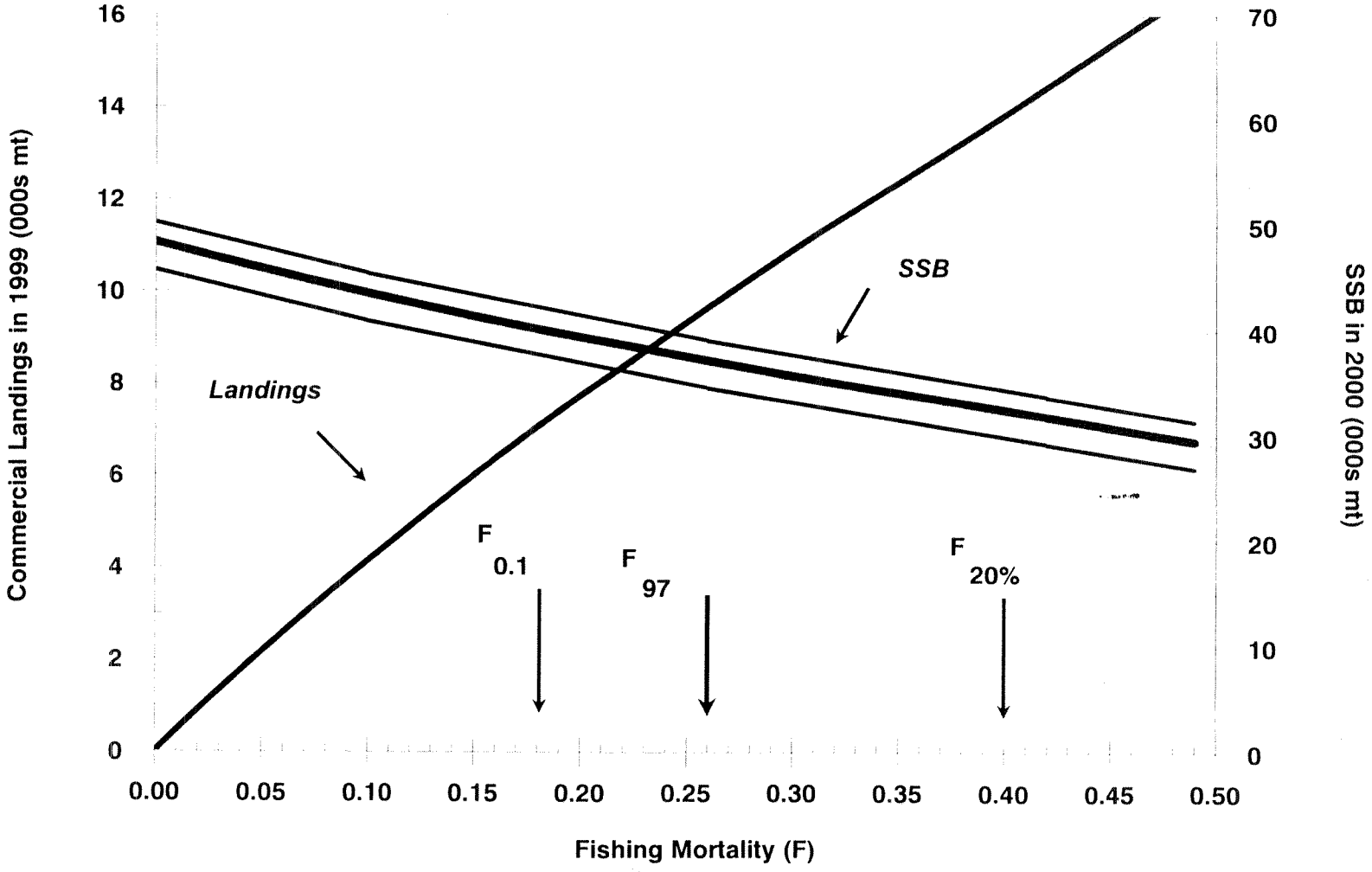
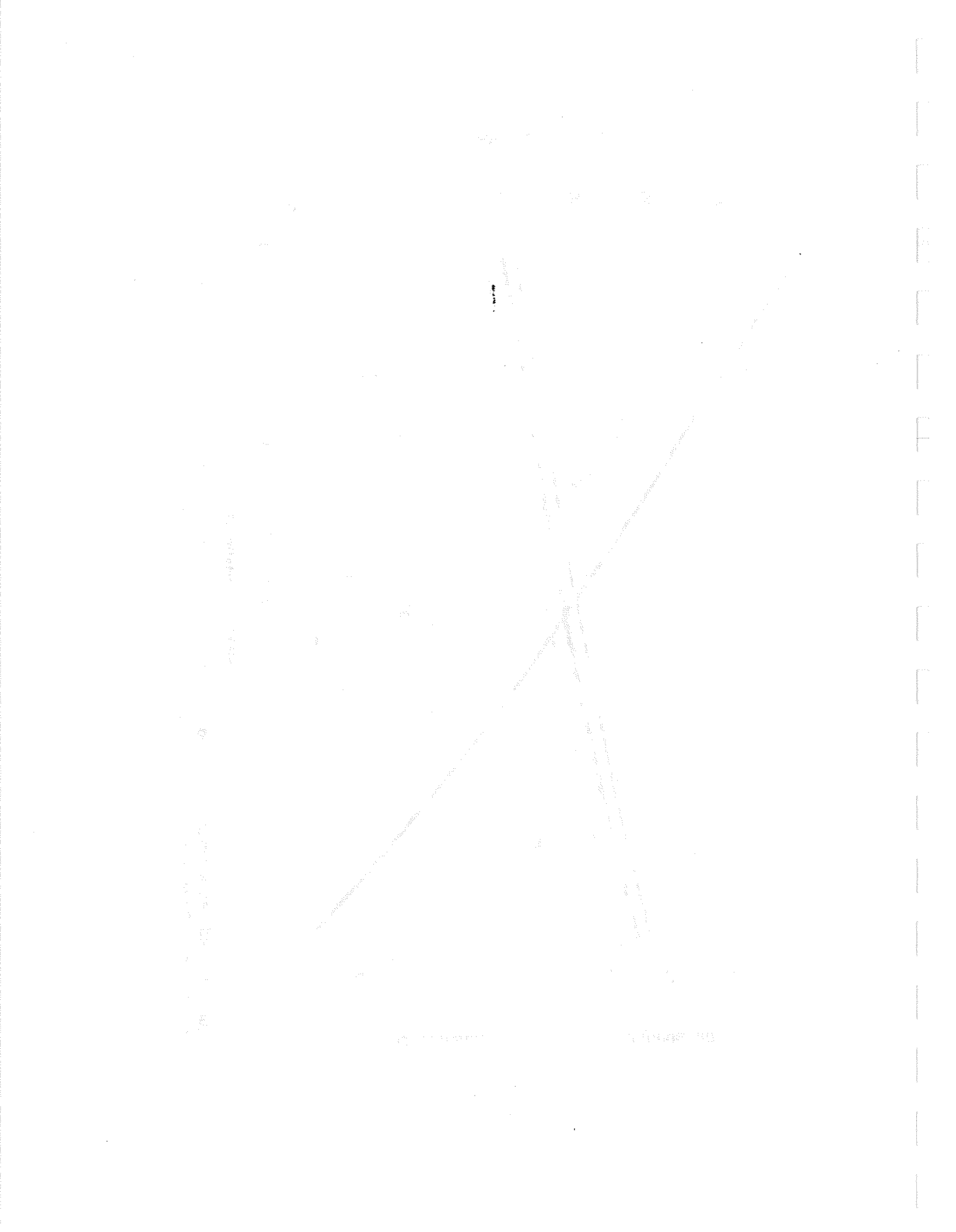


Figure 19. Predicted landings in 1999 and spawning stock biomasses in 2000 of Georges Bank cod over a range of fishing mortalities in 2000 from F = 0. 0 to F = 0.45.



APPENDIX 1

Age-specific bottom trawl survey abundance indices for Georges Bank Cod.

Table 1. Unstandardized (for vessel and door changes) stratified mean catch per tow at age (numbers) of Atlantic cod in NEFSC offshore spring and autumn bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 1997.

Table 2. Standardized (for vessel and door changes) stratified mean catch per tow at age (numbers) of Atlantic cod in NEFSC offshore spring and autumn bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 1997.

Table 3. Stratified mean catch per tow at age (numbers) of Atlantic cod in Canadian spring bottom trawl surveys on Eastern Georges Bank, 1986 - 1998.

Appendix 2:Table 1. Stratified mean catch per tow at age (numbers) and mean weight per tow (kg) of Atlantic cod in NEFSC offshore spring and autumn bottom trawl surveys on Georges Bank, 1963-1997. [a]

Year	Age Group 0	1	2	3	4	5	6	7	8	9	10+	Totals 0+	1+	2+	3+	4+	5+	Stratified Mean Wt (kg) Per Tow
Spring																		
1968	0.329	0.087	1.035	0.529	0.426	0.247	0.158	0.090	0.053	0.036	0.037	3.027	2.698	2.611	1.576	1.047	0.621	7.80
1969	0.000	0.079	0.350	1.141	0.569	0.289	0.209	0.138	0.082	0.046	0.072	2.975	2.975	2.896	2.546	1.405	0.836	11.00
1970	0.000	0.244	0.522	0.308	0.830	0.104	0.420	0.176	0.039	0.087	0.053	2.783	2.783	2.539	2.017	1.709	0.879	9.70
1971	0.000	0.133	0.525	0.322	0.143	0.375	0.091	0.225	0.195	0.051	0.112	2.172	2.172	2.039	1.514	1.192	1.049	8.80
1972	0.036	1.860	1.175	1.693	0.327	0.076	0.208	0.078	0.141	0.074	0.080	5.748	5.712	3.852	2.677	0.984	0.657	11.70
1973 [d]	0.036	0.334	7.464	1.403	1.628	0.273	0.201	0.227	0.032	0.130	0.249	11.977	11.941	11.607	4.143	2.740	1.112	24.50
1974	0.000	0.286	2.921	3.828	0.488	1.284	0.282	0.065	0.165	0.022	0.112	9.453	9.453	9.167	6.246	2.418	1.930	22.50
1975	0.000	0.041	0.242	1.309	1.982	0.167	0.440	0.083	0.060	0.069	0.025	4.418	4.418	4.377	4.135	2.826	0.844	16.10
1976	0.071	0.834	1.232	0.605	0.443	1.008	0.105	0.168	0.023	0.000	0.035	4.524	4.453	3.619	2.387	1.782	1.339	11.50
1977	0.000	0.018	2.261	0.692	0.335	0.179	0.466	0.033	0.042	0.000	0.013	4.039	4.039	4.021	1.760	1.068	0.733	9.50
1978	2.123	0.241	0.120	3.545	0.621	0.499	0.092	0.457	0.033	0.091	0.070	7.892	5.769	5.528	5.408	1.863	1.242	19.30
1979	0.070	0.279	0.871	0.191	1.226	0.347	0.150	0.056	0.093	0.008	0.014	3.305	3.235	2.956	2.085	1.894	0.668	10.50
1980	0.067	0.025	1.452	1.723	0.134	0.950	0.383	0.123	0.020	0.019	0.071	4.967	4.900	4.875	3.423	1.700	1.566	15.30
1981	0.244	1.869	1.555	2.255	1.353	0.081	0.706	0.218	0.117	0.000	0.069	8.467	8.223	6.354	4.799	2.544	1.191	24.00
1982 [e]	0.120	0.396	2.755	1.141	1.051	0.843	0.013	0.242	0.052	0.013	0.028	6.654	6.534	6.138	3.383	2.242	1.191	14.20
1983	0.052	0.211	1.261	1.954	0.491	0.447	0.276	0.035	0.123	0.000	0.087	4.937	4.885	4.674	3.413	1.459	0.968	14.80
1984	0.000	0.258	0.296	0.511	0.744	0.286	0.272	0.143	0.000	0.100	0.005	2.615	2.615	2.357	2.061	1.550	0.806	9.50
1985	0.244	0.098	2.633	0.757	1.058	1.328	0.270	0.203	0.172	0.025	0.150	6.938	6.694	6.596	3.963	3.206	2.148	21.50
1986	0.092	0.871	0.423	1.824	0.360	0.545	0.633	0.063	0.119	0.095	0.015	5.040	4.948	4.077	3.654	1.830	1.470	16.70
1987	0.000	0.034	1.612	0.403	0.752	0.060	0.179	0.147	0.016	0.027	0.025	3.255	3.255	3.221	1.609	1.206	0.454	10.30
1988	0.180	0.700	0.684	3.115	0.413	0.645	0.045	0.020	0.052	0.000	0.007	5.861	5.681	4.981	4.297	1.182	0.769	13.40
1989	0.000	0.481	1.689	0.940	1.939	0.288	0.436	0.064	0.050	0.102	0.085	6.074	6.074	5.593	3.904	2.964	1.025	16.10
1990	0.052	0.246	1.172	2.161	0.827	1.134	0.158	0.176	0.016	0.020	0.034	5.996	5.944	5.698	4.526	2.365	1.538	17.30
1991	0.247	1.352	0.647	1.022	1.118	0.587	0.425	0.049	0.052	0.000	0.057	5.556	5.309	3.957	3.310	2.288	1.170	13.43
1992	0.000	0.123	1.255	0.470	0.163	0.270	0.144	0.161	0.020	0.037	0.028	2.671	2.671	2.548	1.293	0.823	0.660	7.46
1993	0.115	0.017	0.398	1.347	0.222	0.107	0.120	0.037	0.037	0.021	0.055	2.476	2.361	2.344	1.946	0.599	0.377	6.96
1994	0.037	0.156	0.345	0.253	0.274	0.042	0.007	0.056	0.000	0.024	0.000	1.196	1.159	1.003	0.658	0.405	0.131	1.81
1995	0.482	0.050	0.382	0.854	0.534	0.599	0.107	0.234	0.028	0.022	0.000	3.292	2.810	2.760	2.378	1.524	0.990	8.37
1996	0.000	0.073	0.214	0.736	1.247	0.174	0.209	0.028	0.018	0.000	0.000	2.699	2.699	2.626	2.412	1.676	0.429	7.50
1997	0.302	0.291	0.437	0.170	0.489	0.422	0.050	0.134	0.020	0.000	0.000	2.315	2.013	1.722	1.285	1.115	0.626	5.21

[a] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these gear differences.

[d] Excludes unusually high catch of 1894 cod (2558 kg) at Station 230 (Strata tow 20-4).

[e] Excludes unusually high catch of 1032 cod (4096 kg) at Station 323 (Strata tow 16-7).

Appendix 2:Table 1 (Continued). Stratified mean catch per tow at age (numbers) and mean weight per tow (kg) of Atlantic cod in NEFSC offshore spring and autumn bottom trawl surveys on Georges Bank, 1963-1997. [a,b]

Year	Age Group 0	1	2	3	4	5	6	7	8	9	10+	Totals 0+	1+	2+	3+	4+	5+	Stratified Mean Wt (kg) Per Tow
Autumn																		
1963	0.012	0.461	0.499	0.590	0.575	0.227	0.209	0.112	0.066	0.009	0.044	2.804	2.792	2.331	1.832	1.242	0.667	11.00
1964	0.006	0.410	0.448	0.377	0.345	0.093	0.087	0.040	0.032	0.019	0.053	1.910	1.904	1.494	1.046	0.669	0.324	7.10
1965	0.111	0.833	0.640	0.453	0.310	0.107	0.115	0.072	0.052	0.015	0.015	2.723	2.612	1.779	1.139	0.686	0.376	7.20
1966	0.657	1.085	0.641	0.330	0.169	0.064	0.061	0.040	0.025	0.001	0.011	3.084	2.427	1.342	0.701	0.371	0.202	5.00
1967	0.046	4.869	0.855	0.335	0.260	0.085	0.085	0.035	0.033	0.008	0.045	6.656	6.610	1.741	0.886	0.551	0.291	8.40
1968	0.045	0.201	1.033	0.502	0.174	0.047	0.043	0.017	0.015	0.005	0.031	2.113	2.068	1.867	0.834	0.332	0.158	5.30
1969	0.000	0.220	0.399	0.401	0.212	0.060	0.039	0.012	0.015	0.014	0.038	1.410	1.410	1.190	0.791	0.390	0.178	5.00
1970	0.265	1.082	0.867	0.336	0.445	0.098	0.000	0.021	0.035	0.035	0.063	3.247	2.982	1.900	1.033	0.697	0.252	7.70
1971	0.256	0.386	0.405	0.250	0.193	0.305	0.117	0.027	0.057	0.000	0.048	2.044	1.788	1.402	0.997	0.747	0.554	6.10
1972	0.607	4.771	0.830	1.135	0.256	0.156	0.366	0.070	0.131	0.014	0.053	8.389	7.782	3.011	2.181	1.046	0.790	14.20
1973	0.130	1.121	3.891	0.758	1.290	0.135	0.145	0.112	0.040	0.089	0.161	7.872	7.742	6.621	2.730	1.972	0.682	19.00
1974	0.296	0.262	0.419	0.975	0.105	0.073	0.066	0.000	0.044	0.000	0.000	2.240	1.944	1.682	1.263	0.288	0.183	5.10
1975	1.524	0.637	0.270	0.400	1.080	0.072	0.100	0.000	0.000	0.000	0.024	4.107	2.583	1.946	1.676	1.276	0.196	8.70
1976	0.000	3.941	1.328	0.489	0.178	0.474	0.035	0.173	0.025	0.034	0.013	6.690	6.690	2.749	1.421	0.932	0.754	10.90
1977	0.123	0.192	2.778	0.570	0.204	0.141	0.321	0.006	0.022	0.000	0.063	4.420	4.297	4.105	1.327	0.757	0.553	11.50
1978	0.321	1.505	0.207	3.392	0.782	0.272	0.134	0.279	0.041	0.024	0.011	6.968	6.647	5.142	4.935	1.543	0.761	21.50
1979	0.096	1.314	1.393	0.182	1.309	0.240	0.146	0.029	0.093	0.006	0.018	4.826	4.730	3.416	2.023	1.841	0.532	15.20
1980	0.227	0.664	0.458	0.628	0.062	0.204	0.043	0.054	0.020	0.000	0.000	2.360	2.133	1.469	1.011	0.383	0.321	6.20
1981	0.212	2.860	1.826	1.265	0.478	0.044	0.470	0.046	0.052	0.015	0.067	7.335	7.123	4.263	2.437	1.172	0.694	17.50
1982	0.205	0.561	1.342	0.141	0.044	0.062	0.000	0.010	0.000	0.000	0.014	2.379	2.174	1.613	0.271	0.130	0.086	4.30
1983	0.661	0.415	0.655	0.510	0.035	0.030	0.002	0.000	0.008	0.000	0.015	2.331	1.670	1.255	0.600	0.090	0.055	4.00
1984	0.119	1.600	0.065	0.568	0.558	0.011	0.040	0.025	0.004	0.025	0.028	3.043	2.924	1.324	1.259	0.691	0.133	6.30
1985	1.084	0.220	0.803	0.103	0.115	0.101	0.000	0.000	0.004	0.000	0.000	2.430	1.346	1.126	0.323	0.220	0.105	3.50
1986	0.096	2.280	0.153	0.382	0.010	0.061	0.090	0.016	0.000	0.008	0.028	3.124	3.028	0.748	0.595	0.213	0.203	4.70
1987	0.204	0.414	1.353	0.112	0.195	0.028	0.012	0.000	0.000	0.007	0.000	2.325	2.121	1.707	0.354	0.242	0.047	4.40
1988	0.549	0.903	0.433	0.909	0.091	0.178	0.000	0.011	0.039	0.000	0.000	3.113	2.564	1.661	1.228	0.319	0.228	5.80
1989	0.332	3.466	1.304	0.232	0.632	0.070	0.010	0.005	0.000	0.000	0.000	6.051	5.719	2.253	0.949	0.717	0.085	6.90
1990 [f]	0.197	0.458	1.942	1.473	0.265	0.184	0.015	0.016	0.000	0.000	0.028	4.578	4.381	3.923	1.981	0.508	0.243	10.60
1991	0.051	0.525	0.213	0.351	0.035	0.037	0.000	0.000	0.000	0.000	0.000	1.212	1.161	0.636	0.423	0.072	0.037	2.09
1992	0.033	0.454	1.024	0.180	0.112	0.030	0.010	0.000	0.000	0.000	0.000	1.843	1.810	1.356	0.332	0.152	0.040	3.10
1993	0.226	1.228	0.673	0.484	0.021	0.032	0.028	0.000	0.000	0.028	0.000	2.720	2.494	1.266	0.593	0.109	0.088	3.25
1994	0.067	0.406	0.664	0.433	0.153	0.068	0.021	0.000	0.006	0.000	0.000	1.819	1.752	1.346	0.682	0.529	0.376	3.26
1995	0.160	0.245	1.811	1.249	0.087	0.054	0.011	0.000	0.000	0.000	0.000	3.616	3.456	3.211	1.401	0.152	0.065	5.63
1996	0.022	0.240	0.196	0.414	0.143	0.060	0.027	0.000	0.000	0.000	0.000	1.101	1.079	0.840	0.644	0.229	0.086	2.71
1997	0.006	0.236	0.321	0.109	0.129	0.049	0.009	0.007	0.000	0.000	0.000	0.897	0.860	0.624	0.303	0.194	0.065	

[f] Excludes unusually high catch of 111 cod (504 kg) at Station 205 (Strata tow 23-4).

Appendix 1:Table 2. Standardized (for vessel and door changes) stratified mean catch per tow at age (numbers) of Atlantic cod in NEFSC offshore spring and autumn bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 1997. [a,b,c]

	Age Group											Totals					
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
Spring																	
1968	0.513	0.136	1.615	0.825	0.665	0.385	0.246	0.140	0.083	0.056	0.058	4.722	4.209	4.073	2.459	1.633	0.969
1969	0.000	0.123	0.546	1.780	0.888	0.451	0.326	0.215	0.128	0.072	0.112	4.641	4.641	4.518	3.972	2.192	1.304
1970	0.000	0.381	0.814	0.480	1.295	0.162	0.655	0.275	0.061	0.136	0.083	4.341	4.341	3.961	3.147	2.666	1.371
1971	0.000	0.207	0.819	0.502	0.223	0.585	0.142	0.351	0.304	0.080	0.175	3.388	3.388	3.181	2.362	1.860	1.636
1972	0.056	2.902	1.833	2.641	0.510	0.119	0.324	0.122	0.220	0.115	0.125	8.967	8.911	6.009	4.176	1.535	1.025
1973	0.056	0.521	11.644	2.189	2.540	0.426	0.314	0.354	0.050	0.203	0.388	18.684	18.628	18.107	6.463	4.274	1.735
1974	0.000	0.446	4.557	5.972	0.761	2.003	0.440	0.101	0.257	0.034	0.175	14.747	14.747	14.301	9.744	3.772	3.011
1975	0.000	0.064	0.378	2.042	3.092	0.261	0.686	0.129	0.094	0.108	0.039	6.892	6.892	6.828	6.451	4.409	1.317
1976	0.111	1.301	1.922	0.944	0.691	1.572	0.164	0.262	0.036	0.000	0.055	7.057	6.947	5.646	3.724	2.780	2.089
1977	0.000	0.028	3.527	1.080	0.523	0.279	0.727	0.051	0.066	0.000	0.020	6.301	6.301	6.273	2.746	1.666	1.143
1978	3.312	0.376	0.187	5.530	0.969	0.778	0.144	0.713	0.051	0.142	0.109	12.312	9.000	8.624	8.436	2.906	1.938
1979	0.109	0.435	1.359	0.298	1.913	0.541	0.234	0.087	0.145	0.012	0.022	5.156	5.047	4.611	3.253	2.955	1.042
1980	0.083	0.031	1.790	2.124	0.165	1.171	0.472	0.152	0.025	0.024	0.088	6.122	6.039	6.008	4.219	2.095	1.930
1981	0.301	2.303	1.916	2.779	1.667	0.100	0.870	0.269	0.144	0.000	0.085	10.435	10.134	7.831	5.914	3.135	1.468
1982	0.148	0.488	3.395	1.406	1.295	1.039	0.016	0.298	0.064	0.016	0.035	8.200	8.053	7.564	4.169	2.763	1.468
1983	0.081	0.329	1.967	3.048	0.766	0.697	0.431	0.055	0.192	0.000	0.136	7.702	7.621	7.291	5.324	2.276	1.510
1984	0.000	0.402	0.462	0.797	1.161	0.446	0.424	0.223	0.000	0.156	0.008	4.079	4.079	3.677	3.215	2.418	1.257
1985	0.244	0.098	2.633	0.757	1.058	1.328	0.270	0.203	0.172	0.025	0.150	6.938	6.694	6.596	3.963	3.206	2.148
1986	0.092	0.871	0.423	1.824	0.360	0.545	0.633	0.063	0.119	0.095	0.015	5.040	4.948	4.077	3.654	1.830	1.470
1987	0.000	0.034	1.612	0.403	0.752	0.060	0.179	0.147	0.016	0.027	0.025	3.255	3.255	3.221	1.609	1.206	0.454
1988	0.180	0.700	0.684	3.115	0.413	0.645	0.045	0.020	0.052	0.000	0.007	5.861	5.681	4.981	4.297	1.182	0.769
1989	0.000	0.380	1.334	0.743	1.532	0.228	0.344	0.051	0.040	0.081	0.067	4.798	4.798	4.418	3.084	2.342	0.810
1990	0.041	0.194	0.926	1.707	0.653	0.896	0.125	0.139	0.013	0.016	0.027	4.736	4.695	4.501	3.575	1.868	1.215
1991	0.195	1.068	0.511	0.807	0.883	0.464	0.336	0.039	0.041	0.000	0.045	4.389	4.194	3.126	2.615	1.808	0.925
1992	0.000	0.123	1.255	0.470	0.163	0.270	0.144	0.161	0.020	0.037	0.028	2.671	2.671	2.548	1.293	0.823	0.660
1993	0.115	0.017	0.398	1.347	0.222	0.107	0.120	0.037	0.037	0.021	0.055	2.476	2.361	2.344	1.946	0.599	0.377
1994	0.029	0.123	0.273	0.199	0.216	0.033	0.005	0.044	0.000	0.019	0.000	0.943	0.914	0.791	0.518	0.318	0.102
1995	0.482	0.050	0.382	0.854	0.534	0.599	0.107	0.234	0.028	0.022	0.000	3.292	2.810	2.760	2.378	1.524	0.990
1996	0.000	0.073	0.214	0.736	1.247	0.174	0.209	0.028	0.018	0.000	0.000	2.699	2.699	2.626	2.412	1.676	0.429
1997	0.302	0.291	0.437	0.170	0.489	0.422	0.050	0.134	0.020	0.000	0.000	2.315	2.013	1.722	1.285	1.115	0.626

[a] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these gear differences.

[b] During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFSC 1991).

[c] Spring surveys during 1980-1982, 1989-1991 and 1994, and autumn surveys during 1977-1981, 1989-1991, and 1993 were accomplished with the *R/V Delaware II*; in all other years, the surveys were accomplished using the *R/V Albatross IV*. Adjustments have been made to the *R/V Delaware II* catch per tow data to standardize these to *R/V Albatross IV* equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFSC 1991).

[d] Excludes unusually high catch of 1894 cod (2558 kg) at Station 230 (Strata tow 20-4).

[e] Excludes unusually high catch of 1032 cod (4096 kg) at Station 323 (Strata tow 16-7).

Appendix 1:Table 2 (Continued). Standardized (for vessel and door changes) stratified mean catch per tow at age (numbers) of Atlantic cod in NEFSC offshore spring and autumn bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 1997. [b,c]

	Age Group											Totals					
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
Autumn																	
1963	0.019	0.719	0.778	0.920	0.897	0.354	0.326	0.175	0.103	0.014	0.069	4.374	4.356	3.636	2.858	1.938	1.041
1964	0.009	0.640	0.699	0.588	0.538	0.145	0.136	0.062	0.050	0.030	0.083	2.980	2.970	2.331	1.632	1.044	0.505
1965	0.173	1.299	0.998	0.707	0.484	0.167	0.179	0.112	0.081	0.023	0.023	4.248	4.075	2.775	1.777	1.070	0.587
1966	1.025	1.693	1.000	0.515	0.264	0.100	0.095	0.062	0.039	0.002	0.017	4.811	3.786	2.094	1.094	0.579	0.315
1967	0.072	7.596	1.334	0.523	0.406	0.133	0.133	0.055	0.051	0.012	0.070	10.383	10.312	2.716	1.382	0.860	0.454
1968	0.070	0.314	1.611	0.783	0.271	0.073	0.067	0.027	0.023	0.008	0.048	3.296	3.226	2.913	1.301	0.518	0.246
1969	0.000	0.343	0.622	0.626	0.331	0.094	0.061	0.019	0.023	0.022	0.059	2.200	2.200	1.856	1.234	0.608	0.278
1970	0.413	1.688	1.353	0.524	0.694	0.153	0.000	0.033	0.055	0.055	0.098	5.065	4.652	2.964	1.611	1.087	0.393
1971	0.399	0.602	0.632	0.390	0.301	0.476	0.183	0.042	0.089	0.000	0.075	3.189	2.789	2.187	1.555	1.165	0.864
1972	0.947	7.443	1.295	1.771	0.399	0.243	0.571	0.109	0.204	0.022	0.083	13.087	12.140	4.697	3.402	1.632	1.232
1973	0.203	1.749	6.070	1.182	2.012	0.211	0.226	0.175	0.062	0.139	0.251	12.280	12.078	10.329	4.259	3.076	1.064
1974	0.462	0.409	0.654	1.521	0.164	0.114	0.103	0.000	0.069	0.000	0.000	3.494	3.033	2.624	1.970	0.449	0.285
1975	2.377	0.994	0.421	0.624	1.685	0.112	0.156	0.000	0.000	0.000	0.037	6.407	4.029	3.036	2.615	1.991	0.306
1976	0.000	6.148	2.072	0.763	0.278	0.739	0.055	0.270	0.039	0.053	0.020	10.436	10.436	4.288	2.217	1.454	1.176
1977	0.152	0.237	3.424	0.702	0.251	0.174	0.396	0.007	0.027	0.000	0.078	5.447	5.296	5.059	1.635	0.933	0.682
1978	0.396	1.855	0.255	4.180	0.964	0.335	0.165	0.344	0.051	0.030	0.014	8.587	8.192	6.337	6.082	1.902	0.938
1979	0.118	1.619	1.717	0.224	1.613	0.296	0.180	0.036	0.115	0.007	0.022	5.948	5.829	4.210	2.493	2.269	0.656
1980	0.280	0.818	0.564	0.774	0.076	0.251	0.053	0.067	0.025	0.000	0.000	2.908	2.629	1.810	1.246	0.472	0.396
1981	0.261	3.525	2.250	1.559	0.589	0.054	0.579	0.057	0.064	0.018	0.083	9.040	8.778	5.254	3.003	1.444	0.855
1982	0.320	0.875	2.094	0.220	0.069	0.097	0.000	0.016	0.000	0.000	0.022	3.711	3.391	2.516	0.423	0.203	0.134
1983	1.031	0.647	1.022	0.796	0.055	0.047	0.003	0.000	0.012	0.000	0.023	3.636	2.605	1.958	0.936	0.140	0.086
1984	0.186	2.496	0.101	0.886	0.870	0.017	0.062	0.039	0.006	0.039	0.044	4.747	4.561	2.065	1.964	1.078	0.207
1985	1.084	0.220	0.803	0.103	0.115	0.101	0.000	0.000	0.004	0.000	0.000	2.430	1.346	1.126	0.323	0.220	0.105
1986	0.096	2.280	0.153	0.382	0.010	0.061	0.090	0.016	0.000	0.008	0.028	3.124	3.028	0.748	0.595	0.213	0.203
1987	0.204	0.414	1.353	0.112	0.195	0.028	0.012	0.000	0.000	0.007	0.000	2.325	2.121	1.707	0.354	0.242	0.047
1988	0.549	0.903	0.433	0.909	0.091	0.178	0.000	0.011	0.039	0.000	0.000	3.113	2.564	1.661	1.228	0.319	0.228
1989	0.262	2.738	1.030	0.183	0.499	0.055	0.008	0.004	0.000	0.000	0.000	4.780	4.518	1.780	0.750	0.566	0.067
1990 [f]	0.156	0.362	1.534	1.164	0.209	0.145	0.012	0.013	0.000	0.000	0.022	3.617	3.460	3.098	1.564	0.401	0.192
1991	0.040	0.415	0.168	0.277	0.028	0.029	0.000	0.000	0.000	0.000	0.000	0.957	0.917	0.502	0.334	0.057	0.029
1992	0.033	0.454	1.024	0.180	0.112	0.030	0.010	0.000	0.000	0.000	0.000	1.843	1.810	1.356	0.332	0.152	0.040
1993	0.179	0.970	0.532	0.382	0.017	0.025	0.022	0.000	0.000	0.022	0.000	2.149	1.970	1.000	0.468	0.086	0.070
1994	0.067	0.406	0.664	0.433	0.153	0.068	0.021	0.000	0.006	0.000	0.000	1.818	1.751	1.345	0.681	0.248	0.095
1995	0.160	0.245	1.811	1.249	0.087	0.054	0.011	0.000	0.000	0.000	0.000	3.617	3.457	3.212	1.401	0.152	0.065
1996	0.022	0.240	0.196	0.414	0.143	0.060	0.027	0.000	0.000	0.000	0.000	1.102	1.080	0.840	0.644	0.230	0.087
1997	0.006	0.236	0.321	0.109	0.129	0.049	0.009	0.007	0.000	0.000	0.000	0.867	0.860	0.624	0.303	0.194	0.065

[b] During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFSC 1991).

[c] Spring surveys during 1980-1982, 1989-1991 and 1994, and autumn surveys during 1977-1981, 1989-1991, and 1993 were accomplished with the *R/V Delaware II*; in all other years, the surveys were accomplished using the *R/V Albatross IV*. Adjustments have been made to the *R/V Delaware II* catch per tow data to standardize these to *R/V Albatross IV* equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFSC 1991).

[f] Excludes unusually high catch of 111 cod (504 kg) at Station 205 (Strata tow 23-4).

Appendix 1: Table 3. Stratified mean catch per tow at age (numbers) of Atlantic cod in Canadian spring bottom trawl surveys on Eastern Georges Bank, 1986 - 1998.

	Age Group										Totals				
Year	1	2	3	4	5	6	7	8	9	10+	1+	2+	3+	4+	5+
1986	0.60	2.27	2.81	0.37	0.65	0.44	0.26	0.04	0.07	0.03	7.54	6.94	4.67	1.86	1.49
1987	0.25	2.13	0.93	1.09	0.34	0.12	0.22	0.08	0.03	0.07	5.26	5.01	2.88	1.95	0.86
1988	0.28	1.01	4.66	0.58	1.02	0.13	0.08	0.17	0.04	0.07	8.04	7.76	6.75	2.09	1.51
1989	1.63	2.78	1.38	2.85	0.36	0.42	0.05	0.10	0.12	0.06	9.75	8.12	5.34	3.96	1.11
1990	0.42	2.44	3.78	2.08	3.87	0.42	0.93	0.12	0.12	0.35	14.55	14.11	11.67	7.89	5.81
1991	1.18	1.16	1.84	2.15	1.05	1.31	0.16	0.22	0.03	0.09	9.19	8.01	6.85	5.01	2.86
1992	0.11	2.86	1.77	0.80	0.98	0.60	0.43	0.12	0.07	0.02	7.76	7.65	4.79	3.02	2.22
1993	0.05	0.60	2.83	1.04	0.62	1.23	0.44	0.42	0.07	0.12	7.42	7.37	6.77	3.94	2.90
1994	0.02	0.80	0.89	1.65	0.60	0.23	0.45	0.11	0.15	0.04	4.94	4.92	4.12	3.23	1.58
1995	0.07	0.67	1.50	0.86	0.60	0.19	0.04	0.05	0.02	0.02	4.02	3.95	3.28	1.78	0.92
1996	0.14	0.49	2.31	4.02	1.09	0.79	0.33	0.08	0.11	0.03	9.39	9.25	8.76	6.45	2.43
1997	0.32	0.53	0.55	1.25	1.23	0.27	0.06	0.03	0.02	0.01	4.27	3.95	3.42	2.87	1.62
1998	0.01	1.42	2.04	0.79	0.77	0.58	0.14	0.07	0.02	0.04	5.88	5.87	4.45	2.41	1.62

APPENDIX 2

Full Listing of ADAPT VPA Calibration Output and Diagnostics for Georges Bank Cod.

Woods Hole Assessment Toolbox Georges Bank Cod Run Number 9 4/7/98 3:30:37 PM
Georges Bank Cod 1978 - 1998
Input Parameters and Options Selected

Natural mortality is 0.2
Oldest age (not in the plus group) is 9
For all years prior to the terminal year (1997), backcalculated
stock sizes for the following ages used to estimate
total mortality (Z) for age 9 : 4 5 6 7 8 9
This method for estimating F on the oldest age is generally used when a
flat-topped partial recruitment curve is thought to be characteristic of the stock.
F for age 10 + is then calculated from the following
ratios of F[age 10 +] to F[age 9]

1978	1
1979	1
1980	1
1981	1
1982	1
1983	1
1984	1
1985	1
1986	1
1987	1
1988	1
1989	1
1990	1
1991	1
1992	1
1993	1
1994	1
1995	1
1996	1
1997	1

Stock size of the 10 + group is then calculated using
the following method: CATCH EQUATION
Partial recruitment estimate for 1998

1	0.0027
2	0.334
3	0.8209
4	1
5	1
6	1
7	1
8	1
9	1

Objective function is Sum w*(LOG(OBS)-LOG(PRED))**2
Indices normalized (by dividing by mean observed value)
before tuning to VPA stocksizes
Downweighting is not used
Biomass estimates (other than SSB) reflect mean stock sizes.
SSB calculated as in the NEFSC projection program
(see note below SSB table for description of the algorithm).
Initial estimates of parameters for the Marquardt algorithm
and lower and upper bounds on the parameter estimates:

Par.	Initial Est	Lower Bnd	Upper Bnd
N 1	2.00E+03	1.00E+00	1.00E+06
N 2	9.00E+03	1.00E+00	1.00E+06
N 3	4.00E+03	1.00E+00	1.00E+06
N 4	5.00E+03	1.00E+00	1.00E+06
N 5	2.00E+03	1.00E+00	1.00E+06
N 6	2.00E+03	1.00E+00	1.00E+06
N 7	2.00E+03	1.00E+00	1.00E+06
N 8	1.00E+03	1.00E+00	1.00E+06
q spr_36 1	1.00E-04	0.00E+00	1.00E+00
q spr_36 2	1.00E-04	0.00E+00	1.00E+00
q spr_36 3	1.00E-04	0.00E+00	1.00E+00
q spr_36 4	1.00E-04	0.00E+00	1.00E+00
q spr_36 5	1.00E-04	0.00E+00	1.00E+00

```
q spr_36 6    1.00E-04      0.00E+00      1.00E+00
q spr_36 7    1.00E-04      0.00E+00      1.00E+00
q spr_36 8    1.00E-04      0.00E+00      1.00E+00
q spr_41 1    1.00E-04      0.00E+00      1.00E+00
q spr_41 2    1.00E-04      0.00E+00      1.00E+00
q spr_41 3    1.00E-04      0.00E+00      1.00E+00
q spr_41 4    1.00E-04      0.00E+00      1.00E+00
q spr_41 5    1.00E-04      0.00E+00      1.00E+00
q spr_41 6    1.00E-04      0.00E+00      1.00E+00
q spr_41 7    1.00E-04      0.00E+00      1.00E+00
q spr_41 8    1.00E-04      0.00E+00      1.00E+00
q sp_can 1    1.00E-04      0.00E+00      1.00E+00
q sp_can 2    1.00E-04      0.00E+00      1.00E+00
q sp_can 3    1.00E-04      0.00E+00      1.00E+00
q sp_can 4    1.00E-04      0.00E+00      1.00E+00
q sp_can 5    1.00E-04      0.00E+00      1.00E+00
q sp_can 6    1.00E-04      0.00E+00      1.00E+00
q sp_can 7    1.00E-04      0.00E+00      1.00E+00
q sp_can 8    1.00E-04      0.00E+00      1.00E+00
q us0aut 1    1.00E-04      0.00E+00      1.00E+00
q us1aut 2    1.00E-04      0.00E+00      1.00E+00
q us2aut 3    1.00E-04      0.00E+00      1.00E+00
q us3aut 4    1.00E-04      0.00E+00      1.00E+00
q us4aut 5    1.00E-04      0.00E+00      1.00E+00
q us5aut 6    1.00E-04      0.00E+00      1.00E+00
The following indices of abundance are available
 1            spr_36 1
 2            spr_36 2
 3            spr_36 3
 4            spr_36 4
 5            spr_36 5
 6            spr_36 6
 7            spr_36 7
 8            spr_36 8
 9            spr_41 1
 10           spr_41 2
 11           spr_41 3
 12           spr_41 4
 13           spr_41 5
 14           spr_41 6
 15           spr_41 7
 16           spr_41 8
 17           sp_can 1
 18           sp_can 2
 19           sp_can 3
 20           sp_can 4
 21           sp_can 5
 22           sp_can 6
 23           sp_can 7
 24           sp_can 8
 25           us0aut 1
 26           us1aut 2
 27           us2aut 3
 28           us3aut 4
 29           us4aut 5
 30           us5aut 6
 The Indices that will be used in this run are:
spr_36 1
spr_36 2
spr_36 3
spr_36 4
spr_36 5
spr_36 6
spr_36 7
spr_36 8
spr_41 1
spr_41 2
spr_41 3
```

spr_41 4
spr_41 5
spr_41 6
spr_41 7
spr_41 8
sp_can 1
sp_can 2
sp_can 3
sp_can 4
sp_can 5
sp_can 6
sp_can 7
sp_can 8
us0aut 1
us1aut 2
us2aut 3
us3aut 4
us4aut 5
us5aut 6
Obs Indices (before transformation) by index and year; with Index means

	1978	1979	1980	1981	1982	1983	1984
spr_36 1	0.00	0.00	0.00	0.00	0.49	0.33	0.40
spr_36 2	0.00	0.00	0.00	0.00	3.40	1.97	0.46
spr_36 3	0.00	0.00	0.00	0.00	1.41	3.05	0.80
spr_36 4	0.00	0.00	0.00	0.00	1.30	0.77	1.16
spr_36 5	0.00	0.00	0.00	0.00	1.04	0.70	0.45
spr_36 6	0.00	0.00	0.00	0.00	0.02	0.43	0.42
spr_36 7	0.00	0.00	0.00	0.00	0.30	0.06	0.22
spr_36 8	0.00	0.00	0.00	0.00	0.06	0.19	0.00
spr_41 1	0.38	0.44	0.03	2.30	0.00	0.00	0.00
spr_41 2	0.19	1.36	1.79	1.92	0.00	0.00	0.00
spr_41 3	5.53	0.30	2.12	2.78	0.00	0.00	0.00
spr_41 4	0.97	1.91	0.17	1.67	0.00	0.00	0.00
spr_41 5	0.78	0.54	1.17	0.10	0.00	0.00	0.00
spr_41 6	0.14	0.23	0.47	0.87	0.00	0.00	0.00
spr_41 7	0.71	0.09	0.15	0.27	0.00	0.00	0.00
spr_41 8	0.05	0.15	0.03	0.14	0.00	0.00	0.00
sp_can 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sp_can 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sp_can 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sp_can 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sp_can 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sp_can 6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sp_can 7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sp_can 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
us0aut 1	0.15	0.40	0.12	0.28	0.26	0.32	1.03
us1aut 2	0.24	1.86	1.62	0.82	3.53	0.88	0.65
us2aut 3	3.42	0.26	1.72	0.56	2.25	2.09	1.02
us3aut 4	0.70	4.18	0.22	0.77	1.56	0.22	0.80
us4aut 5	0.25	0.96	1.61	0.08	0.59	0.07	0.06
us5aut 6	0.17	0.34	0.30	0.25	0.05	0.10	0.05

	1985	1986	1987	1988	1989	1990	1991
spr_36 1	0.10	0.87	0.03	0.70	0.38	0.19	1.07
spr_36 2	2.63	0.42	1.61	0.68	1.33	0.93	0.51
spr_36 3	0.76	1.82	0.40	3.12	0.74	1.71	0.81
spr_36 4	1.06	0.36	0.75	0.41	1.53	0.65	0.88
spr_36 5	1.33	0.55	0.06	0.65	0.23	0.90	0.46
spr_36 6	0.27	0.63	0.18	0.05	0.34	0.13	0.34
spr_36 7	0.20	0.06	0.15	0.02	0.05	0.14	0.04
spr_36 8	0.17	0.12	0.02	0.05	0.04	0.01	0.04
spr_41 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
spr_41 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
spr_41 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
spr_41 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00

spr_41	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
spr_41	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
spr_41	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
spr_41	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sp_can	1	0.00	0.60	0.25	0.28	1.63	0.42	1.18
sp_can	2	0.00	2.27	2.13	1.01	2.78	2.44	1.16
sp_can	3	0.00	2.81	0.93	4.66	1.38	3.78	1.84
sp_can	4	0.00	0.37	1.09	0.58	2.85	2.08	2.15
sp_can	5	0.00	0.65	0.34	1.02	0.36	3.87	1.05
sp_can	6	0.00	0.44	0.12	0.13	0.42	0.42	1.31
sp_can	7	0.00	0.26	0.22	0.08	0.05	0.93	0.16
sp_can	8	0.00	0.04	0.08	0.17	0.10	0.12	0.22
us0aut	1	0.19	1.08	0.10	0.20	0.55	0.26	0.16
us1aut	2	2.50	0.22	2.28	0.41	0.90	2.74	0.36
us2aut	3	0.10	0.80	0.15	1.35	0.43	1.03	1.53
us3aut	4	0.89	0.10	0.38	0.11	0.91	0.18	1.16
us4aut	5	0.87	0.12	0.01	0.20	0.09	0.50	0.21
us5aut	6	0.02	0.10	0.06	0.03	0.18	0.06	0.15

		1992	1993	1994	1995	1996	1997	1998	Average
spr_36	1	0.12	0.02	0.12	0.05	0.07	0.29	0.00	0.328
spr_36	2	1.26	0.40	0.27	0.38	0.21	0.44	0.00	1.057
spr_36	3	0.47	1.35	0.20	0.85	0.74	0.17	0.00	1.149
spr_36	4	0.16	0.22	0.22	0.53	1.25	0.49	0.00	0.734
spr_36	5	0.27	0.11	0.03	0.60	0.17	0.42	0.00	0.497
spr_36	6	0.14	0.12	0.01	0.11	0.21	0.05	0.00	0.215
spr_36	7	0.16	0.04	0.04	0.23	0.03	0.13	0.00	0.117
spr_36	8	0.02	0.04	0.00	0.03	0.02	0.02	0.00	0.059
spr_41	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.786
spr_41	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.313
spr_41	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.683
spr_41	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.179
spr_41	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.648
spr_41	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.430
spr_41	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.305
spr_41	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.091
sp_can	1	0.11	0.00	0.00	0.07	0.14	0.32	0.01	0.455
sp_can	2	2.86	0.00	0.00	0.67	0.49	0.53	0.67	1.546
sp_can	3	1.77	0.00	0.00	1.50	2.31	0.55	0.95	2.044
sp_can	4	0.80	0.00	0.00	0.86	4.02	1.25	0.35	1.491
sp_can	5	0.98	0.00	0.00	0.60	1.09	1.23	0.77	1.087
sp_can	6	0.60	0.00	0.00	0.19	0.79	0.27	0.58	0.479
sp_can	7	0.43	0.00	0.00	0.04	0.33	0.06	0.14	0.245
sp_can	8	0.12	0.00	0.00	0.05	0.08	0.03	0.07	0.098
us0aut	1	0.04	0.03	0.18	0.07	0.16	0.02	0.01	0.267
us1aut	2	0.42	0.45	0.97	0.41	0.25	0.24	0.24	1.045
us2aut	3	0.17	1.02	0.53	0.66	1.81	0.20	0.32	1.021
us3aut	4	0.28	0.18	0.38	0.43	1.25	0.41	0.11	0.726
us4aut	5	0.03	0.11	0.02	0.15	0.09	0.14	0.13	0.299
us5aut	6	0.03	0.03	0.03	0.07	0.05	0.06	0.05	0.103

Catch at age (thousands) - C:\wstemp\GB_97m2.9

	1978	1979	1980	1981	1982	1983	1984
1	02	34	89	27	331	108	81
2	393	1989	3777	3205	9138	4286	1307
3	7748	900	5828	4221	3824	8063	3423
4	2303	4870	500	2464	2787	2456	3336
5	830	1212	2308	235	2000	1055	840
6	131	458	1076	1406	281	776	516
7	345	77	445	417	673	95	458
8	47	253	87	123	213	235	44
9	40	04	167	130	71	100	171
10	15	48	10	62	83	65	121

1+	11854	9845	14287	12290	19401	17239	10297

	1985	1986	1987	1988	1989	1990	1991
1	134	156	26	10	00	07	52
2	6426	1326	7473	1577	2088	4942	1525
3	2443	4573	1406	8022	2922	5042	3243
4	1368	797	2121	1012	4155	1882	3281
5	1885	480	279	1497	331	2264	1458
6	412	627	252	244	541	229	1088
7	218	87	270	161	82	245	126
8	203	72	63	197	43	36	70
9	21	47	38	50	5[illegible]	17	23
10	97	29	24	47	1[illegible]	38	23
1+	13207	8194	11952	12817	10230	14702	10889

	1992	1993	1994	1995	1996	1997
1	70	04	02	00	01	03
2	4177	1033	398	392	207	517
3	2170	4246	1526	1058	903	639
4	1038	1115	1825	692	1234	881
5	1482	440	394	290	241	794
6	404	472	96	44	123	131
7	309	159	137	26	15	84
8	34	143	46	15	03	16
9	33	32	38	02	05	09
10	10	17	06	01	00	04
1+	9727	7661	4468	2520	2732	3078

CAA Summary for ages 4 - 10

	1978	1979	1980	1981	1982	1983	1984
	3711	6922	4593	4837	6108	4782	5486

	1985	1986	1987	1988	1989	1990	1991
	4204	2139	3047	3208	5220	4711	6069

	1992	1993	1994	1995	1996	1997
	3310	2378	2542	1070	1621	1919

Weight at age (mid year) in kg - C:\wstemp\GB_97m2.9

	1978	1979	1980	1981	1982	1983	1984
1	0.707	0.889	0.836	0.882	0.765	0.971	1.053
2	1.310	1.494	1.460	1.495	1.402	1.490	1.635
3	2.461	2.149	2.468	2.358	2.664	2.377	2.451
4	3.469	4.211	3.668	3.415	3.834	3.309	3.619
5	4.336	4.888	5.647	5.213	5.352	4.637	5.083
6	5.787	7.178	6.676	7.222	6.511	6.393	6.582
7	7.374	9.183	8.390	8.565	9.363	7.964	8.909
8	8.492	10.313	9.089	9.888	9.897	10.286	10.104
9	11.785	11.699	8.432	14.170	12.503	11.227	11.303
10	13.200	12.625	15.400	18.565	16.723	14.554	15.356

	1985	1986	1987	1988	1989	1990	1991
1	0.907	0.929	0.726	0.786	0.809	0.831	1.114
2	1.418	1.475	1.481	1.520	1.617	1.560	1.627
3	2.086	2.447	2.495	2.359	2.269	2.462	2.548
4	3.887	3.660	4.187	3.511	3.772	3.522	3.420

5	5.087	5.603	5.810	5.401	5.396	4.892	4.769
6	6.412	7.191	7.726	6.647	6.694	6.333	5.891
7	8.097	8.915	8.949	8.776	8.222	8.456	7.410
8	10.236	9.955	10.013	9.987	10.718	10.648	10.520
9	11.418	12.687	11.414	11.143	11.665	12.580	9.686
10	13.494	14.104	15.000	15.298	17.111	14.526	15.373

	1992	1993	1994	1995	1996	1997
1	1.148	0.872	0.906	0.906	0.882	0.954
2	1.542	1.534	1.459	1.471	1.507	1.577
3	2.464	2.253	2.168	2.095	2.435	2.321
4	3.843	3.333	3.657	3.830	3.387	3.532
5	4.704	4.967	4.804	5.492	4.912	4.103
6	6.156	6.379	7.432	7.384	6.622	6.019
7	7.509	7.510	8.013	10.715	8.369	8.050
8	9.846	9.217	9.368	11.617	8.438	8.631
9	12.059	9.699	9.698	10.383	12.883	11.870
10	19.025	13.236	16.659	14.953	12.002	12.795

Weights at age at the start of the spawning season are assumed
to be the same as the mid-year weight at age estimates.

Survey Weights - C:\wstemp\GB_97m2.9

	1978	1979	1980	1981	1982	1983	1984
1	0.707	0.889	0.836	0.882	0.765	0.971	1.053
2	1.310	1.494	1.460	1.495	1.402	1.490	1.635
3	2.461	2.149	2.468	2.358	2.664	2.377	2.451
4	3.469	4.211	3.668	3.415	3.834	3.309	3.619
5	4.336	4.888	5.647	5.213	5.352	4.637	5.083
6	5.787	7.178	6.676	7.222	6.511	6.393	6.582
7	7.374	9.183	8.390	8.565	9.363	7.964	8.909
8	8.492	10.313	9.089	9.888	9.897	10.286	10.104
9	11.785	11.699	8.432	14.170	12.503	11.227	11.303
10	13.200	12.625	15.400	18.565	16.723	14.554	15.356

	1985	1986	1987	1988	1989	1990	1991
1	0.907	0.929	0.726	0.786	0.809	0.831	1.114
2	1.418	1.475	1.481	1.520	1.617	1.560	1.627
3	2.086	2.447	2.495	2.359	2.269	2.462	2.548
4	3.887	3.660	4.187	3.511	3.772	3.522	3.420
5	5.087	5.603	5.810	5.401	5.396	4.892	4.769
6	6.412	7.191	7.726	6.647	6.694	6.333	5.891
7	8.097	8.915	8.949	8.776	8.222	8.456	7.410
8	10.236	9.955	10.013	9.987	10.718	10.648	10.520
9	11.418	12.687	11.414	11.143	11.665	12.580	9.686
10	13.494	14.104	15.000	15.298	17.111	14.526	15.373

	1992	1993	1994	1995	1996	1997
1	1.148	0.872	0.906	0.906	0.882	0.954
2	1.542	1.534	1.459	1.471	1.507	1.577
3	2.464	2.253	2.168	2.095	2.435	2.321
4	3.843	3.333	3.657	3.830	3.387	3.532
5	4.704	4.967	4.804	5.492	4.912	4.103
6	6.156	6.379	7.432	7.384	6.622	6.019
7	7.509	7.510	8.013	10.715	8.369	8.050
8	9.846	9.217	9.368	11.617	8.438	8.631
9	12.059	9.699	9.698	10.383	12.883	11.870
10	19.025	13.236	16.659	14.953	12.002	12.795

Percent Mature (females)- C:\wstemp\GB_97m2.9

	1978	1979	1980	1981	1982	1983	1984
1	07	07	07	07	13	13	13
2	34	34	34	34	47	47	47
3	78	78	78	78	84	84	84
4	96	96	96	96	97	97	97
5	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100
8	100	100	100	100	100	100	100
9	100	100	100	100	100	100	100
10	100	100	100	100	100	100	100

	1985	1986	1987	1988	1989	1990	1991
1	13	28	28	28	28	12	12
2	47	67	67	67	67	52	52
3	84	91	91	91	91	90	90
4	97	98	98	98	98	99	99
5	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100
8	100	100	100	100	100	100	100
9	100	100	100	100	100	100	100
10	100	100	100	100	100	100	100

	1992	1993	1994	1995	1996	1997
1	12	12	04	04	04	04
2	52	52	44	44	44	44
3	90	90	93	93	93	93
4	99	99	100	100	100	100
5	100	100	100	100	100	100
6	100	100	100	100	100	100
7	100	100	100	100	100	100
8	100	100	100	100	100	100
9	100	100	100	100	100	100
10	100	100	100	100	100	100

Sex Ratio (Percent Female) - C:\wstemp\GB_97m2.9

	1978	1979	1980	1981	1982	1983	1984
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
7	0.5	0.5	0.5	0.5	0.5	0.5	0.5
8	0.5	0.5	0.5	0.5	0.5	0.5	0.5
9	0.5	0.5	0.5	0.5	0.5	0.5	0.5
10	0.5	0.5	0.5	0.5	0.5	0.5	0.5

	1985	1986	1987	1988	1989	1990	1991
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
7	0.5	0.5	0.5	0.5	0.5	0.5	0.5
8	0.5	0.5	0.5	0.5	0.5	0.5	0.5
9	0.5	0.5	0.5	0.5	0.5	0.5	0.5
10	0.5	0.5	0.5	0.5	0.5	0.5	0.5

	1992	1993	1994	1995	1996	1997

1	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5
7	0.5	0.5	0.5	0.5	0.5	0.5
8	0.5	0.5	0.5	0.5	0.5	0.5
9	0.5	0.5	0.5	0.5	0.5	0.5
10	0.5	0.5	0.5	0.5	0.5	0.5

pF is 0.1667
pM is 0.1667

Weight at age (Jan 1) in kg - C:\wstemp\GB_97m2.9

years	1978	1979	1980	1981	1982	1983	1984
1	0.486	0.694	0.625	0.700	0.548	0.748	0.907
2	1.023	1.028	1.139	1.118	1.112	1.068	1.260
3	1.881	1.678	1.920	1.855	1.996	1.826	1.911
4	2.922	3.219	2.808	2.903	3.007	2.969	2.933
5	3.370	4.118	4.876	4.373	4.275	4.216	4.101
6	4.594	5.579	5.712	6.386	5.826	5.849	5.525
7	6.235	7.290	7.760	7.562	8.223	7.201	7.547
8	7.235	8.721	9.136	9.108	9.207	9.814	8.970
9	10.004	9.967	9.325	11.349	11.119	10.541	10.783
10	13.200	12.625	15.400	18.565	16.723	14.554	15.356

years	1985	1986	1987	1988	1989	1990	1991
1	0.711	0.736	0.502	0.548	0.583	0.594	0.947
2	1.222	1.157	1.173	1.050	1.127	1.123	1.163
3	1.847	1.863	1.918	1.869	1.857	1.995	1.994
4	3.087	2.763	3.201	2.960	2.983	2.827	2.902
5	4.291	4.667	4.611	4.755	4.353	4.296	4.098
6	5.709	6.048	6.579	6.214	6.013	5.846	5.368
7	7.300	7.561	8.022	8.234	7.393	7.524	6.850
8	9.549	8.978	9.448	9.454	9.699	9.357	9.432
9	10.741	11.396	10.660	10.563	10.793	11.612	10.156
10	13.494	14.104	15.000	15.298	17.111	14.526	15.373

years	1992	1993	1994	1995	1996	1997	1998
1	0.993	0.674	0.711	0.702	0.660	0.772	0.680
2	1.311	1.327	1.128	1.154	1.168	1.179	1.179
3	2.002	1.864	1.824	1.748	1.893	1.870	2.109
4	3.129	2.866	2.870	2.882	2.664	2.933	2.880
5	4.011	4.369	4.001	4.482	4.337	3.728	4.254
6	5.418	5.478	6.076	5.956	6.031	5.437	4.516
7	6.651	6.799	7.149	8.924	7.861	7.301	6.663
8	8.542	8.319	8.388	9.648	9.509	8.499	8.876
9	11.263	9.772	9.454	9.862	12.234	10.008	8.765
10	19.025	13.236	16.659	14.953	12.002	12.795	12.795

Residual Sum of Squares from Marquardt Algorithm
Number 1
RSS 1157.33466000196
Lambda 1.00E-02

Number 2
RSS 987.082565198744
Lambda 1.00E-03

Number 3

```
RSS            845.809959977344
Lambda        1.00E-01

Number  4
RSS            736.205524560834
Lambda        1.00E-02

Number  5
RSS            391.062373974453
Lambda        1.00E+00

Number  6
RSS            212.275461456147
Lambda        1.00E-01

Number  7
RSS            161.295571315933
Lambda        1.00E+01

Number  8
RSS            156.895533632029
Lambda        1.00E+00

Number  9
RSS            156.816235769542
Lambda        1.00E-01

Number  10
RSS            156.816181348761
Lambda        1.00E-02

Number  11
RSS            156.816181398489
Lambda        1.00E-03

Number  12
RSS            156.816181342446
Lambda        1.00E-04

RESULTS
-------
Approximate Statistics Assuming Linearity Near Solution
Sum of Squares:  156.816181342446
Mean Square Residuals: 0.46951

           PAR. EST. STD. ERR. T-STATISTIC
                                      C.V.
N  1       4.24E+02  2.15E+02  1.98E+00  0.51
N  2       5.28E+03  1.69E+03  3.12E+00  0.32
N  3       3.72E+03  1.03E+03  3.62E+00  0.28
N  4       1.20E+03  3.61E+02  3.33E+00  0.30
N  5       2.84E+03  7.51E+02  3.78E+00  0.26
N  6       1.52E+03  4.58E+02  3.31E+00  0.30
N  7       4.79E+02  1.54E+02  3.11E+00  0.32
N  8       3.49E+02  1.17E+02  2.99E+00  0.33
q spr_36 1 4.76E-05  8.35E-06  5.70E+00  0.18
q spr_36 2 6.43E-05  1.12E-05  5.75E+00  0.17
q spr_36 3 9.68E-05  1.68E-05  5.77E+00  0.17
q spr_36 4 2.00E-04  3.46E-05  5.77E+00  0.17
q spr_36 5 3.65E-04  6.35E-05  5.75E+00  0.17
q spr_36 6 7.90E-04  1.38E-04  5.73E+00  0.17
q spr_36 7 2.06E-03  3.59E-04  5.74E+00  0.17
q spr_36 8 4.06E-03  7.52E-04  5.39E+00  0.19
q spr_41 1 1.54E-05  5.30E-06  2.90E+00  0.34
q spr_41 2 5.57E-05  1.92E-05  2.90E+00  0.34
q spr_41 3 5.80E-05  2.00E-05  2.90E+00  0.34
q spr_41 4 1.13E-04  3.88E-05  2.90E+00  0.34
q spr_41 5 2.38E-04  8.20E-05  2.90E+00  0.34
```

q spr_41	6	3.96E-04	1.36E-04	2.90E+00	0.34
q spr_41	7	7.13E-04	2.45E-04	2.90E+00	0.34
q spr_41	8	2.41E-03	8.30E-04	2.90E+00	0.34
q sp_can	1	5.90E-05	1.28E-05	4.59E+00	0.22
q sp_can	2	8.51E-05	1.81E-05	4.70E+00	0.21
q sp_can	3	1.21E-04	2.56E-05	4.73E+00	0.21
q sp_can	4	2.10E-04	4.44E-05	4.73E+00	0.21
q sp_can	5	4.09E-04	8.66E-05	4.73E+00	0.21
q sp_can	6	9.89E-04	2.11E-04	4.68E+00	0.21
q sp_can	7	2.04E-03	4.38E-04	4.67E+00	0.21
q sp_can	8	6.72E-03	1.43E-03	4.68E+00	0.21
q us0aut	1	4.66E-05	7.20E-06	6.47E+00	0.15
q us1aut	2	6.03E-05	9.19E-06	6.56E+00	0.15
q us2aut	3	8.35E-05	1.27E-05	6.59E+00	0.15
q us3aut	4	1.47E-04	2.23E-05	6.59E+00	0.15
q us4aut	5	2.26E-04	3.43E-05	6.58E+00	0.15
q us5aut	6	7.45E-04	1.14E-04	6.54E+00	0.15

Catchability Estimates in Original Units

	Estimate	Std.Err.	C.V.
q spr_36 1	1.56E-05	2.73E-06	0.18
q spr_36 2	6.80E-05	1.18E-05	0.17
q spr_36 3	1.11E-04	1.93E-05	0.17
q spr_36 4	1.47E-04	2.54E-05	0.17
q spr_36 5	1.82E-04	3.16E-05	0.17
q spr_36 6	1.70E-04	2.96E-05	0.17
q spr_36 7	2.42E-04	4.21E-05	0.17
q spr_36 8	2.41E-04	4.47E-05	0.19
q spr_41 1	1.21E-05	4.17E-06	0.34
q spr_41 2	7.31E-05	2.52E-05	0.34
q spr_41 3	1.56E-04	5.36E-05	0.34
q spr_41 4	1.33E-04	4.57E-05	0.34
q spr_41 5	1.54E-04	5.31E-05	0.34
q spr_41 6	1.70E-04	5.86E-05	0.34
q spr_41 7	2.18E-04	7.49E-05	0.34
q spr_41 8	2.20E-04	7.58E-05	0.34
q sp_can 1	2.68E-05	5.85E-06	0.22
q sp_can 2	1.32E-04	2.80E-05	0.21
q sp_can 3	2.48E-04	5.23E-05	0.21
q sp_can 4	3.13E-04	6.62E-05	0.21
q sp_can 5	4.45E-04	9.41E-05	0.21
q sp_can 6	4.74E-04	1.01E-04	0.21
q sp_can 7	5.02E-04	1.08E-04	0.21
q sp_can 8	6.59E-04	1.41E-04	0.21
q us0aut 1	1.24E-05	1.92E-06	0.15
q us1aut 2	6.30E-05	9.61E-06	0.15
q us2aut 3	8.53E-05	1.29E-05	0.15
q us3aut 4	1.06E-04	1.62E-05	0.15
q us4aut 5	6.74E-05	1.02E-05	0.15
q us5aut 6	7.64E-05	1.17E-05	0.15

Summary of Residuals
spr_36
Tuned to: 1-Jan
For ages: 1

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	0.488	0.832	0.399	-0.184	1	0.583	0.851	17471
1983	0.329	0.458	0.004	-0.782	1	0.786	1.147	9616
1984	0.402	1.304	0.205	0.265	1	-0.061	-0.089	27397
1985	0.098	0.413	-1.207	-0.884	1	-0.323	-0.471	8682
1986	0.871	2.038	0.978	0.712	1	0.266	0.388	42813
1987	0.034	0.780	-2.265	-0.248	1	-2.017	-2.944	16389
1988	0.700	1.118	0.759	0.111	1	0.648	0.946	23486

1989	0.380	0.752	0.148	-0.285	1	0.433	0.633	15800
1990	0.194	0.445	-0.524	-0.809	1	0.285	0.416	9355
1991	1.068	0.913	1.182	-0.091	1	1.273	1.858	19176
1992	0.123	0.379	-0.979	-0.971	1	-0.009	-0.012	7957
1993	0.017	0.516	-2.958	-0.661	1	-2.297	-3.352	10844
1994	0.123	0.481	-0.979	-0.731	1	-0.249	-0.363	10116
1995	0.050	0.168	-1.880	-1.786	1	-0.094	-0.137	3523
1996	0.073	0.297	-1.501	-1.213	1	-0.288	-0.420	6246
1997	0.291	0.307	-0.118	-1.180	1	1.062	1.549	6456
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.955

spr_36
Tuned to: 1-Jan
For ages: 2

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	3.395	2.179	1.167	0.779	1	0.389	0.567	33867
1983	1.967	0.901	0.621	-0.104	1	0.726	1.059	14005
1984	0.462	0.500	-0.827	-0.693	1	-0.134	-0.196	7775
1985	2.633	1.438	0.913	0.363	1	0.550	0.802	22358
1986	0.423	0.449	-0.915	-0.800	1	-0.116	-0.169	6987
1987	1.612	2.246	0.422	0.809	1	-0.387	-0.564	34912
1988	0.684	0.862	-0.435	-0.149	1	-0.286	-0.417	13395
1989	1.334	1.236	0.233	0.212	1	0.021	0.030	19220
1990	0.926	0.832	-0.132	-0.184	1	0.052	0.075	12936
1991	0.511	0.492	-0.726	-0.709	1	-0.018	-0.026	7653
1992	1.255	1.007	0.172	0.007	1	0.165	0.241	15653
1993	0.398	0.415	-0.976	-0.879	1	-0.097	-0.142	6451
1994	0.273	0.571	-1.353	-0.561	1	-0.793	-1.157	8874
1995	0.382	0.533	-1.017	-0.630	1	-0.388	-0.566	8280
1996	0.214	0.186	-1.597	-1.685	1	0.088	0.128	2884
1997	0.437	0.329	-0.883	-1.112	1	0.229	0.334	5113
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.144

spr_36
Tuned to: 1-Jan
For ages: 3

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	1.406	1.018	0.202	0.018	1	0.184	0.269	10511
1983	3.048	1.884	0.976	0.633	1	0.342	0.499	19459
1984	0.797	0.735	-0.366	-0.308	1	-0.057	-0.084	7588
1985	0.757	0.502	-0.417	-0.689	1	0.272	0.397	5183
1986	1.824	1.209	0.462	0.190	1	0.272	0.397	12490
1987	0.403	0.438	-1.048	-0.826	1	-0.221	-0.323	4521
1988	3.115	2.113	0.997	0.748	1	0.249	0.364	21821
1989	0.743	0.924	-0.436	-0.079	1	-0.356	-0.520	9540
1990	1.707	1.341	0.396	0.293	1	0.103	0.150	13846
1991	0.807	0.593	-0.353	-0.523	1	0.170	0.248	6120
1992	0.470	0.473	-0.894	-0.749	1	-0.145	-0.212	4886
1993	1.347	0.875	0.159	-0.134	1	0.293	0.427	9036
1994	0.199	0.421	-1.753	-0.865	1	-0.888	-1.296	4347
1995	0.854	0.669	-0.297	-0.403	1	0.106	0.155	6906
1996	0.736	0.622	-0.445	-0.475	1	0.029	0.043	6425
1997	0.170	0.210	-1.911	-1.558	1	-0.352	-0.514	2174
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.109

spr_36
Tuned to: 1-Jan

For ages: 4

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	1.295	1.253	0.568	0.225	1	0.342	0.500	6267
1983	0.766	1.029	0.043	0.028	1	0.014	0.021	5146
1984	1.161	1.727	0.459	0.546	1	-0.088	-0.128	8636
1985	1.058	0.623	0.366	-0.473	1	0.839	1.225	3115
1986	0.360	0.406	-0.712	-0.900	1	0.188	0.274	2033
1987	0.752	1.217	0.024	0.197	1	-0.172	-0.252	6088
1988	0.413	0.486	-0.575	-0.722	1	0.147	0.215	2429
1989	1.532	2.121	0.736	0.752	1	-0.016	-0.023	10607
1990	0.653	1.033	-0.117	0.032	1	-0.149	-0.218	5166
1991	0.883	1.354	0.185	0.303	1	-0.119	-0.173	6774
1992	0.163	0.415	-1.505	-0.879	1	-0.625	-0.913	2076
1993	0.222	0.407	-1.196	-0.898	1	-0.297	-0.434	2037
1994	0.216	0.711	-1.223	-0.341	1	-0.882	-1.287	3556
1995	0.534	0.436	-0.318	-0.831	1	0.513	0.749	2178
1996	1.247	0.939	0.530	-0.063	1	0.593	0.865	4696
1997	0.489	0.888	-0.406	-0.118	1	-0.288	-0.420	4443
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.197

spr_36
Tuned to: 1-Jan
For ages: 5

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	1.039	1.716	0.737	0.540	1	0.197	0.288	4698
1983	0.697	0.953	0.338	-0.048	1	0.386	0.564	2609
1984	0.446	0.727	-0.108	-0.319	1	0.210	0.307	1991
1985	1.328	1.480	0.983	0.392	1	0.591	0.862	4052
1986	0.545	0.480	0.092	-0.735	1	0.827	1.207	1313
1987	0.060	0.345	-2.114	-1.065	1	-1.049	-1.531	943
1988	0.645	1.120	0.261	0.113	1	0.147	0.215	3066
1989	0.228	0.392	-0.779	-0.937	1	0.157	0.229	1073
1990	0.896	1.799	0.589	0.587	1	0.002	0.003	4925
1991	0.464	0.923	-0.069	-0.080	1	0.011	0.016	2527
1992	0.270	0.942	-0.610	-0.060	1	-0.550	-0.803	2578
1993	0.107	0.278	-1.536	-1.281	1	-0.255	-0.372	760
1994	0.033	0.241	-2.712	-1.425	1	-1.288	-1.879	659
1995	0.599	0.460	0.187	-0.776	1	0.962	1.404	1260
1996	0.174	0.423	-1.050	-0.861	1	-0.189	-0.276	1157
1997	0.422	0.997	-0.164	-0.003	1	-0.160	-0.234	2729
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.368

spr_36
Tuned to: 1-Jan
For ages: 6

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	0.016	0.469	-2.597	-0.757	1	-1.841	-2.686	594
1983	0.431	1.610	0.696	0.476	1	0.220	0.321	2037
1984	0.424	0.934	0.680	-0.069	1	0.748	1.092	1181
1985	0.270	0.687	0.228	-0.375	1	0.603	0.880	870
1986	0.633	1.274	1.080	0.242	1	0.838	1.223	1612
1987	0.179	0.506	-0.183	-0.681	1	0.498	0.727	640
1988	0.045	0.411	-1.563	-0.889	1	-0.674	-0.984	520
1989	0.344	0.913	0.471	-0.091	1	0.562	0.820	1155

1990	0.125	0.458	-0.542	-0.782	1	0.240	0.350	579
1991	0.336	1.568	0.447	0.450	1	-0.002	-0.004	1984
1992	0.144	0.592	-0.400	-0.523	1	0.123	0.180	750
1993	0.120	0.608	-0.583	-0.498	1	-0.085	-0.124	769
1994	0.005	0.177	-3.761	-1.730	1	-2.031	-2.964	224
1995	0.107	0.144	-0.697	-1.935	1	1.238	1.806	183
1996	0.209	0.608	-0.028	-0.497	1	0.470	0.686	769
1997	0.050	0.577	-1.458	-0.551	1	-0.907	-1.324	730
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.873

spr_36
Tuned to: 1-Jan
For ages: 7

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	0.298	3.480	0.933	1.247	1	-0.314	-0.459	1686
1983	0.055	0.478	-0.757	-0.737	1	-0.020	-0.029	232
1984	0.223	1.992	0.643	0.689	1	-0.047	-0.068	965
1985	0.203	1.033	0.549	0.032	1	0.517	0.754	500
1986	0.063	0.700	-0.621	-0.356	1	-0.265	-0.386	339
1987	0.147	1.553	0.226	0.440	1	-0.214	-0.312	752
1988	0.020	0.612	-1.769	-0.492	1	-1.277	-1.864	296
1989	0.051	0.423	-0.832	-0.861	1	0.028	0.041	205
1990	0.139	0.942	0.170	-0.060	1	0.230	0.336	456
1991	0.039	0.551	-1.101	-0.597	1	-0.504	-0.736	267
1992	0.161	1.320	0.317	0.277	1	0.040	0.058	640
1993	0.037	0.512	-1.153	-0.669	1	-0.485	-0.707	248
1994	0.044	0.418	-0.980	-0.871	1	-0.109	-0.159	203
1995	0.234	0.200	0.691	-1.610	1	2.301	3.358	97
1996	0.028	0.227	-1.432	-1.484	1	0.052	0.076	110
1997	0.134	1.070	0.134	0.068	1	0.066	0.096	519
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.541

spr_36
Tuned to: 1-Jan
For ages: 8

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	0.064	2.099	0.074	0.742	1	-0.668	-0.974	518
1983	0.192	3.130	1.173	1.141	1	0.032	0.046	772
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.172	1.526	1.063	0.422	1	0.640	0.935	376
1986	0.119	0.862	0.694	-0.149	1	0.843	1.231	212
1987	0.016	0.807	-1.312	-0.214	1	-1.098	-1.603	199
1988	0.052	1.508	-0.134	0.411	1	-0.544	-0.794	372
1989	0.040	0.393	-0.396	-0.933	1	0.537	0.784	97
1990	0.013	0.379	-1.520	-0.969	1	-0.551	-0.804	94
1991	0.041	0.617	-0.371	-0.484	1	0.112	0.164	152
1992	0.020	0.424	-1.089	-0.858	1	-0.231	-0.336	104
1993	0.037	0.990	-0.474	-0.010	1	-0.464	-0.677	244
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.028	0.171	-0.753	-1.768	1	1.016	1.482	42
1996	0.018	0.226	-1.194	-1.486	1	0.292	0.426	56
1997	0.020	0.310	-1.089	-1.172	1	0.083	0.121	76
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.398

spr_41
Tuned to: 1-Jan
For ages: 1

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.376	0.427	-0.738	-0.851	1	0.113	0.165	27714
1979	0.435	0.362	-0.592	-1.015	1	0.423	0.618	23514
1980	0.031	0.310	-3.233	-1.172	1	-2.061	-3.008	20105
1981	2.303	0.638	1.075	-0.450	1	1.525	2.225	41394
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.000	0.000	0	0	1	0.000	0.000	00
1987	0.000	0.000	0	0	1	0.000	0.000	00
1988	0.000	0.000	0	0	1	0.000	0.000	00
1989	0.000	0.000	0	0	1	0.000	0.000	00
1990	0.000	0.000	0	0	1	0.000	0.000	00
1991	0.000	0.000	0	0	1	0.000	0.000	00
1992	0.000	0.000	0	0	1	0.000	0.000	00
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.000	0.000	0	0	1	0.000	0.000	00
1996	0.000	0.000	0	0	1	0.000	0.000	00
1997	0.000	0.000	0	0	1	0.000	0.000	00
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 2.475

spr_41
Tuned to: 1-Jan
For ages: 2

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.187	0.238	-1.949	-1.437	1	-0.512	-0.747	4268
1979	1.359	1.264	0.034	0.234	1	-0.199	-0.291	22688
1980	1.790	1.070	0.310	0.068	1	0.242	0.353	19221
1981	1.916	0.912	0.378	-0.092	1	0.470	0.686	16380
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.000	0.000	0	0	1	0.000	0.000	00
1987	0.000	0.000	0	0	1	0.000	0.000	00
1988	0.000	0.000	0	0	1	0.000	0.000	00
1989	0.000	0.000	0	0	1	0.000	0.000	00
1990	0.000	0.000	0	0	1	0.000	0.000	00
1991	0.000	0.000	0	0	1	0.000	0.000	00
1992	0.000	0.000	0	0	1	0.000	0.000	00
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.000	0.000	0	0	1	0.000	0.000	00
1996	0.000	0.000	0	0	1	0.000	0.000	00
1997	0.000	0.000	0	0	1	0.000	0.000	00
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.213

spr_41
Tuned to: 1-Jan
For ages: 3

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	5.530	1.481	0.723	0.393	1	0.330	0.482	25526
1979	0.298	0.182	-2.198	-1.703	1	-0.495	-0.722	3139
1980	2.124	0.974	-0.234	-0.027	1	-0.207	-0.302	16776
1981	2.779	0.715	0.035	-0.336	1	0.371	0.541	12319
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.000	0.000	0	0	1	0.000	0.000	00
1987	0.000	0.000	0	0	1	0.000	0.000	00
1988	0.000	0.000	0	0	1	0.000	0.000	00
1989	0.000	0.000	0	0	1	0.000	0.000	00
1990	0.000	0.000	0	0	1	0.000	0.000	00

1991	0.000	0.000	0	0	1	0.000	0.000	00
1992	0.000	0.000	0	0	1	0.000	0.000	00
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.000	0.000	0	0	1	0.000	0.000	00
1996	0.000	0.000	0	0	1	0.000	0.000	00
1997	0.000	0.000	0	0	1	0.000	0.000	00
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.195

spr_41
Tuned to: 1-Jan
For ages: 4

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.969	0.895	-0.196	-0.110	1	-0.085	-0.125	7947
1979	1.913	1.565	0.484	0.448	1	0.037	0.053	13888
1980	0.165	0.198	-1.966	-1.620	1	-0.346	-0.504	1756
1981	1.667	0.953	0.347	-0.048	1	0.394	0.576	8461
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.000	0.000	0	0	1	0.000	0.000	00
1987	0.000	0.000	0	0	1	0.000	0.000	00
1988	0.000	0.000	0	0	1	0.000	0.000	00
1989	0.000	0.000	0	0	1	0.000	0.000	00
1990	0.000	0.000	0	0	1	0.000	0.000	00
1991	0.000	0.000	0	0	1	0.000	0.000	00
1992	0.000	0.000	0	0	1	0.000	0.000	00
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.000	0.000	0	0	1	0.000	0.000	00
1996	0.000	0.000	0	0	1	0.000	0.000	00
1997	0.000	0.000	0	0	1	0.000	0.000	00
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.104

spr_41
Tuned to: 1-Jan
For ages: 5

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.778	0.685	0.184	-0.378	1	0.562	0.820	2878
1979	0.541	1.053	-0.180	0.051	1	-0.231	-0.337	4422
1980	1.171	1.658	0.592	0.506	1	0.087	0.127	6964
1981	0.100	0.234	-1.868	-1.450	1	-0.418	-0.609	985
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.000	0.000	0	0	1	0.000	0.000	00
1987	0.000	0.000	0	0	1	0.000	0.000	00
1988	0.000	0.000	0	0	1	0.000	0.000	00
1989	0.000	0.000	0	0	1	0.000	0.000	00
1990	0.000	0.000	0	0	1	0.000	0.000	00
1991	0.000	0.000	0	0	1	0.000	0.000	00
1992	0.000	0.000	0	0	1	0.000	0.000	00
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.000	0.000	0	0	1	0.000	0.000	00
1996	0.000	0.000	0	0	1	0.000	0.000	00
1997	0.000	0.000	0	0	1	0.000	0.000	00
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.202

spr_41
Tuned to: 1-Jan
For ages: 6

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.

1978	0.144	0.445	-1.094	-0.809	1	-0.285	-0.416	1124
1979	0.234	0.636	-0.608	-0.453	1	-0.155	-0.227	1605
1980	0.472	1.000	0.093	0.000	1	0.094	0.137	2524
1981	0.870	1.431	0.705	0.358	1	0.346	0.506	3614
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.000	0.000	0	0	1	0.000	0.000	00
1987	0.000	0.000	0	0	1	0.000	0.000	00
1988	0.000	0.000	0	0	1	0.000	0.000	00
1989	0.000	0.000	0	0	1	0.000	0.000	00
1990	0.000	0.000	0	0	1	0.000	0.000	00
1991	0.000	0.000	0	0	1	0.000	0.000	00
1992	0.000	0.000	0	0	1	0.000	0.000	00
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.000	0.000	0	0	1	0.000	0.000	00
1996	0.000	0.000	0	0	1	0.000	0.000	00
1997	0.000	0.000	0	0	1	0.000	0.000	00
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.086

spr_41
Tuned to: 1-Jan
For ages: 7

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.713	1.022	0.848	0.022	1	0.826	1.206	1434
1979	0.087	0.572	-1.255	-0.559	1	-0.696	-1.016	802
1980	0.152	0.641	-0.697	-0.444	1	-0.253	-0.369	900
1981	0.269	0.779	-0.126	-0.250	1	0.123	0.180	1093
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.000	0.000	0	0	1	0.000	0.000	00
1987	0.000	0.000	0	0	1	0.000	0.000	00
1988	0.000	0.000	0	0	1	0.000	0.000	00
1989	0.000	0.000	0	0	1	0.000	0.000	00
1990	0.000	0.000	0	0	1	0.000	0.000	00
1991	0.000	0.000	0	0	1	0.000	0.000	00
1992	0.000	0.000	0	0	1	0.000	0.000	00
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.000	0.000	0	0	1	0.000	0.000	00
1996	0.000	0.000	0	0	1	0.000	0.000	00
1997	0.000	0.000	0	0	1	0.000	0.000	00
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.456

spr_41
Tuned to: 1-Jan
For ages: 8

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.051	0.162	-0.582	-1.820	1	1.239	1.808	67
1979	0.145	2.079	0.463	0.732	1	-0.269	-0.392	862
1980	0.025	1.416	-1.295	0.348	1	-1.642	-2.397	587
1981	0.144	0.805	0.456	-0.216	1	0.673	0.982	334
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.000	0.000	0	0	1	0.000	0.000	00
1987	0.000	0.000	0	0	1	0.000	0.000	00
1988	0.000	0.000	0	0	1	0.000	0.000	00
1989	0.000	0.000	0	0	1	0.000	0.000	00
1990	0.000	0.000	0	0	1	0.000	0.000	00
1991	0.000	0.000	0	0	1	0.000	0.000	00

1992	0.000	0.000	0	0	1	0.000	0.000	00
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.000	0.000	0	0	1	0.000	0.000	00
1996	0.000	0.000	0	0	1	0.000	0.000	00
1997	0.000	0.000	0	0	1	0.000	0.000	00
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 1.74

sp_can
Tuned to: 1-Jan
For ages: 1

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.600	2.524	0.276	0.926	1	-0.650	-0.949	42813
1987	0.250	0.966	-0.600	-0.034	1	-0.565	-0.825	16389
1988	0.280	1.384	-0.487	0.325	1	-0.812	-1.185	23486
1989	1.630	0.931	1.275	-0.071	1	1.346	1.964	15800
1990	0.420	0.551	-0.081	-0.595	1	0.514	0.750	9355
1991	1.180	1.130	0.952	0.123	1	0.829	1.210	19176
1992	0.110	0.469	-1.421	-0.757	1	-0.664	-0.969	7957
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.070	0.208	-1.873	-1.572	1	-0.301	-0.439	3523
1996	0.140	0.368	-1.180	-0.999	1	-0.180	-0.263	6246
1997	0.320	0.381	-0.353	-0.966	1	0.613	0.895	6456
1998	0.010	0.025	-3.819	-3.689	1	-0.130	-0.190	424

Partial Variance: 0.526

sp_can
Tuned to: 1-Jan
For ages: 2

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	2.270	0.594	0.384	-0.520	1	0.904	1.320	6987
1987	2.130	2.970	0.320	1.089	1	-0.768	-1.121	34912
1988	1.010	1.139	-0.426	0.131	1	-0.556	-0.812	13395
1989	2.780	1.635	0.587	0.492	1	0.095	0.139	19220
1990	2.440	1.100	0.456	0.096	1	0.360	0.526	12936
1991	1.160	0.651	-0.287	-0.429	1	0.142	0.207	7653
1992	2.860	1.332	0.615	0.286	1	0.329	0.480	15653
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.670	0.704	-0.836	-0.350	1	-0.486	-0.709	8280
1996	0.490	0.245	-1.149	-1.405	1	0.256	0.373	2884
1997	0.530	0.435	-1.071	-0.833	1	-0.238	-0.348	5113
1998	0.670	0.449	-0.836	-0.800	1	-0.037	-0.053	5283

Partial Variance: 0.241

sp_can
Tuned to: 1-Jan
For ages: 3

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00

1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	2.810	1.513	0.318	0.414	1	-0.096	-0.140	12490
1987	0.930	0.548	-0.787	-0.602	1	-0.185	-0.271	4521
1988	4.660	2.644	0.824	0.972	1	-0.148	-0.216	21821
1989	1.380	1.156	-0.393	0.145	1	-0.538	-0.784	9540
1990	3.780	1.678	0.615	0.517	1	0.098	0.142	13846
1991	1.840	0.741	-0.105	-0.299	1	0.194	0.283	6120
1992	1.770	0.592	-0.144	-0.524	1	0.380	0.555	4886
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	1.500	0.837	-0.309	-0.178	1	-0.131	-0.191	6906
1996	2.310	0.778	0.123	-0.250	1	0.373	0.544	6425
1997	0.550	0.263	-1.313	-1.334	1	0.022	0.031	2174
1998	0.950	0.451	-0.766	-0.797	1	0.031	0.046	3718

Partial Variance: 0.072

sp_can
Tuned to: 1-Jan
For ages: 4

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.370	0.427	-1.394	-0.851	1	-0.543	-0.793	2033
1987	1.090	1.279	-0.313	0.246	1	-0.559	-0.817	6088
1988	0.580	0.510	-0.944	-0.673	1	-0.271	-0.396	2429
1989	2.850	2.229	0.648	0.801	1	-0.153	-0.224	10607
1990	2.080	1.086	0.333	0.082	1	0.251	0.366	5166
1991	2.150	1.423	0.366	0.353	1	0.013	0.019	6774
1992	0.800	0.436	-0.623	-0.830	1	0.207	0.302	2076
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.860	0.458	-0.550	-0.782	1	0.231	0.338	2178
1996	4.020	0.987	0.992	-0.013	1	1.005	1.467	4696
1997	1.250	0.934	-0.176	-0.069	1	-0.107	-0.157	4443
1998	0.350	0.252	-1.449	-1.376	1	-0.073	-0.106	1202

Partial Variance: 0.194

sp_can
Tuned to: 1-Jan
For ages: 5

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.650	0.537	-0.514	-0.621	1	0.107	0.156	1313
1987	0.340	0.386	-1.162	-0.952	1	-0.211	-0.308	943
1988	1.020	1.255	-0.064	0.227	1	-0.291	-0.424	3066
1989	0.360	0.439	-1.105	-0.823	1	-0.282	-0.412	1073
1990	3.870	2.016	1.270	0.701	1	0.569	0.830	4925
1991	1.050	1.034	-0.035	0.034	1	-0.069	-0.100	2527
1992	0.980	1.055	-0.104	0.053	1	-0.157	-0.230	2578

1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.600	0.516	-0.594	-0.662	1	0.068	0.099	1260
1996	1.090	0.474	0.003	-0.747	1	0.750	1.094	1157
1997	1.230	1.117	0.123	0.110	1	0.013	0.019	2729
1998	0.770	1.163	-0.345	0.151	1	-0.496	-0.723	2841

Partial Variance: 0.142

sp_can
Tuned to: 1-Jan
For ages: 6

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.440	1.594	-0.085	0.466	1	-0.551	-0.804	1612
1987	0.120	0.633	-1.384	-0.457	1	-0.928	-1.354	640
1988	0.130	0.514	-1.304	-0.665	1	-0.639	-0.932	520
1989	0.420	1.142	-0.132	0.133	1	-0.265	-0.386	1155
1990	0.420	0.572	-0.132	-0.558	1	0.426	0.622	579
1991	1.310	1.961	1.006	0.674	1	0.332	0.485	1984
1992	0.600	0.741	0.225	-0.299	1	0.524	0.765	750
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.190	0.181	-0.925	-1.711	1	0.786	1.147	183
1996	0.790	0.761	0.500	-0.273	1	0.774	1.129	769
1997	0.270	0.721	-0.573	-0.327	1	-0.247	-0.360	730
1998	0.580	1.498	0.191	0.404	1	-0.213	-0.311	1516

Partial Variance: 0.363

sp_can
Tuned to: 1-Jan
For ages: 7

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00
1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.260	0.694	0.058	-0.366	1	0.423	0.618	339
1987	0.220	1.539	-0.109	0.431	1	-0.540	-0.789	752
1988	0.080	0.606	-1.121	-0.501	1	-0.620	-0.905	296
1989	0.050	0.419	-1.591	-0.870	1	-0.721	-1.052	205
1990	0.930	0.933	1.332	-0.069	1	1.401	2.045	456
1991	0.160	0.546	-0.428	-0.606	1	0.178	0.260	267
1992	0.430	1.308	0.561	0.268	1	0.292	0.427	640
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.040	0.198	-1.814	-1.619	1	-0.195	-0.285	97
1996	0.330	0.225	0.296	-1.494	1	1.790	2.612	110
1997	0.060	1.061	-1.409	0.059	1	-1.468	-2.142	519
1998	0.140	0.979	-0.561	-0.021	1	-0.540	-0.788	479

Partial Variance: 0.939

sp_can
Tuned to: 1-Jan
For ages: 8

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.000	0.000	0	0	1	0.000	0.000	00
1979	0.000	0.000	0	0	1	0.000	0.000	00

1980	0.000	0.000	0	0	1	0.000	0.000	00
1981	0.000	0.000	0	0	1	0.000	0.000	00
1982	0.000	0.000	0	0	1	0.000	0.000	00
1983	0.000	0.000	0	0	1	0.000	0.000	00
1984	0.000	0.000	0	0	1	0.000	0.000	00
1985	0.000	0.000	0	0	1	0.000	0.000	00
1986	0.040	1.426	-0.898	0.355	1	-1.253	-1.829	212
1987	0.080	1.337	-0.205	0.290	1	-0.495	-0.722	199
1988	0.170	2.497	0.549	0.915	1	-0.366	-0.534	372
1989	0.100	0.651	0.018	-0.429	1	0.447	0.653	97
1990	0.120	0.628	0.201	-0.465	1	0.666	0.971	94
1991	0.220	1.021	0.807	0.021	1	0.786	1.148	152
1992	0.120	0.702	0.201	-0.354	1	0.555	0.810	104
1993	0.000	0.000	0	0	1	0.000	0.000	00
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.050	0.282	-0.675	-1.264	1	0.589	0.860	42
1996	0.080	0.375	-0.205	-0.982	1	0.777	1.134	56
1997	0.030	0.513	-1.186	-0.668	1	-0.518	-0.755	76
1998	0.070	2.342	-0.338	0.851	1	-1.189	-1.735	349

Partial Variance: 0.632

us0aut
Tuned to: 1-Jan
For ages: 1

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.152	1.291	-0.562	0.255	1	-0.818	-1.193	27714
1979	0.396	1.095	0.395	0.091	1	0.304	0.444	23514
1980	0.118	0.936	-0.816	-0.066	1	-0.750	-1.094	20105
1981	0.280	1.928	0.048	0.656	1	-0.608	-0.887	41394
1982	0.261	0.814	-0.022	-0.206	1	0.184	0.269	17471
1983	0.320	0.448	0.182	-0.803	1	0.985	1.438	9616
1984	1.031	1.276	1.352	0.244	1	1.108	1.617	27397
1985	0.186	0.404	-0.361	-0.906	1	0.545	0.795	8682
1986	1.084	1.994	1.402	0.690	1	0.712	1.039	42813
1987	0.096	0.763	-1.022	-0.270	1	-0.752	-1.097	16389
1988	0.204	1.094	-0.268	0.090	1	-0.358	-0.522	23486
1989	0.549	0.736	0.722	-0.307	1	1.028	1.501	15800
1990	0.262	0.436	-0.018	-0.831	1	0.813	1.186	9355
1991	0.156	0.893	-0.537	-0.113	1	-0.423	-0.618	19176
1992	0.040	0.371	-1.897	-0.993	1	-0.905	-1.320	7957
1993	0.033	0.505	-2.090	-0.683	1	-1.407	-2.053	10844
1994	0.179	0.471	-0.399	-0.753	1	0.354	0.516	10116
1995	0.067	0.164	-1.382	-1.808	1	0.426	0.622	3523
1996	0.160	0.291	-0.511	-1.235	1	0.724	1.056	6246
1997	0.022	0.301	-2.495	-1.202	1	-1.294	-1.888	6456
1998	0.006	0.020	-3.795	-3.925	1	0.130	0.190	424

Partial Variance: 0.64

us1aut
Tuned to: 1-Jan
For ages: 2

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.237	0.257	-1.484	-1.358	1	-0.126	-0.185	4268
1979	1.855	1.368	0.573	0.313	1	0.260	0.380	22688
1980	1.619	1.159	0.437	0.147	1	0.290	0.424	19221
1981	0.818	0.987	-0.245	-0.013	1	-0.233	-0.339	16380
1982	3.525	2.041	1.215	0.714	1	0.502	0.732	33867
1983	0.875	0.844	-0.178	-0.169	1	-0.009	-0.012	14005
1984	0.647	0.469	-0.480	-0.758	1	0.278	0.406	7775
1985	2.496	1.348	0.870	0.298	1	0.572	0.835	22358
1986	0.220	0.421	-1.559	-0.865	1	-0.694	-1.013	6987
1987	2.280	2.104	0.780	0.744	1	0.036	0.052	34912
1988	0.414	0.807	-0.926	-0.214	1	-0.712	-1.040	13395
1989	0.903	1.158	-0.147	0.147	1	-0.294	-0.428	19220
1990	2.738	0.780	0.963	-0.249	1	1.212	1.768	12936
1991	0.362	0.461	-1.061	-0.774	1	-0.287	-0.419	7653
1992	0.415	0.943	-0.924	-0.058	1	-0.866	-1.264	15653
1993	0.454	0.389	-0.834	-0.945	1	0.110	0.161	6451

1994	0.970	0.535	-0.075	-0.626	1	0.551	0.804	8874
1995	0.406	0.499	-0.946	-0.695	1	-0.251	-0.366	8280
1996	0.245	0.174	-1.451	-1.750	1	0.299	0.436	2884
1997	0.240	0.308	-1.472	-1.177	1	-0.295	-0.430	5113
1998	0.236	0.318	-1.488	-1.144	1	-0.344	-0.502	5283

Partial Variance: 0.25

us2aut
Tuned to: 1-Jan
For ages: 3

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	3.424	2.132	1.210	0.757	1	0.453	0.661	25526
1979	0.255	0.262	-1.388	-1.339	1	-0.049	-0.071	3139
1980	1.717	1.401	0.519	0.337	1	0.182	0.266	16776
1981	0.564	1.029	-0.594	0.028	1	-0.622	-0.908	12319
1982	2.250	0.878	0.790	-0.130	1	0.920	1.343	10511
1983	2.094	1.625	0.718	0.486	1	0.232	0.339	19459
1984	1.022	0.634	0.001	-0.456	1	0.457	0.667	7588
1985	0.101	0.433	-2.314	-0.837	1	-1.476	-2.155	5183
1986	0.803	1.043	-0.241	0.042	1	-0.283	-0.413	12490
1987	0.153	0.378	-1.898	-0.974	1	-0.924	-1.349	4521
1988	1.353	1.822	0.281	0.600	1	-0.319	-0.465	21821
1989	0.433	0.797	-0.858	-0.227	1	-0.631	-0.921	9540
1990	1.030	1.156	0.008	0.145	1	-0.137	-0.200	13846
1991	1.534	0.511	0.407	-0.671	1	1.078	1.573	6120
1992	0.168	0.408	-1.805	-0.896	1	-0.909	-1.326	4886
1993	1.024	0.755	0.003	-0.282	1	0.284	0.415	9036
1994	0.532	0.363	-0.652	-1.013	1	0.361	0.527	4347
1995	0.664	0.577	-0.431	-0.550	1	0.120	0.175	6906
1996	1.811	0.537	0.573	-0.623	1	1.195	1.744	6425
1997	0.196	0.182	-1.651	-1.706	1	0.055	0.081	2174
1998	0.321	0.311	-1.157	-1.169	1	0.012	0.018	3718

Partial Variance: 0.457

us3aut
Tuned to: 1-Jan
For ages: 4

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.702	1.166	-0.033	0.154	1	-0.187	-0.273	7947
1979	4.180	2.038	1.751	0.712	1	1.039	1.516	13888
1980	0.224	0.258	-1.175	-1.356	1	0.181	0.264	1756
1981	0.774	1.242	0.065	0.217	1	-0.152	-0.222	8461
1982	1.559	0.920	0.765	-0.084	1	0.849	1.238	6267
1983	0.220	0.755	-1.193	-0.281	1	-0.913	-1.332	5146
1984	0.796	1.267	0.093	0.237	1	-0.144	-0.211	8636
1985	0.886	0.457	0.200	-0.783	1	0.982	1.434	3115
1986	0.103	0.298	-1.952	-1.209	1	-0.743	-1.084	2033
1987	0.382	0.893	-0.642	-0.113	1	-0.529	-0.772	6088
1988	0.112	0.356	-1.869	-1.032	1	-0.837	-1.222	2429
1989	0.909	1.557	0.225	0.443	1	-0.217	-0.317	10607
1990	0.183	0.758	-1.378	-0.277	1	-1.101	-1.606	5166
1991	1.164	0.994	0.473	-0.006	1	0.478	0.698	6774
1992	0.277	0.305	-0.963	-1.189	1	0.226	0.329	2076
1993	0.180	0.299	-1.394	-1.208	1	-0.186	-0.272	2037
1994	0.382	0.522	-0.642	-0.650	1	0.009	0.013	3556
1995	0.433	0.320	-0.516	-1.140	1	0.624	0.911	2178
1996	1.249	0.689	0.543	-0.372	1	0.915	1.336	4696
1997	0.414	0.652	-0.561	-0.428	1	-0.134	-0.195	4443
1998	0.109	0.176	-1.896	-1.735	1	-0.160	-0.234	1202

Partial Variance: 0.41

us4aut
Tuned to: 1-Jan
For ages: 5

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.251	0.649	-0.174	-0.432	1	0.258	0.376	2878
1979	0.964	0.997	1.171	-0.003	1	1.174	1.713	4422
1980	1.613	1.571	1.686	0.452	1	1.235	1.802	6964

1981	0.076	0.222	-1.369	-1.505	1	0.135	0.198	985
1982	0.589	1.060	0.679	0.058	1	0.621	0.906	4698
1983	0.069	0.588	-1.466	-0.530	1	-0.935	-1.365	2609
1984	0.055	0.449	-1.692	-0.801	1	-0.892	-1.301	1991
1985	0.870	0.914	1.069	-0.090	1	1.159	1.691	4052
1986	0.115	0.296	-0.955	-1.217	1	0.262	0.383	1313
1987	0.010	0.213	-3.397	-1.548	1	-1.850	-2.699	943
1988	0.195	0.691	-0.427	-0.369	1	-0.058	-0.084	3066
1989	0.091	0.242	-1.189	-1.419	1	0.230	0.335	1073
1990	0.499	1.111	0.513	0.105	1	0.408	0.595	4925
1991	0.209	0.570	-0.357	-0.562	1	0.205	0.299	2527
1992	0.028	0.581	-2.368	-0.542	1	-1.825	-2.664	2578
1993	0.112	0.171	-0.981	-1.763	1	0.782	1.141	760
1994	0.017	0.149	-2.867	-1.907	1	-0.960	-1.401	659
1995	0.153	0.284	-0.669	-1.258	1	0.589	0.859	1260
1996	0.087	0.261	-1.234	-1.343	1	0.109	0.159	1157
1997	0.143	0.615	-0.737	-0.485	1	-0.251	-0.367	2729
1998	0.129	0.641	-0.840	-0.445	1	-0.395	-0.576	2841

Partial Variance: 0.79

us5aut
Tuned to: 1-Jan
For ages: 6

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1978	0.174	0.838	0.528	-0.177	1	0.705	1.029	1124
1979	0.335	1.196	1.184	0.179	1	1.004	1.466	1605
1980	0.296	1.881	1.060	0.632	1	0.428	0.624	2524
1981	0.251	2.693	0.895	0.991	1	-0.096	-0.140	3614
1982	0.054	0.443	-0.642	-0.815	1	0.174	0.254	594
1983	0.097	1.518	-0.056	0.417	1	-0.473	-0.691	2037
1984	0.047	0.881	-0.780	-0.127	1	-0.653	-0.953	1181
1985	0.017	0.648	-1.797	-0.434	1	-1.364	-1.990	870
1986	0.101	1.201	-0.015	0.184	1	-0.199	-0.290	1612
1987	0.061	0.477	-0.520	-0.739	1	0.220	0.321	640
1988	0.028	0.387	-1.298	-0.948	1	-0.350	-0.511	520
1989	0.178	0.861	0.551	-0.150	1	0.701	1.023	1155
1990	0.055	0.432	-0.623	-0.840	1	0.217	0.317	579
1991	0.145	1.478	0.346	0.391	1	-0.045	-0.065	1984
1992	0.029	0.559	-1.263	-0.582	1	-0.681	-0.994	750
1993	0.030	0.573	-1.229	-0.556	1	-0.673	-0.982	769
1994	0.025	0.167	-1.412	-1.788	1	0.377	0.550	224
1995	0.068	0.136	-0.411	-1.993	1	1.582	2.309	183
1996	0.054	0.573	-0.642	-0.556	1	-0.086	-0.125	769
1997	0.060	0.544	-0.536	-0.609	1	0.073	0.107	730
1998	0.049	1.130	-0.739	0.122	1	-0.861	-1.256	1516

Partial Variance: 0.472

Standardized residuals by index and year; with row/column/grand means

	1978	1979	1980	1981	1982	1983	1984
spr_36 1	0.000	0.000	0.000	0.000	0.851	1.147	-0.089
spr_36 2	0.000	0.000	0.000	0.000	0.567	1.059	-0.196
spr_36 3	0.000	0.000	0.000	0.000	0.269	0.499	-0.084
spr_36 4	0.000	0.000	0.000	0.000	0.500	0.021	-0.128
spr_36 5	0.000	0.000	0.000	0.000	0.288	0.564	0.307
spr_36 6	0.000	0.000	0.000	0.000	-2.686	0.321	1.092
spr_36 7	0.000	0.000	0.000	0.000	-0.459	-0.029	-0.068
spr_36 8	0.000	0.000	0.000	0.000	-0.974	0.046	0.000
spr_41 1	0.165	0.618	-3.008	2.225	0.000	0.000	0.000
spr_41 2	-0.747	-0.291	0.353	0.686	0.000	0.000	0.000
spr_41 3	0.482	-0.722	-0.302	0.541	0.000	0.000	0.000
spr_41 4	-0.125	0.053	-0.504	0.576	0.000	0.000	0.000
spr_41 5	0.820	-0.337	0.127	-0.609	0.000	0.000	0.000
spr_41 6	-0.416	-0.227	0.137	0.506	0.000	0.000	0.000
spr_41 7	1.206	-1.016	-0.369	0.180	0.000	0.000	0.000
spr_41 8	1.808	-0.392	-2.397	0.982	0.000	0.000	0.000

sp_can 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sp_can 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sp_can 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sp_can 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sp_can 5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sp_can 6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sp_can 7	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sp_can 8	0.000	0.000	0.000	0.000	0.000	0.000	0.000
us0aut 1	-1.193	0.444	-1.094	-0.887	0.269	1.438	1.617
us1aut 2	-0.185	0.380	0.424	-0.339	0.732	-0.012	0.406
us2aut 3	0.661	-0.071	0.266	-0.908	1.343	0.339	0.667
us3aut 4	-0.273	1.516	0.264	-0.222	1.238	-1.332	-0.211
us4aut 5	0.376	1.713	1.802	0.198	0.906	-1.365	-1.301
us5aut 6	1.029	1.466	0.624	-0.140	0.254	-0.691	-0.953
Col Avg	0.258	0.224	-0.263	0.199	0.221	0.143	0.081

	1985	1986	1987	1988	1989	1990	1991
spr_36 1	-0.471	0.388	-2.944	0.946	0.633	0.416	1.858
spr_36 2	0.802	-0.169	-0.564	-0.417	0.030	0.075	-0.026
spr_36 3	0.397	0.397	-0.323	0.364	-0.520	0.150	0.248
spr_36 4	1.225	0.274	-0.252	0.215	-0.023	-0.218	-0.173
spr_36 5	0.862	1.207	-1.531	0.215	0.229	0.003	0.016
spr_36 6	0.880	1.223	0.727	-0.984	0.820	0.350	-0.004
spr_36 7	0.754	-0.386	-0.312	-1.864	0.041	0.336	-0.736
spr_36 8	0.935	1.231	-1.603	-0.794	0.784	-0.804	0.164
spr_41 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 7	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 8	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sp_can 1	0.000	-0.949	-0.825	-1.185	1.964	0.750	1.210
sp_can 2	0.000	1.320	-1.121	-0.812	0.139	0.526	0.207
sp_can 3	0.000	-0.140	-0.271	-0.216	-0.784	0.142	0.283
sp_can 4	0.000	-0.793	-0.817	-0.396	-0.224	0.366	0.019
sp_can 5	0.000	0.156	-0.308	-0.424	-0.412	0.830	-0.100
sp_can 6	0.000	-0.804	-1.354	-0.932	-0.386	0.622	0.485
sp_can 7	0.000	0.618	-0.789	-0.905	-1.052	2.045	0.260
sp_can 8	0.000	-1.829	-0.722	-0.534	0.653	0.971	1.148
us0aut 1	0.795	1.039	-1.097	-0.522	1.501	1.186	-0.618
us1aut 2	0.835	-1.013	0.052	-1.040	-0.428	1.768	-0.419
us2aut 3	-2.155	-0.413	-1.349	-0.465	-0.921	-0.200	1.573
us3aut 4	1.434	-1.084	-0.772	-1.222	-0.317	-1.606	0.698
us4aut 5	1.691	0.383	-2.699	-0.084	0.335	0.595	0.299
us5aut 6	-1.990	-0.290	0.321	-0.511	1.023	0.317	-0.065
Col Avg	0.428	0.017	-0.843	-0.526	0.140	0.392	0.288

	1992	1993	1994	1995	1996	1997	1998
spr_36 1	-0.012	-3.352	-0.363	-0.137	-0.420	1.549	0.000
spr_36 2	0.241	-0.142	-1.157	-0.566	0.128	0.334	0.000
spr_36 3	-0.212	0.427	-1.296	0.155	0.043	-0.514	0.000
spr_36 4	-0.913	-0.434	-1.287	0.749	0.865	-0.420	0.000
spr_36 5	-0.803	-0.372	-1.879	1.404	-0.276	-0.234	0.000
spr_36 6	0.180	-0.124	-2.964	1.806	0.686	-1.324	0.000
spr_36 7	0.058	-0.707	-0.159	3.358	0.076	0.096	0.000
spr_36 8	-0.336	-0.677	0.000	1.482	0.426	0.121	0.000
spr_41 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 5	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 7	0.000	0.000	0.000	0.000	0.000	0.000	0.000
spr_41 8	0.000	0.000	0.000	0.000	0.000	0.000	0.000

sp_can 1	-0.969	0.000	0.000	-0.439	-0.263	0.895	-0.190
sp_can 2	0.480	0.000	0.000	-0.709	0.373	-0.348	-0.053
sp_can 3	0.555	0.000	0.000	-0.191	0.544	0.031	0.046
sp_can 4	0.302	0.000	0.000	0.338	1.467	-0.157	-0.106
sp_can 5	-0.230	0.000	0.000	0.099	1.094	0.019	-0.723
sp_can 6	0.765	0.000	0.000	1.147	1.129	-0.360	-0.311
sp_can 7	0.427	0.000	0.000	-0.285	2.612	-2.142	-0.788
sp_can 8	0.810	0.000	0.000	0.860	1.134	-0.755	-1.735
us0aut 1	-1.320	-2.053	0.516	0.622	1.056	-1.888	0.190
us1aut 2	-1.264	0.161	0.804	-0.366	0.436	-0.430	-0.502
us2aut 3	-1.326	0.415	0.527	0.175	1.744	0.081	0.018
us3aut 4	0.329	-0.272	0.013	0.911	1.336	-0.195	-0.234
us4aut 5	-2.664	1.141	-1.401	0.859	0.159	-0.367	-0.576
us5aut 6	-0.994	-0.982	0.550	2.309	-0.125	0.107	-1.256
Col Avg	-0.313	-0.498	-0.623	0.617	0.647	-0.268	-0.444

STOCK NUMBERS (Jan 1) in thousands - C:\wstemp\GB_97m2.9

	1978	1979	1980	1981	1982	1983	1984
1	27714	23514	20105	41394	17471	9616	27397
2	4268	22688	19221	16380	33867	14005	7775
3	25526	3139	16776	12319	10511	19459	7588
4	7947	13888	1756	8461	6267	5146	8636
5	2878	4422	6964	985	4698	2609	1991
6	1124	1605	2524	3614	594	2037	1181
7	1434	802	900	1093	1686	232	965
8	67	862	587	334	518	772	104
9	146	12	477	402	162	231	419
10	54	148	28	190	187	148	293
1+	71158	71081	69337	85172	75960	54254	56350

	1985	1986	1987	1988	1989	1990	1991
1	8682	42813	16389	23486	15800	9355	19176
2	22358	6987	34912	13395	19220	12936	7653
3	5183	12490	4521	21821	9540	13846	6120
4	3115	2033	6088	2429	10607	5166	6774
5	4052	1313	943	3066	1073	4925	2527
6	870	1612	640	520	1155	579	1984
7	500	339	752	296	205	456	267
8	376	212	199	372	97	94	152
9	45	124	109	106	126	40	44
10	206	76	68	98	45	89	43
1+	45387	68000	64622	65589	57868	47488	44740

	1992	1993	1994	1995	1996	1997	1998
1	7957	10844	10116	3523	6246	6456	424
2	15653	6451	8874	8280	2884	5113	5283
3	4886	9036	4347	6906	6425	2174	3718
4	2076	2037	3556	2178	4696	4443	1202
5	2578	760	659	1260	1157	2729	2841
6	750	769	224	183	769	730	1516
7	640	248	203	97	110	519	479
8	104	244	59	42	56	76	349
9	61	55	70	07	21	43	48
10	18	29	11	03	01	19	39
1+	34723	30473	28120	22479	22365	22301	15898

FISHING MORTALITY - C:\wstemp\GB_97m2.9

	1978	1979	1980	1981	1982	1983	1984
1	0.00	0.00	0.00	0.00	0.02	0.01	0.00
2	0.11	0.10	0.24	0.24	0.35	0.41	0.21
3	0.41	0.38	0.48	0.48	0.51	0.61	0.69
4	0.39	0.49	0.38	0.39	0.68	0.75	0.56
5	0.38	0.36	0.46	0.31	0.64	0.59	0.63
6	0.14	0.38	0.64	0.56	0.74	0.55	0.66
7	0.31	0.11	0.79	0.55	0.58	0.60	0.74
8	1.48	0.39	0.18	0.52	0.61	0.41	0.63
9	0.36	0.44	0.49	0.44	0.66	0.65	0.60
10	0.36	0.44	0.49	0.44	0.66	0.65	0.60

	1985	1986	1987	1988	1989	1990	1991
1	0.02	0.00	0.00	0.00	0.00	0.00	0.00
2	0.38	0.24	0.27	0.14	0.13	0.55	0.25
3	0.74	0.52	0.42	0.52	0.41	0.51	0.88
4	0.66	0.57	0.49	0.62	0.57	0.52	0.77
5	0.72	0.52	0.40	0.78	0.42	0.71	1.02
6	0.74	0.56	0.57	0.73	0.73	0.57	0.93
7	0.66	0.33	0.51	0.92	0.58	0.90	0.74
8	0.91	0.47	0.43	0.88	0.67	0.55	0.71
9	0.72	0.54	0.49	0.74	0.58	0.62	0.86
10	0.72	0.54	0.49	0.74	0.58	0.62	0.86

	1992	1993	1994	1995	1996	1997
1	0.01	0.00	0.00	0.00	0.00	0.00
2	0.35	0.19	0.05	0.05	0.08	0.12
3	0.67	0.73	0.49	0.19	0.17	0.39
4	0.80	0.93	0.84	0.43	0.34	0.25
5	1.01	1.02	1.08	0.29	0.26	0.39
6	0.91	1.13	0.64	0.31	0.19	0.22
7	0.76	1.23	1.37	0.35	0.16	0.20
8	0.45	1.04	1.94	0.50	0.06	0.26
9	0.91	1.04	0.91	0.38	0.31	0.26
10	0.91	1.04	0.91	0.38	0.31	0.26

Average F for 2,8 3,8 4,8 5,8 6,8

	1978	1979	1980	1981	1982	1983	1984
2,8	0.46	0.32	0.45	0.44	0.59	0.56	0.59
3,8	0.52	0.35	0.49	0.47	0.63	0.59	0.65
4,8	0.54	0.35	0.49	0.47	0.65	0.58	0.64
5,8	0.58	0.31	0.52	0.48	0.64	0.54	0.67
6,8	0.64	0.29	0.54	0.54	0.64	0.52	0.68

	1985	1986	1987	1988	1989	1990	1991
2,8	0.69	0.46	0.44	0.65	0.50	0.62	0.76
3,8	0.74	0.49	0.47	0.74	0.56	0.63	0.84
4,8	0.74	0.49	0.48	0.78	0.59	0.65	0.83
5,8	0.76	0.47	0.48	0.83	0.60	0.68	0.85
6,8	0.77	0.45	0.50	0.84	0.66	0.68	0.79

	1992	1993	1994	1995	1996	1997
2,8	0.71	0.90	0.92	0.30	0.18	0.26
3,8	0.77	1.01	1.06	0.35	0.20	0.29
4,8	0.79	1.07	1.17	0.38	0.20	0.26
5,8	0.78	1.11	1.26	0.36	0.17	0.27
6,8	0.70	1.14	1.32	0.39	0.14	0.23

BACKCALCULATED PARTIAL RECRUITMENT

	1978	1979	1980	1981	1982	1983	1984
1	0.00	0.00	0.01	0.00	0.03	0.02	0.00
2	0.07	0.21	0.31	0.43	0.48	0.55	0.28
3	0.28	0.78	0.61	0.85	0.69	0.82	0.93
4	0.26	1.00	0.48	0.69	0.91	1.00	0.75
5	0.26	0.74	0.58	0.54	0.86	0.79	0.85
6	0.09	0.77	0.81	1.00	1.00	0.73	0.89
7	0.21	0.23	1.00	0.97	0.79	0.80	1.00
8	1.00	0.80	0.23	0.93	0.82	0.55	0.85
9	0.24	0.89	0.62	0.79	0.89	0.87	0.81
10	0.24	0.89	0.62	0.79	0.89	0.87	0.81

	1985	1986	1987	1988	1989	1990	1991
1	0.02	0.01	0.00	0.00	0.00	0.00	0.00
2	0.42	0.41	0.47	0.15	0.18	0.61	0.25
3	0.81	0.91	0.74	0.57	0.57	0.57	0.87
4	0.73	1.00	0.85	0.67	0.78	0.57	0.75
5	0.80	0.91	0.69	0.85	0.57	0.79	1.00
6	0.82	0.99	1.00	0.80	1.00	0.64	0.92
7	0.72	0.59	0.89	1.00	0.80	1.00	0.73
8	1.00	0.83	0.75	0.96	0.92	0.62	0.70
9	0.79	0.95	0.86	0.80	0.79	0.69	0.85
10	0.79	0.95	0.86	0.80	0.79	0.69	0.85

	1992	1993	1994	1995	1996	1997
1	0.01	0.00	0.00	0.00	0.00	0.00
2	0.35	0.16	0.03	0.11	0.24	0.30
3	0.67	0.60	0.25	0.37	0.49	1.00
4	0.80	0.75	0.43	0.86	1.00	0.63
5	1.00	0.83	0.56	0.59	0.76	0.99
6	0.90	0.92	0.33	0.62	0.57	0.56
7	0.76	1.00	0.71	0.70	0.48	0.50
8	0.44	0.85	1.00	1.00	0.18	0.67
9	0.90	0.84	0.47	0.76	0.90	0.67
10	0.90	0.84	0.47	0.76	0.90	0.67

MEAN BIOMASS

	1978	1979	1980	1981	1982	1983	1984
1	17758	18931	15198	33079	11991	8412	26106
2	4814	29258	22652	19778	36453	15602	10451
3	47056	5116	29982	21115	20011	31669	12314
4	20861	42241	4890	21844	16003	10993	21923
5	9451	16546	28839	4029	17042	8355	6881
6	5522	8746	11415	18262	2506	9175	5217
7	8287	6326	4789	6593	10955	1269	5569
8	276	6709	4441	2351	3515	5941	712
9	1318	108	2905	4201	1358	1746	3262
10	549	1382	315	2602	2097	1453	3100
1+	115891	135363	125424	133852	121931	94614	95535

	1985	1986	1987	1988	1989	1990	1991
1	7078	35979	10775	16727	11585	7043	19334
2	24032	8355	41254	17265	26497	14206	10033
3	7021	21801	8401	36673	16180	24355	9530
4	8108	5194	18446	5827	27936	12999	14853
5	13466	5249	4129	10573	4321	15822	6976
6	3613	8113	3450	2249	5038	2552	6995
7	2721	2344	4832	1566	1168	2341	1283

8	2327	1541	1478	2269	693	700	1049
9	337	1113	897	766	1023	347	263
10	1817	755	737	975	534	885	410
1+	70521	90443	94400	94890	94974	81250	70725

	1992	1993	1994	1995	1996	1997
1	8240	8568	8306	2893	4993	5581
2	18571	8177	11451	10758	3786	6905
3	8023	13240	6805	12005	13084	3806
4	5034	4069	8094	6183	12274	12653
5	7035	2181	1783	5463	4554	8464
6	2793	2710	1128	1058	4211	3584
7	3082	992	819	798	771	3446
8	758	1287	229	351	414	527
9	445	305	413	55	211	408
10	209	217	110	39	08	194
1+	54190	41745	39139	39603	44304	45569	00

Summaries for ages 2,8 3,8 4,8 5,8 6,8

	1978	1979	1980	1981	1982	1983	1984
2,8	96266	211208	318215	412185	518670	601673	664741
3,8	756193	841877	926233	1000425	1070457	1137858	1190475
4,8	1234872	1315440	1369814	1422892	1472912	1508645	1548948
5,8	1572484	1610811	1660294	1691529	1725546	1750286	1768666
6,8	1782751	1804532	1825176	1852382	1869357	1885742	1897241

	1985	1986	1987	1988	1989	1990	1991
2,8	1958529	2011126	2093116	2169538	2251370	2324345	2375064
3,8	2412320	2456561	2497298	2556454	2611790	2670559	2711245
4,8	2741480	2763920	2796255	2818739	2857894	2892308	2923464
5,8	2945591	2962837	2976727	2993383	3004602	3026017	3042320
6,8	3050981	3062978	3072738	3078822	3085720	3091313	3100640

	1992	1993	1994	1995	1996	1997
2,8	3145936	3178591	3208901	3245517	3284610	3323995
3,8	3350720	3375199	3394057	3419915	3455222	3487702
4,8	3506404	3517643	3529696	3543549	3565772	3594446
5,8	3608114	3615284	3619244	3626914	3636863	3652884
6,8	3659517	3664506	3666682	3668888	3674284	3681840

SSB AT THE START OF THE SPAWNING SEASON -MALES AND FEMALES (MT)

	1978	1979	1980	1981	1982	1983	1984
1	913	1104	850	1960	1200	903	3124
2	1410	7539	6913	5782	16138	6345	4303
3	33845	3729	22417	15929	15642	26060	10501
4	20219	38256	4297	21379	15793	12649	21658
5	8798	16585	30442	3958	17473	9639	7111
6	4882	8130	12541	20323	2957	10520	5656
7	8215	5550	5918	7296	12172	1460	6227
8	367	6810	5034	2696	4165	6840	811
9	1331	112	3963	4097	1561	2113	3956
10	653	1681	388	3168	2710	1873	3940
1+	80633	89496	92765	86590	89813	78403	67287

	1985	1986	1987	1988	1989	1990	1991
1	774	8525	2226	3485	2493	645	2106
2	11653	5036	25369	8909	13745	6670	4294
3	6879	18782	7116	32911	14555	22071	9170
4	8076	4844	17034	6148	27285	12834	16565
5	14910	5436	3939	12390	4214	18179	8458
6	4244	8587	3706	2766	5950	2975	8817
7	3166	2347	5367	2026	1329	2859	1563
8	2986	1705	1693	2935	813	772	1231
9	416	1251	1033	957	1196	410	374
10	2384	945	910	1285	675	1132	558
1+	55488	57457	68393	73812	72255	68547	53137

	1992	1993	1994	1995	1996	1997
1	916	848	278	96	159	193
2	9734	4168	4224	4032	1414	2516
3	7610	12976	6571	10529	10634	3425
4	5439	4787	8587	5649	11428	12094
5	8451	2710	2129	5202	4648	9222
6	3379	3374	1185	1000	4345	3698
7	3622	1330	1115	788	813	3544
8	801	1650	349	361	508	601
9	572	435	553	63	235	398
10	288	308	151	47	09	225
1+	40812	32587	25142	27767	34193	35915

APPENDIX 3

Precision Estimates of 1997 Fishing Mortality and Spawning Stock Biomass for Georges Bank Cod.

BOOTSTRAP RESULTS FOR Run:9 (50)
COD: GEORGES BANK STOCK

Appendix 3: Table 1.
BOOTSTRAP OUTPUT VARIABLE: N_hat
Age-specific stocksizes (on Jan 1, 1997) estimated by NLLS

The number of bootstraps: 1000
Bootstrap Output Variable: N hat

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
N 1	424	459	184	0.43
N 2	5283	5459	1229	0.23
N 3	3718	3816	719	0.19
N 4	1202	1225	269	0.22
N 5	2841	2899	567	0.20
N 6	1516	1540	340	0.22
N 7	479	483	115	0.24
N 8	349	355	85	0.24

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
N 1	34	06	8.11	390	0.470852
N 2	176	39	3.33	5108	0.240553
N 3	98	23	2.63	3620	0.198627
N 4	23	08	1.92	1179	0.227949
N 5	59	18	2.07	2782	0.203710
N 6	25	11	1.63	1491	0.228320
N 7	04	04	0.82	475	0.242927
N 8	06	03	1.76	343	0.248517

Appendix 3: Table 2. Bootstrap Output Variable: Q_unscaled

FLEET	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
q spr_361	0.0000156	0.0000158	0.0000020	0.13
q spr_362	0.0000680	0.0000679	0.0000089	0.13
q spr_363	0.0001112	0.0001112	0.0000137	0.12
q spr_364	0.0001468	0.0001475	0.0000178	0.12
q spr_365	0.0001816	0.0001839	0.0000242	0.13
q spr_366	0.0001698	0.0001717	0.0000232	0.14
q spr_367	0.0002420	0.0002455	0.0000310	0.13
q spr_368	0.0002411	0.0002439	0.0000323	0.13
q spr_411	0.0000121	0.0000125	0.0000032	0.26
q spr_412	0.0000731	0.0000758	0.0000201	0.28
q spr_413	0.0001557	0.0001605	0.0000387	0.25
q spr_414	0.0001328	0.0001382	0.0000357	0.27
q spr_415	0.0001542	0.0001579	0.0000405	0.26
q spr_416	0.0001703	0.0001732	0.0000450	0.26
q spr_417	0.0002176	0.0002205	0.0000539	0.25
q spr_418	0.0002201	0.0002246	0.0000565	0.26
q sp_can1	0.0000268	0.0000271	0.0000044	0.16
q sp_can2	0.0001315	0.0001329	0.0000200	0.15
q sp_can3	0.0002476	0.0002503	0.0000388	0.16
q sp_can4	0.0003133	0.0003165	0.0000478	0.15
q sp_can5	0.0004450	0.0004519	0.0000652	0.15
q sp_can6	0.0004737	0.0004822	0.0000715	0.15
q sp_can7	0.0005019	0.0005064	0.0000742	0.15
q sp_can8	0.0006594	0.0006715	0.0001052	0.16
q us0aut1	0.0000124	0.0000124	0.0000014	0.11
q us1aut2	0.0000630	0.0000636	0.0000070	0.11
q us2aut3	0.0000853	0.0000860	0.0000094	0.11
q us3aut4	0.0001065	0.0001075	0.0000119	0.11
q us4aut5	0.0000674	0.0000680	0.0000074	0.11
q us5aut6	0.0000764	0.0000772	0.0000086	0.11

FLEET	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
q spr_361	0.00000022	0.000000064	1.402	0.000015372	0.13
q spr_362	-0.00000007	0.000000281	-0.101	0.000068042	0.13
q spr_363	-0.00000003	0.000000432	-0.031	0.000111277	0.12
q spr_364	0.00000078	0.000000563	0.530	0.000145975	0.12
q spr_365	0.00000229	0.000000764	1.259	0.000179291	0.13
q spr_366	0.00000191	0.000000734	1.127	0.000167900	0.14
q spr_367	0.00000349	0.000000981	1.442	0.000238480	0.13
q spr_368	0.00000279	0.000001020	1.156	0.000238298	0.14
q spr_411	0.00000036	0.000000101	2.937	0.000011758	0.27
q spr_412	0.00000271	0.000000636	3.706	0.000070412	0.29
q spr_413	0.00000482	0.000001224	3.097	0.000150863	0.26
q spr_414	0.00000536	0.000001128	4.033	0.000127443	0.28
q spr_415	0.00000376	0.000001282	2.440	0.000150390	0.27
q spr_416	0.00000294	0.000001423	1.724	0.000167341	0.27
q spr_417	0.00000289	0.000001705	1.326	0.000214732	0.25
q spr_418	0.00000454	0.000001786	2.065	0.000215549	0.26
q sp_can1	0.00000024	0.000000138	0.890	0.000026610	0.16
q sp_can2	0.00000133	0.000000633	1.009	0.000130217	0.15
q sp_can3	0.00000271	0.000001228	1.093	0.000244917	0.16
q sp_can4	0.00000322	0.000001511	1.028	0.000310036	0.15
q sp_can5	0.00000688	0.000002062	1.546	0.000438114	0.15
q sp_can6	0.00000847	0.000002261	1.788	0.000465222	0.15
q sp_can7	0.00000455	0.000002347	0.907	0.000497344	0.15
q sp_can8	0.00001216	0.000003328	1.843	0.000647228	0.16
q us0aut1	-0.00000001	0.000000044	-0.066	0.000012432	0.11
q us1aut2	0.00000063	0.000000221	1.002	0.000062384	0.11
q us2aut3	0.00000066	0.000000298	0.768	0.000084643	0.11
q us3aut4	0.00000105	0.000000376	0.986	0.000105437	0.11
q us4aut5	0.00000058	0.000000233	0.855	0.000066816	0.11
q us5aut6	0.00000071	0.000000271	0.922	0.000075745	0.11

Appendix 3: Table 3.

Bootstrap Output Variable: F t

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0005	0.0005	0.0001	0.23
Age 2	0.1185	0.1194	0.0219	0.18
Age 3	0.3928	0.4003	0.0781	0.20
Age 4	0.2474	0.2503	0.0441	0.18
Age 5	0.3880	0.3966	0.0779	0.20
Age 6	0.2212	0.2304	0.0536	0.24
Age 7	0.1972	0.2037	0.0464	0.24
Age 8	0.2634	0.2703	0.0295	0.11
Age 9	0.2634	0.2703	0.0295	0.11
Age 10	0.2634	0.2703	0.0295	0.11

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
Age 1	0.0000088	0.0000038	1.716	0.0005048	0.24
Age 2	0.0008873	0.0006931	0.749	0.1176145	0.19
Age 3	0.0074731	0.0024708	1.902	0.3853626	0.20
Age 4	0.0029643	0.0013942	1.198	0.2443942	0.18
Age 5	0.0085726	0.0024634	2.209	0.3794469	0.21
Age 6	0.0092079	0.0016960	4.163	0.2120020	0.25
Age 7	0.0065333	0.0014675	3.313	0.1906780	0.24
Age 8	0.0068195	0.0009337	2.589	0.2566303	0.12
Age 9	0.0068195	0.0009337	2.589	0.2566303	0.12
Age 10	0.0068195	0.0009337	2.589	0.2566303	0.12

Appendix 3: Table 4.
Bootstrap Output Variable: F full t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
0.2634	0.2703	0.0295	0.11

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
0.00682	0.00093	2.59	0.25663	0.12

Appendix 3: Table 5.

Bootstrap Output Variable: SSB spawn t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
35915.2427	36399.4903	2975.1526	0.08

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
484.25	94.08	1.35	35430.99	0.08

APPENDIX 4

Full Listing of ASPIC Output and Diagnostics for Georges Bank Cod.

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.65)

BOT Mode

Author: Michael H. Prager
National Marine Fisheries Service
Southwest Fisheries Science Center
3150 Paradise Drive
Tiburon, California 94920 USA

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	35	Number of bootstrap trials:	500
Number of data series:	4	Lower bound on MSY:	1.000E+00
Objective function computed:	in EFFORT	Upper bound on MSY:	5.000E+02
Relative conv. criterion (simplex):	1.000E-08	Lower bound on r:	1.000E-02
Relative conv. criterion (restart):	3.000E-08	Upper bound on r:	1.500E+00
Relative conv. criterion (effort):	1.000E-04	Random number seed:	1964285
Maximum F allowed in fitting:	5.000	Monte Carlo search trials:	50000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 0

Normal convergence.

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)

1 USA Fall Survey	1.000			
	35			
2 USA Spring Survey- #36	0.507	1.000		
	21	21		
3 Canadian Spring survey	0.361	0.219	1.000	
	10	10	10	
4 USA Spring Survey #41	0.501	0.000	0.000	1.000
	9	0	0	9
	1	2	3	4

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1R > 2	0.000E+00	1	N/A	1.000E+00	N/A	
Loss(1) USA Fall Survey	6.893E+00	35	2.089E-01	1.000E+00	1.006E+00	0.435
Loss(2) USA Spring Survey- #36	3.515E+00	21	1.850E-01	1.000E+00	1.136E+00	0.457
Loss(3) Canadian Spring survey	3.379E+00	10	4.224E-01	1.000E+00	4.974E-01	-0.059
Loss(4) USA Spring Survey #41	1.206E+00	9	1.723E-01	1.000E+00	1.219E+00	-0.182

TOTAL OBJECTIVE FUNCTION: 1.49929019E+01

Number of restarts required for convergence:	23
Est. B-ratio coverage index (0 worst, 2 best):	1.2667
Est. B-ratio nearness index (0 worst, 1 best):	1.0000

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1963	1.525E+00	1.500E+00	1	1
MSY	Maximum sustainable yield	3.325E+01	3.000E+01	1	1
r	Intrinsic rate of increase	4.881E-01	5.000E-01	1	1
.....	Catchability coefficients by fishery:				
q(1)	USA Fall Survey	6.722E-02	1.200E-01	1	1
q(2)	USA Spring Survey- #36	1.260E-01	2.200E-01	1	1
q(3)	Canadian Spring survey	5.713E-01	1.110E+00	1	1
q(4)	USA Spring Survey #41	1.362E-01	1.000E-01	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	3.325E+01	Kr/4	
K	Maximum stock biomass	2.725E+02		
Bmsy	Stock biomass at MSY	1.362E+02	K/2	
Fmsy	Fishing mortality at MSY	2.441E-01	r/2	
F(0.1)	Management benchmark	2.197E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	3.292E+01	0.99*MSY	
B-ratio	Ratio of B(1998) to Bmsy	4.921E-01		
F-ratio	Ratio of F(1997) to Fmsy	7.047E-01		
Y-ratio	Proportion of MSY avail in 1998	7.421E-01	2*Br-Br^2	Ye(1998) = 2.467E+01
.....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	USA Fall Survey	3.631E+00	r/2q(1)	f(0.1) = 3.268E+00

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1963	0.132	2.078E+02	2.063E+02	2.719E+01	2.719E+01	2.445E+01	5.400E-01	1.525E+00
2	1964	0.123	2.050E+02	2.048E+02	2.516E+01	2.516E+01	2.481E+01	5.033E-01	1.505E+00
3	1965	0.193	2.047E+02	1.983E+02	3.833E+01	3.833E+01	2.633E+01	7.922E-01	1.502E+00
4	1966	0.295	1.927E+02	1.801E+02	5.313E+01	5.313E+01	2.972E+01	1.209E+00	1.414E+00
5	1967	0.221	1.693E+02	1.666E+02	3.675E+01	3.675E+01	3.160E+01	9.041E-01	1.243E+00
6	1968	0.272	1.641E+02	1.584E+02	4.314E+01	4.314E+01	3.235E+01	1.116E+00	1.205E+00
7	1969	0.252	1.533E+02	1.507E+02	3.794E+01	3.794E+01	3.287E+01	1.032E+00	1.126E+00
8	1970	0.169	1.483E+02	1.520E+02	2.565E+01	2.565E+01	3.280E+01	6.916E-01	1.088E+00
9	1971	0.179	1.554E+02	1.576E+02	2.818E+01	2.818E+01	3.243E+01	7.325E-01	1.141E+00
10	1972	0.154	1.597E+02	1.632E+02	2.506E+01	2.506E+01	3.194E+01	6.290E-01	1.172E+00
11	1973	0.172	1.665E+02	1.679E+02	2.892E+01	2.892E+01	3.146E+01	7.060E-01	1.222E+00
12	1974	0.160	1.691E+02	1.710E+02	2.733E+01	2.733E+01	3.108E+01	6.548E-01	1.241E+00
13	1975	0.142	1.728E+02	1.757E+02	2.501E+01	2.501E+01	3.046E+01	5.833E-01	1.269E+00
14	1976	0.109	1.783E+02	1.832E+02	1.993E+01	1.993E+01	2.929E+01	4.457E-01	1.309E+00
15	1977	0.145	1.876E+02	1.882E+02	2.737E+01	2.737E+01	2.841E+01	5.959E-01	1.377E+00
16	1978	0.191	1.887E+02	1.853E+02	3.536E+01	3.536E+01	2.894E+01	7.819E-01	1.385E+00
17	1979	0.217	1.823E+02	1.778E+02	3.862E+01	3.862E+01	3.015E+01	8.902E-01	1.338E+00
18	1980	0.292	1.738E+02	1.650E+02	4.812E+01	4.812E+01	3.172E+01	1.194E+00	1.276E+00
19	1981	0.278	1.574E+02	1.523E+02	4.235E+01	4.235E+01	3.277E+01	1.139E+00	1.155E+00
20	1982	0.423	1.478E+02	1.350E+02	5.716E+01	5.716E+01	3.316E+01	1.735E+00	1.085E+00
21	1983	0.425	1.238E+02	1.151E+02	4.889E+01	4.889E+01	3.241E+01	1.740E+00	9.088E-01
22	1984	0.374	1.073E+02	1.035E+02	3.868E+01	3.868E+01	3.132E+01	1.531E+00	7.879E-01
23	1985	0.387	9.998E+01	9.641E+01	3.727E+01	3.727E+01	3.040E+01	1.584E+00	7.339E-01
24	1986	0.272	9.311E+01	9.533E+01	2.590E+01	2.590E+01	3.025E+01	1.113E+00	6.835E-01
25	1987	0.317	9.746E+01	9.728E+01	3.088E+01	3.088E+01	3.053E+01	1.301E+00	7.154E-01
26	1988	0.426	9.711E+01	9.215E+01	3.924E+01	3.924E+01	2.975E+01	1.745E+00	7.128E-01
27	1989	0.388	8.762E+01	8.529E+01	3.310E+01	3.310E+01	2.860E+01	1.590E+00	6.432E-01
28	1990	0.570	8.312E+01	7.460E+01	4.250E+01	4.250E+01	2.641E+01	2.334E+00	6.101E-01
29	1991	0.638	6.702E+01	5.902E+01	3.763E+01	3.763E+01	2.254E+01	2.612E+00	4.920E-01
30	1992	0.609	5.193E+01	4.688E+01	2.857E+01	2.857E+01	1.893E+01	2.497E+00	3.812E-01
31	1993	0.597	4.229E+01	3.869E+01	2.311E+01	2.311E+01	1.620E+01	2.447E+00	3.105E-01
32	1994	0.430	3.538E+01	3.529E+01	1.517E+01	1.517E+01	1.500E+01	1.761E+00	2.597E-01
33	1995	0.200	3.521E+01	3.939E+01	7.859E+00	7.859E+00	1.644E+01	8.175E-01	2.584E-01
34	1996	0.182	4.378E+01	4.902E+01	8.905E+00	8.905E+00	1.961E+01	7.443E-01	3.214E-01
35	1997	0.172	5.449E+01	6.066E+01	1.043E+01	1.043E+01	2.299E+01	7.047E-01	3.999E-01
36	1998		6.705E+01						4.921E-01

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) USA Fall Survey

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed yield	Model yield	Resid in log effort	Resid in yield
1	1963	1.527E+00	1.961E+00	0.1318	2.719E+01	2.719E+01	-0.24962	0.000E+00
2	1964	2.169E+00	1.828E+00	0.1228	2.516E+01	2.516E+01	0.17142	0.000E+00
3	1965	3.276E+00	2.876E+00	0.1933	3.833E+01	3.833E+01	0.13019	0.000E+00
4	1966	6.560E+00	4.389E+00	0.2950	5.313E+01	5.313E+01	0.40179	0.000E+00
5	1967	2.702E+00	3.283E+00	0.2207	3.675E+01	3.675E+01	-0.19460	0.000E+00
6	1968	5.016E+00	4.051E+00	0.2723	4.314E+01	4.314E+01	0.21357	0.000E+00
7	1969	4.742E+00	3.746E+00	0.2518	3.794E+01	3.794E+01	0.23581	0.000E+00
8	1970	2.052E+00	2.511E+00	0.1688	2.565E+01	2.565E+01	-0.20188	0.000E+00
9	1971	2.846E+00	2.660E+00	0.1788	2.818E+01	2.818E+01	0.06784	0.000E+00
10	1972	1.090E+00	2.284E+00	0.1535	2.506E+01	2.506E+01	-0.74012	0.000E+00
11	1973	9.391E-01	2.563E+00	0.1723	2.892E+01	2.892E+01	-1.00422	0.000E+00
12	1974	3.333E+00	2.377E+00	0.1598	2.733E+01	2.733E+01	0.33786	0.000E+00
13	1975	1.774E+00	2.118E+00	0.1424	2.501E+01	2.501E+01	-0.17742	0.000E+00
14	1976	1.126E+00	1.618E+00	0.1088	1.993E+01	1.993E+01	-0.36303	0.000E+00
15	1977	2.189E+00	2.164E+00	0.1454	2.737E+01	2.737E+01	0.01184	0.000E+00
16	1978	1.517E+00	2.839E+00	0.1908	3.536E+01	3.536E+01	-0.62648	0.000E+00
17	1979	2.341E+00	3.233E+00	0.2173	3.862E+01	3.862E+01	-0.32277	0.000E+00
18	1980	7.181E+00	4.337E+00	0.2915	4.812E+01	4.812E+01	0.50427	0.000E+00
19	1981	2.229E+00	4.136E+00	0.2780	4.235E+01	4.235E+01	-0.61822	0.000E+00
20	1982	8.284E+00	6.300E+00	0.4235	5.716E+01	5.716E+01	0.27373	0.000E+00
21	1983	7.521E+00	6.319E+00	0.4247	4.889E+01	4.889E+01	0.17413	0.000E+00
22	1984	3.755E+00	5.560E+00	0.3737	3.868E+01	3.868E+01	-0.39239	0.000E+00
23	1985	1.065E+01	5.752E+00	0.3866	3.727E+01	3.727E+01	0.61596	0.000E+00
24	1986	5.511E+00	4.042E+00	0.2717	2.590E+01	2.590E+01	0.30994	0.000E+00
25	1987	7.018E+00	4.723E+00	0.3174	3.088E+01	3.088E+01	0.39613	0.000E+00
26	1988	6.766E+00	6.335E+00	0.4258	3.924E+01	3.924E+01	0.06574	0.000E+00
27	1989	7.195E+00	5.773E+00	0.3880	3.310E+01	3.310E+01	0.22020	0.000E+00
28	1990	5.986E+00	8.476E+00	0.5697	4.250E+01	4.250E+01	-0.34774	0.000E+00
29	1991	2.688E+01	9.485E+00	0.6375	3.763E+01	3.763E+01	1.04161	0.000E+00
30	1992	9.215E+00	9.066E+00	0.6094	2.857E+01	2.857E+01	0.01634	0.000E+00
31	1993	1.051E+01	8.887E+00	0.5973	2.311E+01	2.311E+01	0.16740	0.000E+00
32	1994	4.597E+00	6.394E+00	0.4298	1.517E+01	1.517E+01	-0.33008	0.000E+00
33	1995	1.403E+00	2.968E+00	0.1995	7.859E+00	7.859E+00	-0.74908	0.000E+00
34	1996	3.298E+00	2.703E+00	0.1817	8.905E+00	8.905E+00	0.19910	0.000E+00
35	1997	5.492E+00	2.559E+00	0.1720	1.043E+01	1.043E+01	0.76363	0.000E+00

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1

Year	Residual	-2 -1.5 -1 -0.5 0 0.5 1 1.5 2
1963	-0.2496	===== |
1964	0.1714	| ===
1965	0.1302	| ===
1966	0.4018	| ========
1967	-0.1946	==== |
1968	0.2136	| ====
1969	0.2358	| =====
1970	-0.2019	==== |
1971	0.0678	| =
1972	-0.7401	========== |
1973	-1.0042	========== |
1974	0.3379	| =======
1975	-0.1774	==== |
1976	-0.3630	======= |
1977	0.0118	|
1978	-0.6265	========== |
1979	-0.3228	====== |
1980	0.5043	| ==========
1981	-0.6182	========== |
1982	0.2737	| =====
1983	0.1741	| ===
1984	-0.3924	======== |
1985	0.6160	| ==========
1986	0.3099	| ======
1987	0.3961	| ========
1988	0.0657	| =
1989	0.2202	| ====
1990	-0.3477	======= |
1991	1.0416	| ==========
1992	0.0163	|
1993	0.1674	| ===
1994	-0.3301	======= |
1995	-0.7491	========== |
1996	0.1991	| ====
1997	0.7636	| ==========

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) USA Spring Survey- #36

Data type IO: Start-of-year biomass index Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1963	0.000E+00	0.000E+00	0.0	*	2.617E+01	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	2.583E+01	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	2.578E+01	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	2.427E+01	0.00000	0.0
5	1967	0.000E+00	0.000E+00	0.0	*	2.132E+01	0.00000	0.0
6	1968	1.000E+00	1.000E+00	0.0	1.260E+01	2.067E+01	-0.49520	-8.074E+00
7	1969	1.000E+00	1.000E+00	0.0	1.780E+01	1.932E+01	-0.08173	-1.516E+00
8	1970	1.000E+00	1.000E+00	0.0	1.560E+01	1.868E+01	-0.18005	-3.077E+00
9	1971	1.000E+00	1.000E+00	0.0	1.420E+01	1.958E+01	-0.32115	-5.378E+00
10	1972	1.000E+00	1.000E+00	0.0	1.900E+01	2.011E+01	-0.05692	-1.113E+00
11	1973	0.000E+00	0.000E+00	0.0	*	2.098E+01	0.00000	0.0
12	1974	0.000E+00	0.000E+00	0.0	*	2.130E+01	0.00000	0.0
13	1975	0.000E+00	0.000E+00	0.0	*	2.177E+01	0.00000	0.0
14	1976	0.000E+00	0.000E+00	0.0	*	2.246E+01	0.00000	0.0
15	1977	0.000E+00	0.000E+00	0.0	*	2.364E+01	0.00000	0.0
16	1978	0.000E+00	0.000E+00	0.0	*	2.377E+01	0.00000	0.0
17	1979	0.000E+00	0.000E+00	0.0	*	2.296E+01	0.00000	0.0
18	1980	0.000E+00	0.000E+00	0.0	*	2.189E+01	0.00000	0.0
19	1981	0.000E+00	0.000E+00	0.0	*	1.983E+01	0.00000	0.0
20	1982	1.000E+00	1.000E+00	0.0	1.540E+01	1.862E+01	-0.18988	-3.220E+00
21	1983	1.000E+00	1.000E+00	0.0	2.400E+01	1.560E+01	0.43095	8.403E+00
22	1984	1.000E+00	1.000E+00	0.0	1.540E+01	1.352E+01	0.13008	1.878E+00
23	1985	1.000E+00	1.000E+00	0.0	2.150E+01	1.259E+01	0.53476	8.905E+00
24	1986	1.000E+00	1.000E+00	0.0	1.670E+01	1.173E+01	0.35330	4.971E+00
25	1987	1.000E+00	1.000E+00	0.0	1.030E+01	1.228E+01	-0.17560	-1.977E+00
26	1988	1.000E+00	1.000E+00	0.0	1.350E+01	1.223E+01	0.09853	1.267E+00
27	1989	1.000E+00	1.000E+00	0.0	1.080E+01	1.104E+01	-0.02180	-2.381E-01
28	1990	1.000E+00	1.000E+00	0.0	1.160E+01	1.047E+01	0.10239	1.129E+00
29	1991	1.000E+00	1.000E+00	0.0	9.000E+00	8.443E+00	0.06385	5.567E-01
30	1992	1.000E+00	1.000E+00	0.0	7.500E+00	6.542E+00	0.13669	9.582E-01
31	1993	1.000E+00	1.000E+00	0.0	7.300E+00	5.328E+00	0.31489	1.972E+00
32	1994	1.000E+00	1.000E+00	0.0	1.200E+00	4.457E+00	-1.31215	-3.257E+00
33	1995	1.000E+00	1.000E+00	0.0	8.400E+00	4.435E+00	0.63867	3.965E+00
34	1996	1.000E+00	1.000E+00	0.0	7.500E+00	5.516E+00	0.30730	1.984E+00
35	1997	1.000E+00	1.000E+00	0.0	5.200E+00	6.864E+00	-0.27759	-1.664E+00

* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2

Year	Residual	-2 -1.5 -1 -0.5 0 0.5 1 1.5 2
1963	0.0000	|
1964	0.0000	|
1965	0.0000	|
1966	0.0000	|
1967	0.0000	|
1968	-0.4952	========== |
1969	-0.0817	== |
1970	-0.1800	==== |
1971	-0.3211	====== |
1972	-0.0569	= |
1973	0.0000	|
1974	0.0000	|
1975	0.0000	|
1976	0.0000	|
1977	0.0000	|
1978	0.0000	|
1979	0.0000	|
1980	0.0000	|
1981	0.0000	|
1982	-0.1899	==== |
1983	0.4310	| =========
1984	0.1301	| ===
1985	0.5348	| ============
1986	0.3533	| =======
1987	-0.1756	==== |
1988	0.0985	| ==
1989	-0.0218	|
1990	0.1024	| ==
1991	0.0638	| =
1992	0.1367	| ===
1993	0.3149	| ======
1994	-1.3121	========================== |
1995	0.6387	| ==============
1996	0.3073	| ======
1997	-0.2776	====== |

RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) Canadian Spring survey

Data type IO: Start-of-year biomass index Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1963	0.000E+00	0.000E+00	0.0	*	1.187E+02	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	1.171E+02	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	1.169E+02	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	1.101E+02	0.00000	0.0
5	1967	0.000E+00	0.000E+00	0.0	*	9.671E+01	0.00000	0.0
6	1968	0.000E+00	0.000E+00	0.0	*	9.377E+01	0.00000	0.0
7	1969	0.000E+00	0.000E+00	0.0	*	8.760E+01	0.00000	0.0
8	1970	0.000E+00	0.000E+00	0.0	*	8.471E+01	0.00000	0.0
9	1971	0.000E+00	0.000E+00	0.0	*	8.879E+01	0.00000	0.0
10	1972	0.000E+00	0.000E+00	0.0	*	9.122E+01	0.00000	0.0
11	1973	0.000E+00	0.000E+00	0.0	*	9.515E+01	0.00000	0.0
12	1974	0.000E+00	0.000E+00	0.0	*	9.659E+01	0.00000	0.0
13	1975	0.000E+00	0.000E+00	0.0	*	9.874E+01	0.00000	0.0
14	1976	0.000E+00	0.000E+00	0.0	*	1.018E+02	0.00000	0.0
15	1977	0.000E+00	0.000E+00	0.0	*	1.072E+02	0.00000	0.0
16	1978	0.000E+00	0.000E+00	0.0	*	1.078E+02	0.00000	0.0
17	1979	0.000E+00	0.000E+00	0.0	*	1.041E+02	0.00000	0.0
18	1980	0.000E+00	0.000E+00	0.0	*	9.929E+01	0.00000	0.0
19	1981	0.000E+00	0.000E+00	0.0	*	8.992E+01	0.00000	0.0
20	1982	0.000E+00	0.000E+00	0.0	*	8.445E+01	0.00000	0.0
21	1983	0.000E+00	0.000E+00	0.0	*	7.074E+01	0.00000	0.0
22	1984	0.000E+00	0.000E+00	0.0	*	6.133E+01	0.00000	0.0
23	1985	0.000E+00	0.000E+00	0.0	*	5.712E+01	0.00000	0.0
24	1986	1.000E+00	1.000E+00	0.0	4.114E+01	5.320E+01	-0.25703	-1.206E+01
25	1987	1.000E+00	1.000E+00	0.0	2.098E+01	5.568E+01	-0.97608	-3.470E+01
26	1988	1.000E+00	1.000E+00	0.0	4.388E+01	5.548E+01	-0.23460	-1.160E+01
27	1989	1.000E+00	1.000E+00	0.0	3.346E+01	5.006E+01	-0.40290	-1.660E+01
28	1990	1.000E+00	1.000E+00	0.0	1.281E+02	4.749E+01	0.99237	8.062E+01
29	1991	1.000E+00	1.000E+00	0.0	5.672E+01	3.829E+01	0.39285	1.843E+01
30	1992	1.000E+00	1.000E+00	0.0	3.300E+01	2.967E+01	0.10639	3.331E+00
31	1993	0.000E+00	0.000E+00	0.0	*	2.416E+01	0.00000	0.0
32	1994	0.000E+00	0.000E+00	0.0	*	2.021E+01	0.00000	0.0
33	1995	1.000E+00	1.000E+00	0.0	1.605E+01	2.012E+01	-0.22576	-4.065E+00
34	1996	1.000E+00	1.000E+00	0.0	6.266E+01	2.502E+01	0.91821	3.764E+01
35	1997	1.000E+00	1.000E+00	0.0	2.275E+01	3.113E+01	-0.31359	-8.379E+00

* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3

Year	Residual	-1 -0.75 -0.5 -0.25 0 0.25 0.5 0.75 1
1963	0.0000	
1964	0.0000	
1965	0.0000	
1966	0.0000	
1967	0.0000	
1968	0.0000	
1969	0.0000	
1970	0.0000	
1971	0.0000	
1972	0.0000	
1973	0.0000	
1974	0.0000	
1975	0.0000	
1976	0.0000	
1977	0.0000	
1978	0.0000	
1979	0.0000	
1980	0.0000	
1981	0.0000	
1982	0.0000	
1983	0.0000	
1984	0.0000	
1985	0.0000	
1986	-0.2570	==========
1987	-0.9761	==========
1988	-0.2346	=========
1989	-0.4029	================
1990	0.9924	==========
1991	0.3928	================
1992	0.1064	====
1993	0.0000	
1994	0.0000	
1995	-0.2258	=========
1996	0.9182	==========
1997	-0.3136	============

RESULTS FOR DATA SERIES # 4 (NON-BOOTSTRAPPED) USA Spring Survey #41

Data type IO: Start-of-year biomass index Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1963	0.000E+00	0.000E+00	0.0	*	2.831E+01	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	2.793E+01	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	2.788E+01	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	2.625E+01	0.00000	0.0
5	1967	0.000E+00	0.000E+00	0.0	*	2.306E+01	0.00000	0.0
6	1968	0.000E+00	0.000E+00	0.0	*	2.236E+01	0.00000	0.0
7	1969	0.000E+00	0.000E+00	0.0	*	2.089E+01	0.00000	0.0
8	1970	0.000E+00	0.000E+00	0.0	*	2.020E+01	0.00000	0.0
9	1971	0.000E+00	0.000E+00	0.0	*	2.117E+01	0.00000	0.0
10	1972	0.000E+00	0.000E+00	0.0	*	2.175E+01	0.00000	0.0
11	1973	1.000E+00	1.000E+00	0.0	3.970E+01	2.269E+01	0.55954	1.701E+01
12	1974	1.000E+00	1.000E+00	0.0	3.640E+01	2.303E+01	0.45766	1.337E+01
13	1975	1.000E+00	1.000E+00	0.0	2.600E+01	2.354E+01	0.09927	2.457E+00
14	1976	1.000E+00	1.000E+00	0.0	1.860E+01	2.429E+01	-0.26672	-5.686E+00
15	1977	1.000E+00	1.000E+00	0.0	1.540E+01	2.556E+01	-0.50671	-1.016E+01
16	1978	1.000E+00	1.000E+00	0.0	3.120E+01	2.570E+01	0.19377	5.496E+00
17	1979	1.000E+00	1.000E+00	0.0	1.690E+01	2.483E+01	-0.38470	-7.929E+00
18	1980	1.000E+00	1.000E+00	0.0	1.670E+01	2.367E+01	-0.34900	-6.975E+00
19	1981	1.000E+00	1.000E+00	0.0	2.610E+01	2.144E+01	0.19662	4.659E+00
20	1982	0.000E+00	0.000E+00	0.0	*	2.014E+01	0.00000	0.0
21	1983	0.000E+00	0.000E+00	0.0	*	1.687E+01	0.00000	0.0
22	1984	0.000E+00	0.000E+00	0.0	*	1.462E+01	0.00000	0.0
23	1985	0.000E+00	0.000E+00	0.0	*	1.362E+01	0.00000	0.0
24	1986	0.000E+00	0.000E+00	0.0	*	1.268E+01	0.00000	0.0
25	1987	0.000E+00	0.000E+00	0.0	*	1.328E+01	0.00000	0.0
26	1988	0.000E+00	0.000E+00	0.0	*	1.323E+01	0.00000	0.0
27	1989	0.000E+00	0.000E+00	0.0	*	1.194E+01	0.00000	0.0
28	1990	0.000E+00	0.000E+00	0.0	*	1.132E+01	0.00000	0.0
29	1991	0.000E+00	0.000E+00	0.0	*	9.131E+00	0.00000	0.0
30	1992	0.000E+00	0.000E+00	0.0	*	7.075E+00	0.00000	0.0
31	1993	0.000E+00	0.000E+00	0.0	*	5.762E+00	0.00000	0.0
32	1994	0.000E+00	0.000E+00	0.0	*	4.820E+00	0.00000	0.0
33	1995	0.000E+00	0.000E+00	0.0	*	4.796E+00	0.00000	0.0
34	1996	0.000E+00	0.000E+00	0.0	*	5.965E+00	0.00000	0.0
35	1997	0.000E+00	0.000E+00	0.0	*	7.423E+00	0.00000	0.0

* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 4

Year	Residual	-1 -0.75 -0.5 -0.25 0 0.25 0.5 0.75 1
1963	0.0000	
1964	0.0000	
1965	0.0000	
1966	0.0000	
1967	0.0000	
1968	0.0000	
1969	0.0000	
1970	0.0000	
1971	0.0000	
1972	0.0000	
1973	0.5595	======================
1974	0.4577	==================
1975	0.0993	====
1976	-0.2667	==========
1977	-0.5067	====================
1978	0.1938	========
1979	-0.3847	===============
1980	-0.3490	==============
1981	0.1966	========
1982	0.0000	
1983	0.0000	
1984	0.0000	
1985	0.0000	
1986	0.0000	
1987	0.0000	
1988	0.0000	
1989	0.0000	
1990	0.0000	
1991	0.0000	
1992	0.0000	
1993	0.0000	
1994	0.0000	
1995	0.0000	
1996	0.0000	
1997	0.0000	

RESULTS OF BOOTSTRAPPED ANALYSIS

Param name	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
B1ratio	1.588E+00	1.525E+00	-3.95%	1.018E+00	2.376E+00	1.231E+00	2.061E+00	8.302E-01	0.523
K	2.754E+02	2.725E+02	-1.08%	1.799E+02	6.578E+02	2.187E+02	3.881E+02	1.693E+02	0.615
r	4.804E-01	4.881E-01	1.61%	1.762E-01	8.058E-01	3.128E-01	6.333E-01	3.205E-01	0.667
q(1)	6.584E-02	6.722E-02	2.09%	3.424E-02	1.000E-01	4.744E-02	8.093E-02	3.349E-02	0.509
q(2)	1.233E-01	1.260E-01	2.13%	6.460E-02	1.973E-01	9.035E-02	1.600E-01	6.969E-02	0.565
q(3)	5.705E-01	5.713E-01	0.15%	2.932E-01	9.033E-01	4.203E-01	7.332E-01	3.129E-01	0.549
q(4)	1.365E-01	1.362E-01	-0.18%	7.881E-02	2.020E-01	1.073E-01	1.682E-01	6.096E-02	0.447
MSY	3.268E+01	3.325E+01	1.75%	2.673E+01	3.589E+01	3.004E+01	3.436E+01	4.319E+00	0.132
Ye(1998)	2.472E+01	2.467E+01	-0.17%	1.403E+01	3.369E+01	1.944E+01	2.981E+01	1.037E+01	0.420
Bmsy	1.377E+02	1.362E+02	-1.08%	8.997E+01	3.289E+02	1.094E+02	1.940E+02	8.466E+01	0.615
Fmsy	2.402E-01	2.441E-01	1.61%	8.811E-02	4.029E-01	1.564E-01	3.167E-01	1.603E-01	0.667
fmsy(1)	3.643E+00	3.631E+00	-0.34%	2.664E+00	4.319E+00	3.182E+00	4.002E+00	8.195E-01	0.225
fmsy(2)	1.981E+00	1.937E+00	-2.18%	1.527E+00	2.328E+00	1.773E+00	2.158E+00	3.848E-01	0.194
fmsy(3)	4.376E-01	4.272E-01	-2.39%	3.286E-01	5.639E-01	3.881E-01	5.081E-01	1.200E-01	0.274
fmsy(4)	1.800E+00	1.792E+00	-0.47%	1.184E+00	2.373E+00	1.517E+00	2.097E+00	5.808E-01	0.323
F(0.1)	2.162E-01	2.197E-01	1.45%	7.930E-02	3.626E-01	1.408E-01	2.850E-01	1.442E-01	0.667
Y(0.1)	3.235E+01	3.292E+01	1.73%	2.646E+01	3.553E+01	2.974E+01	3.402E+01	4.276E+00	0.132
B-ratio	4.918E-01	4.921E-01	0.07%	2.711E-01	7.432E-01	3.759E-01	6.198E-01	2.439E-01	0.496
F-ratio	7.014E-01	7.047E-01	0.48%	4.555E-01	1.287E+00	5.525E-01	9.418E-01	3.893E-01	0.555
Y-ratio	7.417E-01	7.421E-01	0.05%	4.686E-01	9.340E-01	6.105E-01	8.554E-01	2.449E-01	0.330
f0.1(1)	3.279E+00	3.268E+00	-0.31%	2.397E+00	3.887E+00	2.864E+00	3.602E+00	7.376E-01	0.225
f0.1(2)	1.782E+00	1.744E+00	-1.96%	1.374E+00	2.095E+00	1.596E+00	1.942E+00	3.463E-01	0.194
f0.1(3)	3.939E-01	3.845E-01	-2.15%	2.958E-01	5.075E-01	3.493E-01	4.573E-01	1.080E-01	0.274
f0.1(4)	1.620E+00	1.612E+00	-0.42%	1.065E+00	2.136E+00	1.365E+00	1.888E+00	5.227E-01	0.323
q2/q1	1.871E+00	1.874E+00	0.15%	1.593E+00	2.227E+00	1.724E+00	2.055E+00	3.303E-01	0.176
q3/q1	8.449E+00	8.500E+00	0.60%	6.607E+00	1.040E+01	7.454E+00	9.520E+00	2.066E+00	0.245
q4/q1	2.026E+00	2.027E+00	0.05%	1.556E+00	2.544E+00	1.768E+00	2.262E+00	4.937E-01	0.244

NOTES ON BOOTSTRAPPED ESTIMATES:

- The bootstrapped results shown were computed from 500 trials.
- These results are conditional on the constraints placed upon MSY and r in the input file (ASPIC.INP).
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- The bias corrections used here are based on medians. This is an accepted statistical procedure, but may estimate nonzero bias for unbiased, skewed estimators.

Trials replaced for lack of convergence: 14
Trials replaced for MSY out-of-bounds: 0
Trials replaced for r out-of-bounds: 0
Residual-adjustment factor: 1.0502

APPENDIX 5

Estimation of SFA requirements by applying a Beverton-Holt model derived from backcasted (1963-1977) and VPA (1978-1997) estimates of spawning stock biomass and recruitment.

by

Loretta O'Brien and Steve Cadrin

Introduction

Estimates of F_{msy} and B_{msy} are needed to fulfill the SFA (Sustainable Fisheries Act) requirements. The TRAC (Transboundary Assessment Review Committee) recommended that the current stock/recruit relationship derived from 1978-1997 data be expanded by back-casting estimates of spawning stock biomass (SSB) and recruits to 1963.

Methods and Results

A survey SSB index was derived from mature biomass of Georges Bank cod (strata 13-25) from NEFSC spring (1968-1994) and autumn (1963-1994) stratified mean weight per tow indices estimated by Cadrin and Mayo (1996). This time series of mature biomass was fit to an intergrated moving average model (Fogarty *et al.*1986) to obtain smoothed indices that account for autocorrelation in the survey indices (Cadrin and Mayo 1996; Pennington 1985,1986).

The smoothed survey SSB indices for spring and autumn 1978-1994 were ln transformed and regressed against ln transformed VPA estimates of 1978-1994 spawning stock biomass (SSB) obtained from Serchuk *et al.* (1994). Estimates of SSB prior to 1978 (Table 1, Figures 1 and 2) were then predicted from the ln transformed mature biomass indices for spring (1968-1994) and autumn (1963-1994) by applying the regression relationship:

spring: $SSB = (SV + 14.199) / 1.50$, $R^2 = 0.73$ $SE = 0.265$
autumn: $SSB = (SV + 13.707) / 1.38$, $R^2 = 0.62$ $SE = 0.342$

Estimates of recruitment prior to 1978 were predicted from the regression relationship of survey indices to VPA estimated recruits. Age 1 stratified mean number per tow indices derived from NEFSC autumn bottom trawl surveys from 1978-1994 were regressed against age 1 VPA estimates from 1978-1994. Recruits at age 1 from 1963-1977 were then predicted (Table 1, Figure 3) from the 1963-1997 age 1 survey indices by applying the regression relationship:

autumn: $Recruits = (Svage1 - 0.021443) / .000064$ $R^2 = 0.55$ $SE = 0.692$

Yield per recruit and the Beverton-Holt stock-recruitment relationship were used to estimate equilibrium yield, spawning stock biomass, and recruitment (Sissenwine and Shepherd 1987, Sinclair 1997). Beverton-Holt spawner-recruit parameters were estimated using non-linear regression (Hilborn and Walters 1992) and fitted with a Gauss-Newton iterative search algorithm (SAS 1990) using the 1978-1997 spawner and recruit data from the current 1997 assessment (O'Brien 1998, Overholtz 1997). Parameter estimates were derived for the backcasted spring

(1968-1977 + VPA 1978-1997) and autumn (1963-1977 + VPA 1978-1997) series, and for the current VPA 1977-1997 estimates (Table 2, Figures 4-6). Spawning stock biomass per recruit from the current YPR analysis (O'Brien 1998) was used to estimate the equilibrium stock and recruitment for each of the Beverton-Holt curves and the biological reference points of B_{msy} and F_{msy} (Table 2, Figures 7-10).

Discussion

The biological reference points estimated from the spring and autumn S/R relationships are similar to each other (Table 2, Figs. 8 and 9), but very different from the S/R relationship derived directly from the VPA estimates (Table 2, Figs. 7 and 10), particularly for the B_{MSY} estimate. These differences are most likely associated with the variability in estimating the backcasted recruitment and SSB. A more precise estimate of age 1 recruits might be obtained from the survey data by using all the ages in a catch-curve analysis. A re-parameterization of the Beverton-Holt stock-recruit relationship to include an environmental factor (e.g., temperature anomalies) may provide more representative parameters and explain more of the variation in the final biological reference point estimates.

Literature Cited

Cadrin, S. and R.K. Mayo. 1996. Predicting spawning stock biomass for Georges Bank and Gulf of Maine Atlantic cod stocks with research vessel survey data. NEFSC Ref. Doc. 96-05c.

Fogarty, M.J., J.S. Idoine, F.P. Almeida, and M. Pennington. 1986. Modelling trends in abundance based on research vessel surveys. ICES C.M. 1986/ G:92.

O'Brien, L. 1998. Assessment of the Georges Bank cod stock for 1997. Transboundary Assessment Review Committee Working Paper.

Overholtz, W.J. , S.A. Murawski, P.J. Rago, W.L. Gabriel, M.Terceiro. 1997. Ten year projections of landings, spawning stock biomass and recruitment for the five groundfish stocks considered at SAW-24. SAW-24 SARC Working Paper Gen. 2. 69 pgs.

Pennington, M. 1985. Estimating the relative abundance of fish from a series of trawl survey. Biometrics 41: 197-202.

Pennington, M. 1986. Some statistical techniques for estimating abundance indices from trawl surveys. Fish. Bull. U.S. 84: 519-526

SAS, 1990. The NLIN Procedure. SAS/STAT Users's Guide, Version 6, 4th edition, Vol.2 SAS Institute Inc.

Sinclair, A. 1997. Biological reference points relevant to a precautionary approach to fisheries management : and example for Southern Gulf of St. Lawrence cod. NAFO SCR Doc. 97/77.

APPENDIX 5

Estimation of SFA requirements by applying a Beverton-Holt model derived from backcasted (1963-1977) and VPA (1978-1997) estimates of spawning stock biomass and recruitment.

by

Loretta O'Brien and Steve Cadrin

Introduction

Estimates of F_{msy} and B_{msy} are needed to fulfill the SFA (Sustainable Fisheries Act) requirements. The TRAC (Transboundary Assessment Review Committee) recommended that the current stock/recruit relationship derived from 1978-1997 data be expanded by back-casting estimates of spawning stock biomass (SSB) and recruits to 1963.

Methods and Results

A survey SSB index was derived from mature biomass of Georges Bank cod (strata 13-25) from NEFSC spring (1968-1994) and autumn (1963-1994) stratified mean weight per tow indices estimated by Cadrin and Mayo (1996). This time series of mature biomass was fit to an intergrated moving average model (Fogarty *et al.* 1986) to obtain smoothed indices that account for autocorrelation in the survey indices (Cadrin and Mayo 1996; Pennington 1985,1986).

The smoothed survey SSB indices for spring and autumn 1978-1994 were ln transformed and regressed against ln transformed VPA estimates of 1978-1994 spawning stock biomass (SSB) obtained from Serchuk *et al.* (1994). Estimates of SSB prior to 1978 (Appendix 5: Table 1, Figures 1 and 2) were then predicted from the ln transformed mature biomass indices for spring (1968-1994) and autumn (1963-1994) by applying the regression relationship:

spring: $SSB = (SV + 14.199) / 1.50$, $R^2 = 0.73$ $SE = 0.265$
autumn: $SSB = (SV + 13.707) / 1.38$, $R^2 = 0.62$ $SE = 0.342$

Estimates of recruitment prior to 1978 were predicted from the regression relationship of survey indices to VPA estimated recruits. Age 1 stratified mean number per tow indices derived from NEFSC autumn bottom trawl surveys for 1978 to 1994 were regressed against age 1 VPA estimates for 1978 to 1994. Recruits at age 1 for 1963 to 1977 were then predicted (Appendix 5 Table 1, Figure 3) from the 1963 to 1997 age 1 survey indices by applying the regression relationship:

autumn: $Recruits = (Svage1 - 0.021443) / .000064$ $R^2 = 0.55$ $SE = 0.692$

Yield per recruit and the Beverton-Holt stock-recruitment relationship were used to estimate equilibrium yield, spawning stock biomass, and recruitment (Sissenwine and Shepherd 1987, Sinclair 1997). Beverton-Holt spawner-recruit parameters were estimated using non-linear regression (Hilborn and Walters 1992) and fitted with a Gauss-Newton iterative search algorithm (SAS 1990) using the 1978-1997 spawner and recruit data from this assessment. Parameter

estimates were derived for the backcasted spring (1968-1977 + VPA 1978-1997) and autumn (1963-1977 + VPA 1978-1997) series, and for the current VPA 1977-1997 estimates (Appendix 5: Table 2, Figures 4-6). Spawning stock biomass per recruit from the current YPR analysis was used to estimate the equilibrium stock and recruitment for each of the Beverton-Holt curves and the biological reference points of B_{msy} and F_{msy} (Appendix 5:Table 2, Figures 7-9).

Discussion

The biological reference points estimated from the spring and autumn S-R relationships are similar to each other (Appendix 5:Table 2, Figs. 8 and 9), but very different from the S-R relationship derived directly from the VPA estimates (Appendix 5:Table 2, Fig. 7), particularly for the B_{MSY} estimate. These differences are most likely associated with the variability in estimating the backcasted recruitment and SSB. A more precise estimate of age 1 recruits might be obtained from the survey data by using all the ages in a catch-curve analysis. A re-parameterization of the Beverton-Holt stock-recruit relationship to include an environmental factor (e.g., temperature anomalies) may provide more representative parameters and explain more of the variation in the final biological reference point estimates.

Literature Cited

Cadrin, S. and R.K. Mayo. 1996. Predicting spawning stock biomass for Georges Bank and Gulf of Maine Atlantic cod stocks with research vessel survey data. NEFSC Ref. Doc. 96-05c.

Fogarty, M.J., J.S. Idoine, F.P. Almeida, and M. Pennington. 1986. Modelling trends in abundance based on research vessel surveys. ICES C.M. 1986/ G:92.

Hilborn, R. and C.J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics & uncertainty. Chapman and Hall, New York. 570 p.

Pennington, M. 1985. Estimating the relative abundance of fish from a series of trawl survey. Biometrics 41: 197-202.

Pennington, M. 1986. Some statistical techniques for estimating abundance indices from trawl surveys. Fish. Bull. U.S. 84: 519-526

SAS, 1990. The NLIN Procedure. SAS/STAT Users's Guide, Version 6, 4th edition, Vol.2 SAS Institute Inc.

Serchuk, F.M., R.K. Mayo, and L. O'Brien. 1994. Assessment of the Georges Bank Cod Stock for 1994. NEFSC Ref. Doc. 94-25, 88 p.

Sinclair, A. 1997. Biological reference points relevant to a precautionary approach to fisheries management : and example for Southern Gulf of St. Lawrence cod. NAFO SCR Doc. 97/77.

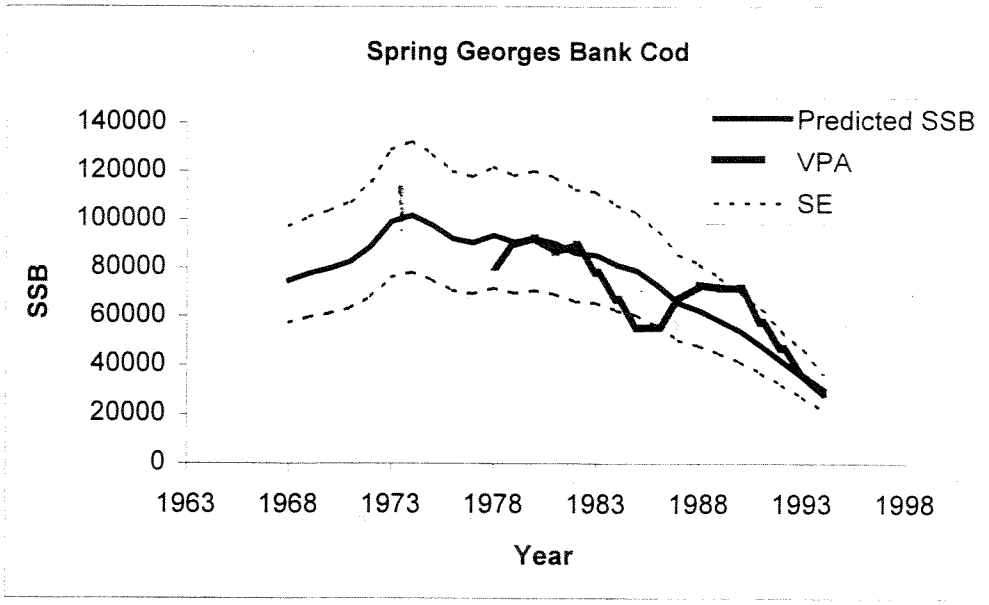
Sissenwine, M.P. and J.G. Shepherd. 1987. An alternative perspective on recruitment overfishing and biological reference points. Can. J. Aquat. Sci. 44: 913-918.

Appendix 5 Table 1. Back casted estimates (1963-1977) of SSB and recruits derived from regression relationships of NEFSC survey indices and VPA estimates of spawning stock and recuitment, and current VPA (1978-1997) estimates of SSB and recruits.

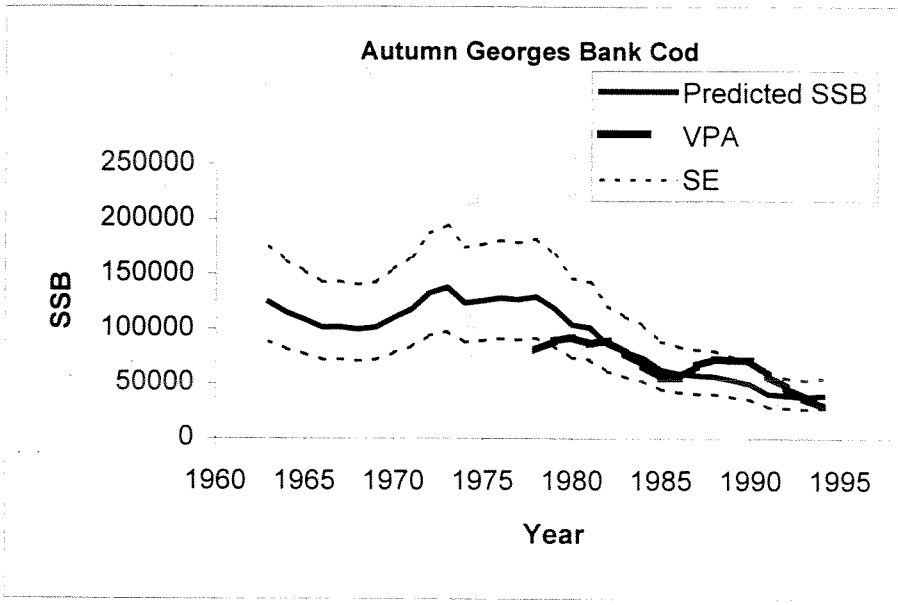
Year	Autumn SSB	Spring SSB	Recruits (lagged)
63	124.53		9.67
64	115.08		19.97
65	108.70		26.12
66	101.35		118.37
67	101.72		4.57
68	99.67	74.50	5.03
69	101.48	77.65	26.04
70	110.12	79.66	9.07
71	118.03	82.44	115.98
72	132.74	88.83	27.00
73	138.05	99.04	6.06
74	123.83	101.70	15.20
75	125.89	97.58	95.74
76	128.43	92.04	3.37
77	126.93	90.29	28.65
78	80.63	80.63	23.51
79	89.50	89.50	20.11
80	92.77	92.77	41.39
81	86.59	86.59	17.47
82	89.81	89.81	9.62
83	78.40	78.40	27.40
84	67.29	67.29	8.68
85	55.49	55.49	42.81
86	57.46	57.46	16.39
87	68.39	68.39	23.49
88	73.81	73.81	15.80
89	72.26	72.26	9.36
90	68.55	68.55	19.18
91	53.14	53.14	7.96
92	40.81	40.81	10.84
93	32.59	32.59	10.12
94	25.14	25.14	3.52
95	27.77	27.77	6.25
96	34.19	34.19	6.46
97	35.92	35.92	0.42

Appendix 5 Table 2. Estimates of Beverton-Holt stock-recruit parameters, a and b, and the standard error for four time periods, and the corresponding biological reference points, F_{msy}, B_{msy}, and MSY.

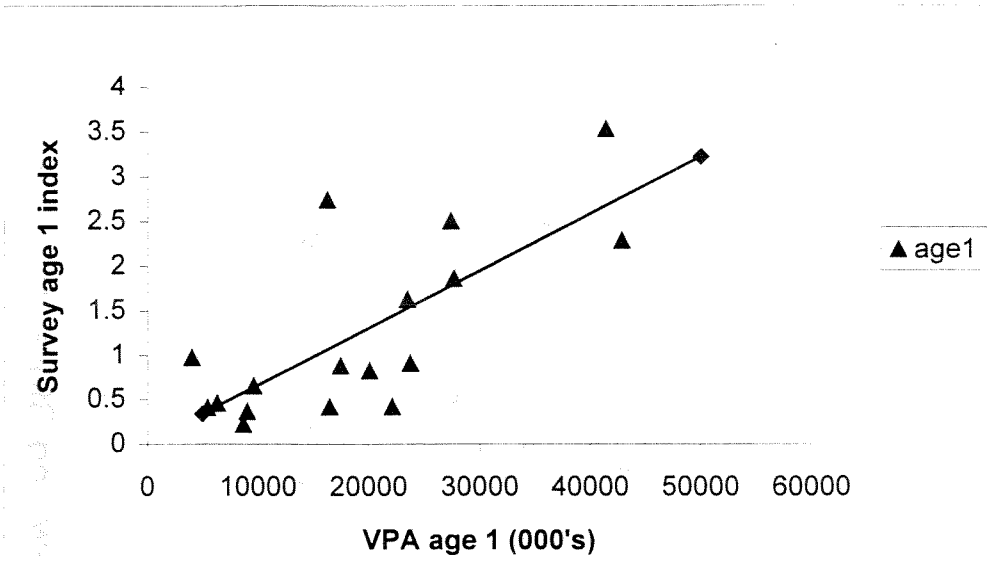
	a	b	SE		F_{msy}	B_{msy} (mt)	MSY (mt)
Spring 1968-1977,1978-1997	17448.55	85911.38	0.9146		0.15	108,400	15,500
Autumn 1963-1977,1978-1997	12941.07	71010.78	0.9841		0.10	110,000	10,600
Current 1978-1997	31693.46	96279.86	0.7933		0.15	257,000	36,600
Overholtz (1997) 1978-1995	37745.13	95826.72	0.2940		0.20	249,000	46,700
ASPIC O'Brien 1998				F4-8= 0.24	0.36	136,000	33,000
ASPIC Cadrin et al. 1998				Fsfa=0.14	0.32	108,000	35,000



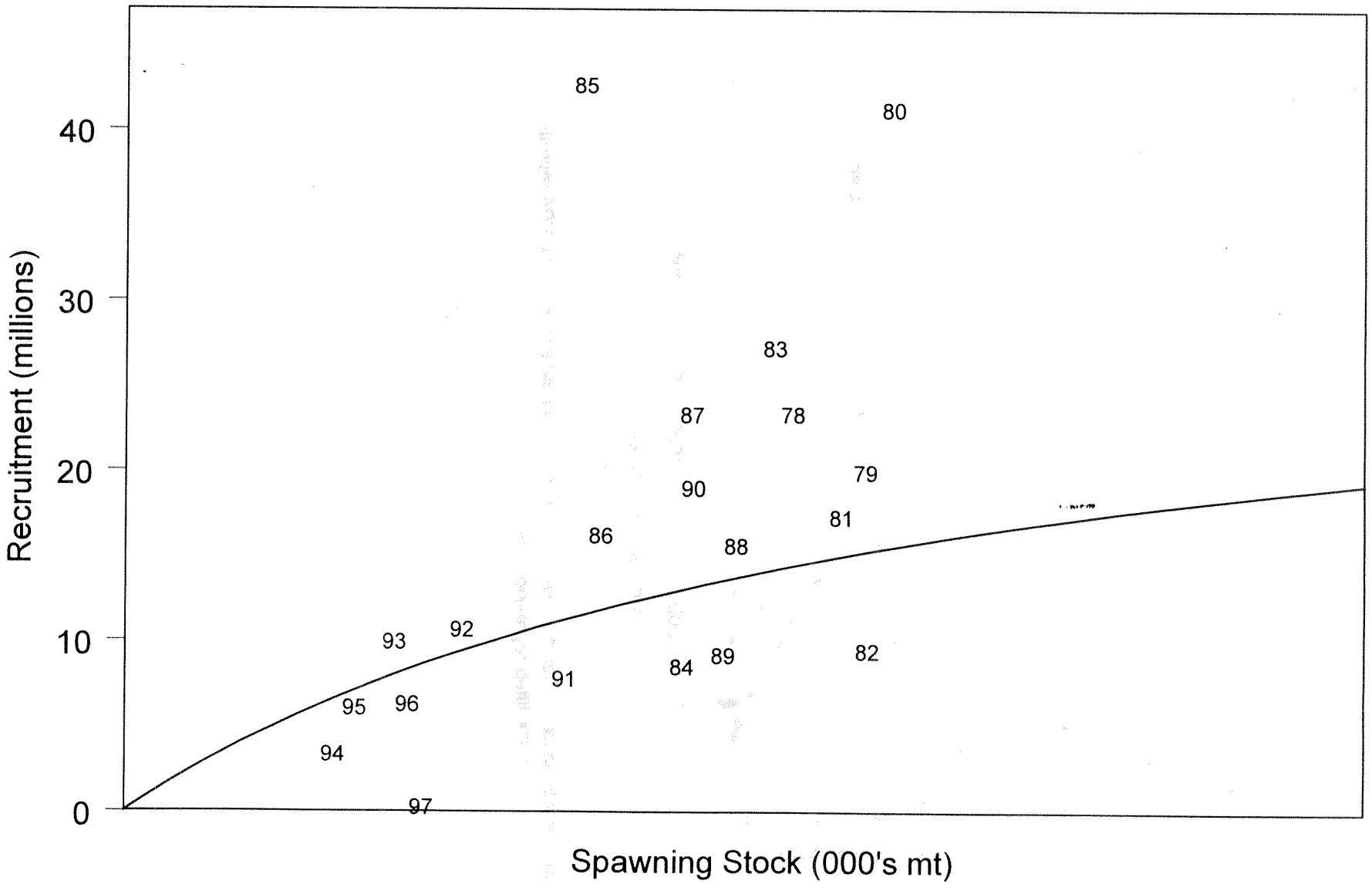
Appendix 5 Figure 1. Predicted spring SSB with standard error (SE) and the VPA estimated SSB.



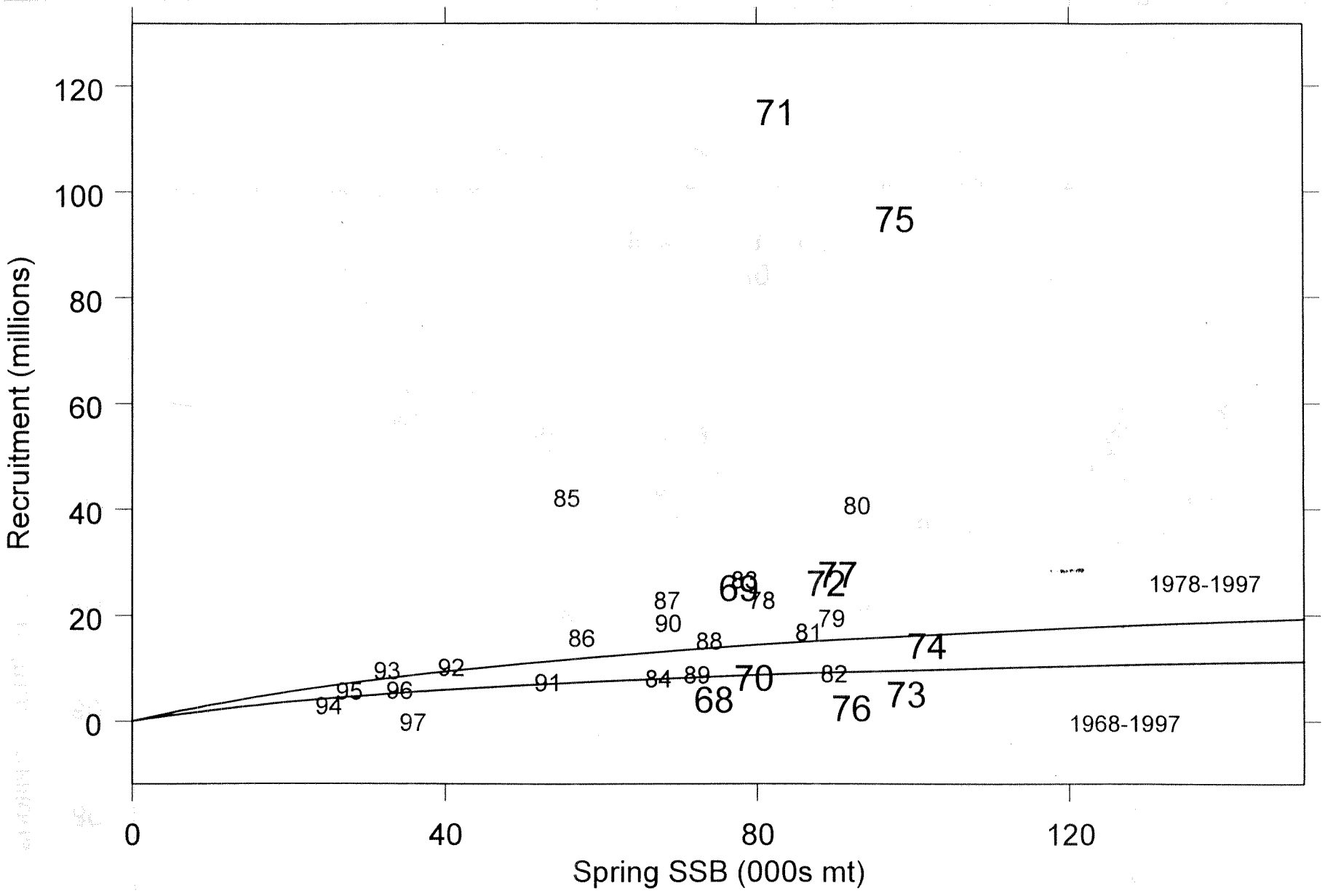
Appendix 5 Figure 2. Predicted autumn SSB with standard error (SE) and the VPA estimated SSB.



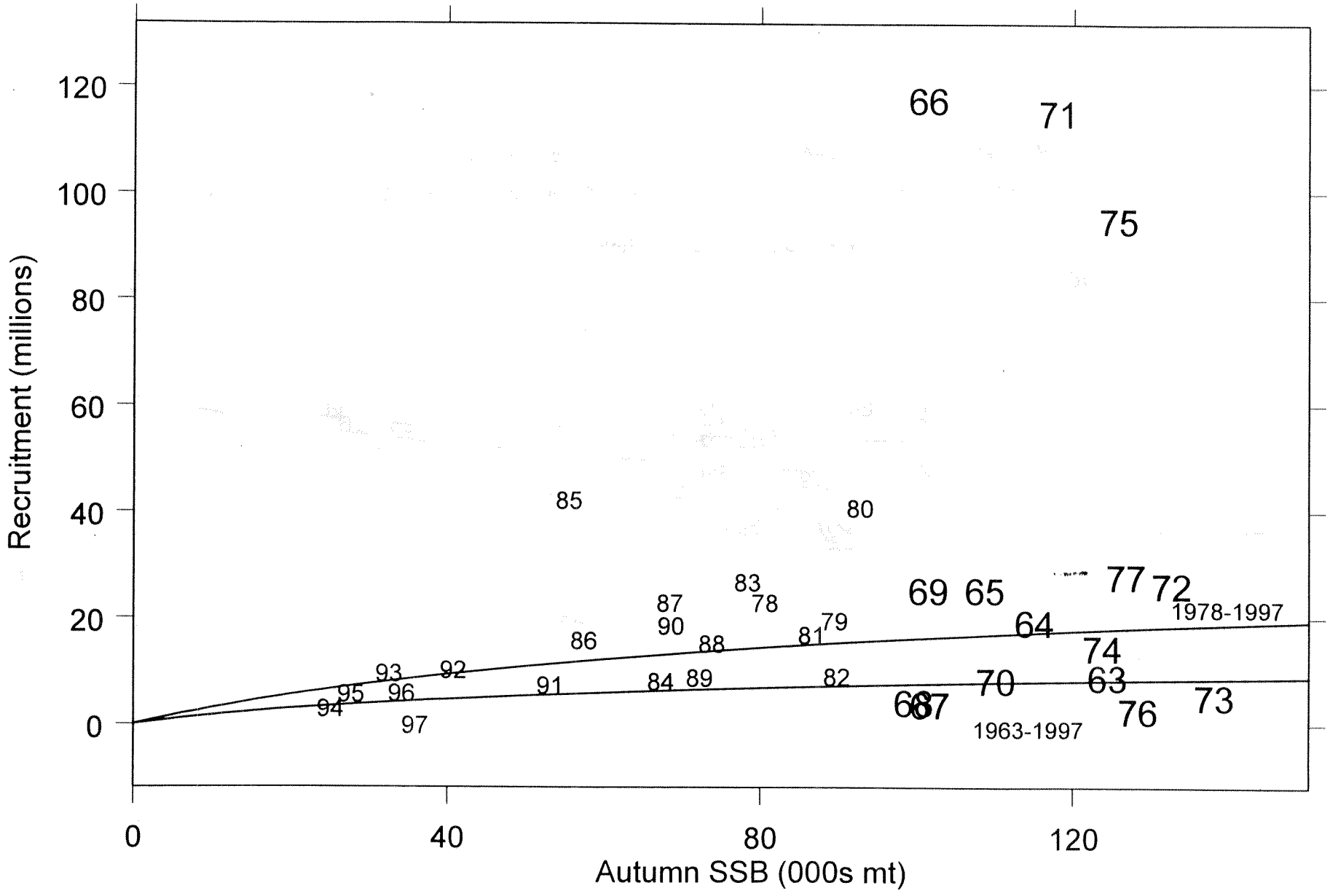
Appendix 5 Figure 3. Age 1 survey recruits regressed against age one VPA recruits, with the fitted regression line.



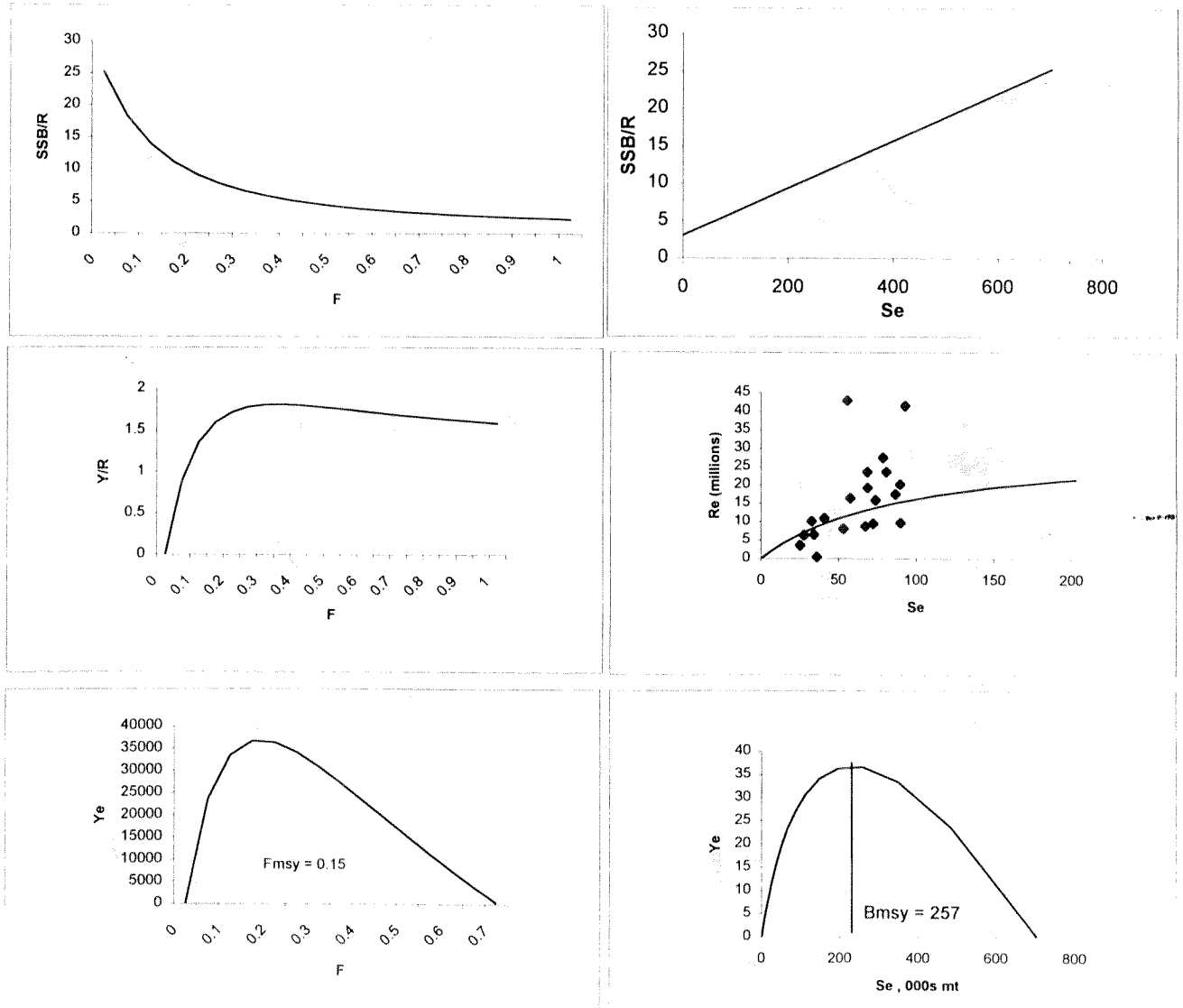
Appendix 5 Figure 4. Georges Bank cod stock-recruit data fitted with a Beverton-Holt curve, 1978-1997.



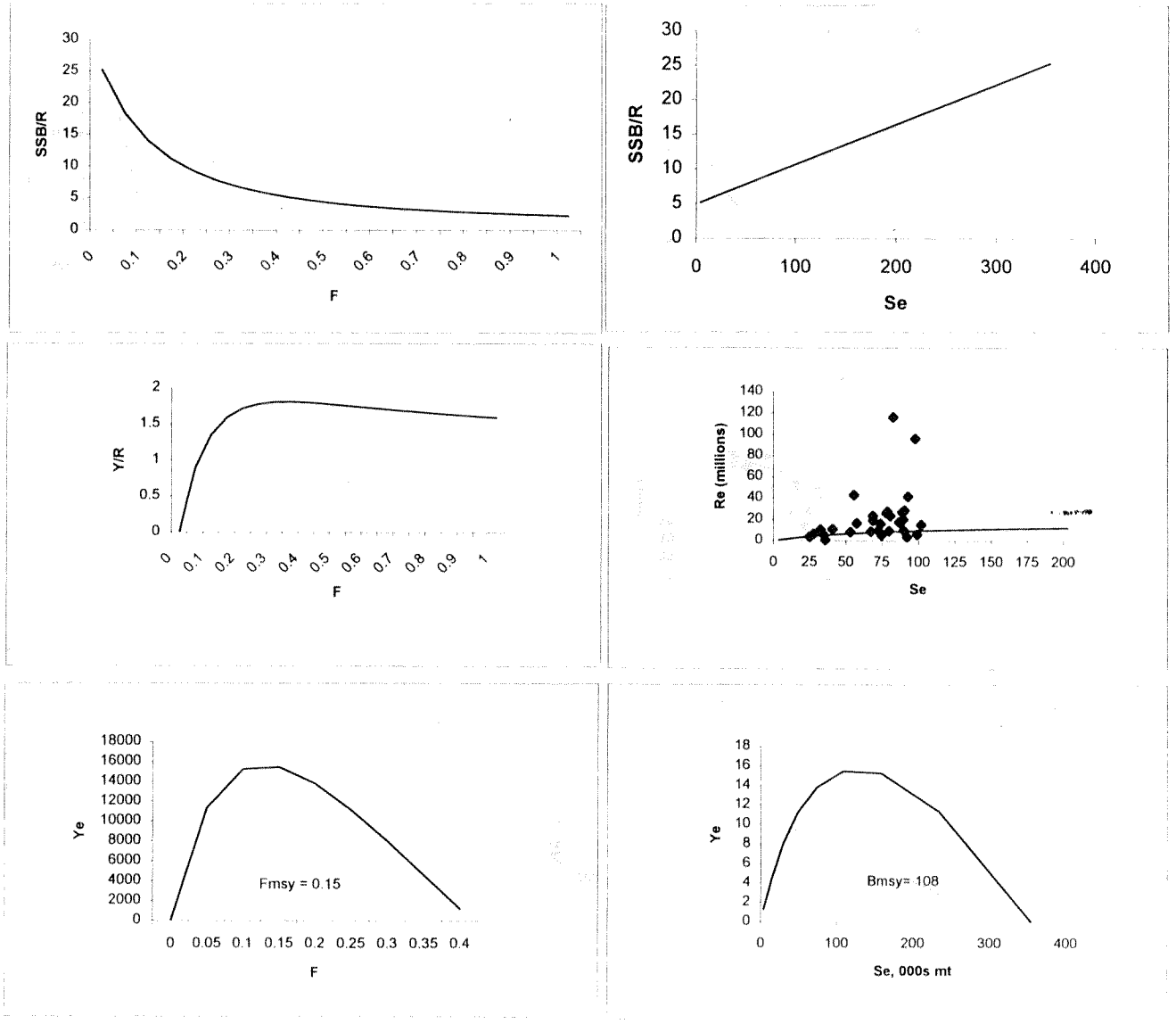
Appendix 5 Figure 5. Georges Bank cod stock-recruit data, backcasted for spring 1968-1977 and derived from VPA for 1978-1997, fitted with Beverton-Holt curves.



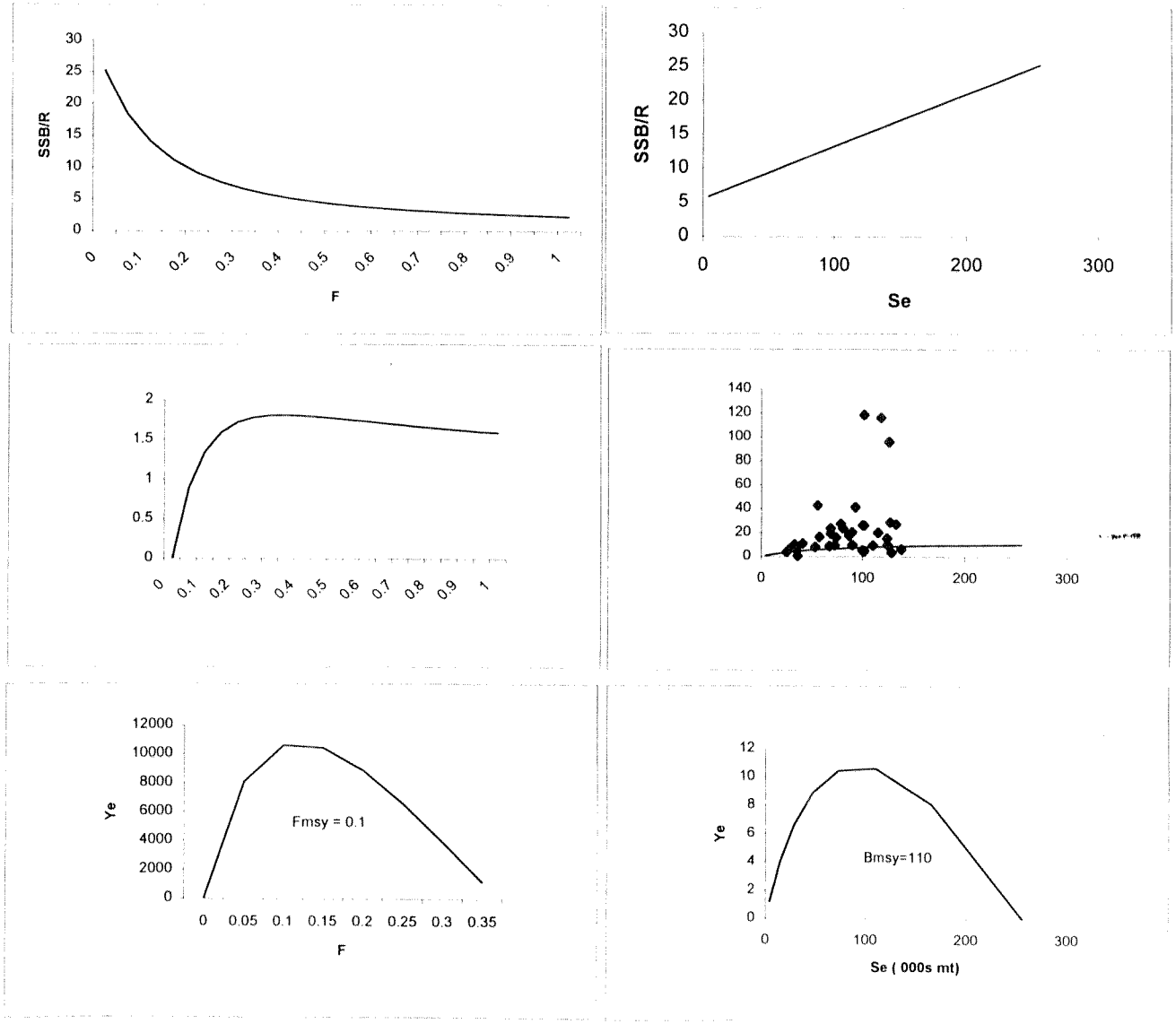
Appendix 5 Figure 6. Georges Bank cod stock-recruit data, backcasted for autumn 1963-1977 and derived from VPA for 1978-1997, fitted with Beverton-Holt curves.



Appendix 5 Figure 7. Equilibrium yield per recruit (Ye) and spawning stock biomass per recruit (Se) based on a Beverton-Holt model (estimated from 78-97 data) with estimates of B_{msy} and F_{msy}



Appendix 5 Figure 8. Equilibrium yield per recruit (Ye) and spawning stock biomass per recruit (Se) based on a Beverton-Holt model (estimated from spring 68-77 data) with estimates of B_{msy} and F_{msy}.



Appendix 5 Figure 9. Equilibrium yield per recruit (Ye) and spawning stock biomass per recruit (Se) based on a Beverton-Holt model (estimated from autumn 1963-1977 data) with estimates of Bmsy and Fmsy

Research Communications Unit
Northeast Fisheries Science Center
National Marine Fisheries Service, NOAA
166 Water St.
Woods Hole, MA 02543-1026

STANDARD MAIL A

Publications and Reports of the Northeast Fisheries Science Center

The mission of NOAA's National Marine Fisheries Service (NMFS) is "stewardship of living marine resources for the benefit of the nation through their science-based conservation and management and promotion of the health of their environment." As the research arm of the NMFS's Northeast Region, the Northeast Fisheries Science Center (NEFSC) supports the NMFS mission by "planning, developing, and managing multidisciplinary programs of basic and applied research to: 1) better understand the living marine resources (including marine mammals) of the Northwest Atlantic, and the environmental quality essential for their existence and continued productivity; and 2) describe and provide to management, industry, and the public, options for the utilization and conservation of living marine resources and maintenance of environmental quality which are consistent with national and regional goals and needs, and with international commitments." To assist itself in providing data, information, and advice to its constituents, the NEFSC issues publications and reports in three categories:

***NOAA Technical Memorandum NMFS-NE* Series**--This irregular series includes: data reports of long-term or large area studies; synthesis reports for major resources or habitats; annual reports of assessment or monitoring programs; documentary reports of oceanographic conditions or phenomena; manuals describing field and lab techniques; literature surveys of major resource or habitat topics; findings of task forces or working groups; summary reports of scientific or technical workshops; and indexed and/or annotated bibliographies. All issues receive internal scientific review and most issues receive technical and copy editing. Limited free copies are available from authors or the NEFSC. Issues are also available from the National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161.

***Northeast Fisheries Science Center Reference Document* Series**--This irregular series includes: data reports on field and lab observations or experiments; progress reports on continuing experiments, monitoring, and assessments; background papers for scientific or technical workshops; and simple bibliographies. Issues receive internal scientific review but no technical or copy editing. No subscriptions. Free distribution of single copies.

Information Report Series--These reports are issued in several series, including: *News Release, Fishermen's Report*, and *The Shark Tagger*. Content is timely, special-purpose data and/or information. Level of scientific review and technical and copy editing varies by series. All series available through free subscription except for *The Shark Tagger* which is available only to participants in the NMFS Cooperative Shark Tagging Program.

To obtain a copy of a technical memorandum or a reference document, or to subscribe to an information report, write: Research Communications Unit, Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543-1026. An annual list of NEFSC publications and reports is available upon request at the above address. Any use of trade names in any NEFSC publication or report does not imply endorsement.