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The 2001 Assessment of the Gulf of Maine Atlantic Cod Stock

by

Ralph K. Mayo, Eric M. Thunberg,
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A Report of the 33rd Northeast Regional Stock Assessment Workshop

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ABSTRACT

The status of the Gulf of Maine cod (*Gadus morhua*) stock is reviewed, and terminal year VPA estimates of 2000 fishing mortality and spawning stock biomass and the survivors in 2001 are presented. Precision estimates of the 2000 fishing mortality and spawning stock biomass estimates for Gulf of Maine cod are also provided. Short-term projections of 2002 catches and resulting 2003 spawning stock biomass at various levels of 2002 fishing mortality are also given. Long-term (25-yr) projections were conducted to evaluate relative trajectories of stock biomass and catch under various fishing mortality scenarios, and an age-structured production model was applied to estimate MSY-based reference points.

The 2001 assessment is based on several sources of information including: the age composition of USA commercial and recreational landings, commercial fishing vessel trip reports (VTR), Northeast Fisheries Science Center (NEFSC) sea sample data, MRFSS estimates of recreational harvest, NEFSC and Massachusetts Division of Marine Fisheries (DMF) spring and autumn research vessel survey data, and standardized USA commercial fishing effort data. This assessment updates the analyses presented in the 1998 assessment of the Gulf of Maine cod stock (NEFSC 1998, Mayo *et al.* 1998) as well as those prepared in 1999 and 2000 by the Northern Demersal Working Group (NEFSC 2000, 2001).

Total landings of Gulf of Maine cod equaled 4,156 metric tons (mt) in 1998, declined to 1,636 mt in 1999, and increased to 3,730 mt in 2000. The sharp decline in landings between 1998 and 1999 and the subsequent increase in 2000 likely reflects the imposition of very low trip limits during 1999 and the subsequent relaxation of these limits in early 2000. It is probable that the extent of discarding increased sharply in 1999 in response to these reduced trip limits.

Commercial landings per unit of standardized effort declined steadily between 1982 and 1987, increased during 1988-1990 but declined sharply in 1992 and remained low in 1993. Fishery-independent spring and autumn bottom trawl surveys conducted by the NEFSC have documented a steady decline in total stock biomass since the 1960s; the largest decreases occurred during the 1980s. Although the most recent indices suggest a slight increase, overall, the Gulf of Maine cod stock biomass remains low relative to the 1960s and 1970s. Except for the 1998 year class, recent recruitment has been well below average.

Total stock biomass (ages 1+) declined from a maximum of 41,900 mt in 1990 to 14,800 mt in 1998, but has since increased to 20,400 mt in 2000. Spawning stock biomass (SSB) declined from over 24,200 mt in 1990 to a low of 9,900 mt in 1998, but increased to 13,100 mt in 2000. Mean biomass for ages 1+ declined from a maximum of 42,700 mt in 1989 to 14,800 mt in 1997 and 1998, but increased sharply between 1999 and 2000 to 25,900 mt, due, in part, to the impact of the 1998 year class. B_{msy} is now estimated to be 90,300 mt (total stock biomass, ages 1+) with a corresponding F_{msy} of 0.23, (fully recruited, ages 4+). With respect to the age-structured MSY-based reference points, 2001 total stock biomass is slightly above 1/4 B_{msy} and 2000 F is over 3 times F_{msy}. Fully recruited fishing mortality appears to have declined slightly during 1998 - 2000 compared to pre-1998 fishing mortality rates, although F in 2000 (0.73) remained high relative to fully recruited F reference points ($F_{0.1}$ = 0.15; F_{msy} = 0.23; F_{max} = 0.27).

INTRODUCTION

Atlantic cod (*Gadus morhua*) in the Gulf of Maine region have been commercially exploited since the 17th century, and reliable landings statistics are available since 1893. Historically, the Gulf of Maine fishery can be separated into four periods (Figure 1): (1) an early era from 1893-1915 in which record-high landings (> 17,000 mt) in 1895 and 1906 were followed by about 10 years of sharply-reduced catches; (2) a later period from 1916-1940 in which annual landings were relatively stable, fluctuating between 5,000 and 11,500 mt, and averaging 8,300 mt per year; (3) a period from 1941-1963 when landings sharply increased (1945: 14,500 mt) and then rapidly decreased, reaching a record-low of 2,600 mt in 1957; and (4) the most recent period from 1964 onward during which Gulf of Maine landings have generally increased but have declined steadily since the early 1990s. Total landings doubled between 1964 and 1968, doubled again between 1968 and 1977, and averaged 12,200 mt per year during 1976-1985. Gulf of Maine cod landings subsequently increased, reaching 17,800 mt in 1991, the highest level since the early 1900s. Total landings declined sharply in 1992 to 10,891 mt, and have since decreased steadily to 1,636 mt in 1999 before increasing to 3,730 mt in 2000.

This report presents an updated and revised analytical assessment of the Gulf of Maine cod stock (NAFO Division 5Y) for the period 1982-2000 based on analyses of commercial, recreational and and research vessel survey data through 2000. From the early 1960s through 1993, information on the catch quantity by market category was derived from reports of landings transactions submitted voluntarily by processors and dealers. More detailed data on fishing effort and location of fishing activity were obtained for a subset of trips from personal interviews of fishing captains conducted by port agents in the major ports of the Northeast. Information acquired during the course of these interviews was used to augment the total catch information obtained from the dealer. Procedures for collecting and processing commercial fishery data in the Northeast were revised after 1993.

Beginning in 1994, data on number of hauls, average haul time, and catch locale were obtained from logbooks submitted to National Marine Fisheries Service (NMFS) by operators fishing for groundfish in the Northeast under a mandatory reporting program. Estimates of total catch by species and market category were derived from mandatory dealer reports submitted on a trip basis to NMFS. Catches (landed and discarded portions) by market category were allocated to stock based on a matched subset of trips between the dealer and logbook databases. Data in both databases were stratified by calendar quarter, port group, and gear group to form a pool of observations from which proportions of catch by stock could be allocated to market category within the matched subset. The cross-products of the market category by stock proportions derived from the matched subset were employed to compute the total catch by stock, market category, calendar quarter, port group, and gear group in the full dealer database. A full description of the proration methodology and an evaluation of the 1994-1996 logbook data is given in Wigley *et al.* (1998) and DeLong *et al.* (MS 1997).

An initial analytical assessment of this stock was presented at the Seventh NEFC Stock Assessment Workshop in November 1988 (NEFC 1989) and subsequent assessments were reviewed at the 12th, 15th, 19th, 24th and 27th Northeast Regional Stock Assessment Workshops in June 1991, December

1992, December 1994, June 1997 and June 1998 (NEFSC 1991, 1993, 1995, 1997, 1998; Mayo 1995, 1998; Mayo *et al.* 1993, 1998). Interim assessments were reviewed by the Northern Demersal Working Group in July 1999 (NEFSC 2000) and August 2000 (NEFSC 2001a). The present assessment was reviewed at the 33rd Northeast Regional Stock Assessment Workshop in June 2001 (NEFSC 2001b).

THE FISHERY

Management History

Fishing for Gulf of Maine cod had been managed under international treaty prior to 1977 and by domestic management authority since 1977 (Table 1). Annual Total Allowable Catches (TACs) were first established under the International Commission for the Northwest Atlantic Fisheries (ICNAF) for Division 5Y (i.e., the Gulf of Maine) cod in 1973. The TAC remained at 10,000 mt from 1973-1975; the 1976 TAC was reduced to 8,000 mt and the TAC proposed for 1977 was reduced further to 5,000 mt.

Following implementation of the Magnuson Fishery Conservation and Management Act (FCMA) in 1977, management of this stock fell under the auspices of the New England Fishery Management Council. TACs were carried forward for the first few years under the Fishery Management Plan for Atlantic Groundfish, and were distributed among vessel tonnage classes and quarters of the years until 1982 when the "Interim" Plan for Atlantic groundfish was implemented. This plan eliminated all direct catch controls (quotas) and established mesh size and minimum landing size regulations as the primary regulatory measures for cod, haddock and yellowtail flounder.

Management of the Gulf of Maine cod fishery has been carried out since 1985 under the Northeast Multi-species Fishery Management Plan (FMP). This plan and its Amendments 1 through 4 essentially carried forward the regulatory measures originally implemented in 1982 under the "Interim" Plan. Beginning in 1994, with the implementation of Amendment 5, the primary goal of the FMP became a reduction in fishing mortality for 5 key monitoring stocks. This was to be achieved through a combination of reductions in days at sea (DAS) usage and, under Amendment 7, an additional series of seasonal and year-round area closures oriented primarily towards Gulf of Maine stocks.

Commercial Fishery Landings

Annual commercial landings data for Gulf of Maine cod in years prior to 1994 were obtained from trip-level detailed landings records contained in master data files maintained by the Northeast Fisheries Science Center, Woods Hole, Massachusetts (1963-1993) and from summary reports of the Bureau of Commercial Fisheries and its predecessor the U.S. Fish Commission (1895-1962). Beginning in 1994, landings estimates were derived from dealer reports prorated to stock based on the distribution of reported landed catch contained in fishing vessel logbooks as described above.

Total commercial landings in 2000 were 3,730 mt, approximately 130% greater than in 1999 but

10% less than in 1998 (Table 2, Figure 1). Since 1977, the USA fishery has accounted for all of the commercial catch. Canadian landings reported as Gulf of Maine catch during 1977-1990 are believed by Canadian scientists to be misreported catches from the Scotian Shelf stock (Campana and Simon 1985; Campana and Hamel 1990). Although otter trawl catches account for most of the landings (54% by weight in 2000), the otter trawl percentage has declined considerably compared to the period prior to 1993. Most of this change can be attributed to an increase in the percentage of cod taken by sink gillnets since 1993, although the percentage from combined handline and line trawls also increased substantially during the 1990s (Table 3).

Commercial Fishery Discards

Discard rates have been routinely calculated for Gulf of Maine cod by quarter and gear from NEFSC sea sampling data collected since 1989 (Table 4). Discard and kept components of the catch were summed for all observed tows, within each gear type, occurring in Division 5Y, and the ratio of the discarded- to-kept quantity was applied to landings for the corresponding quarter and gear type within each year. Data were available for otter trawls, shrimp trawls, and sink gillnets.

For otter trawl gear, discard-to-kept ratios (D/K) and absolute quantities of discarded cod declined from relatively high values in 1989 and 1990 to relatively low levels from 1991 through1998 as D/K ratios generally fluctuated between 0.002 and 0.155. In the shrimp trawl fishery, D/K ratios remained high throughout 1989-1991, but declined substantially in 1992 and remained negligible in 1993. Sea sampling data for 1994-2000 were minimal; therefore, landings by this gear component were not distinguished from all other otter trawls in the proration scheme employed to derive the landings by stock for the present assessment. Consequently, discard estimates from both otter trawl and shrimp trawl gear were combined for the 1994-2000 period. D/K ratios from the sink gill net fishery remained relatively low between 1989 and 1998, generally in the range of 0.05 or so. In 1999, discard ratios increased sharply for otter trawl and sink gill nets during the second and third quarters, declined from these peak levels in the fourth quarter, but continued to remain relatively high through all of 2000 compared to pre-1999 ratios.

Discards of Gulf of Maine cod ranged from 139 mt in 1998 to 3,598 mt in 1990 (Table 4). Discards exceeded 1,000 mt in each year between 1989 and 1991 before declining steadily since 1992. The relatively high discard rates calculated for otter trawl and shrimp trawl gear during 1989-1991 coincide with recruitment of the strong 1987 year class to the small mesh shrimp trawl gear and then the large mesh general otter trawl gear. Available length composition data for these gear types suggest that most of the discarded cod were about 30-50 cm with a mode around 40 cm. Discards emanating from these two gears are the likely result of minimum size regulations. In contrast, the relatively low, but persistent, discards of cod in the gillnet fishery comprised fish of all lengths, up to 125 cm. The larger size range reflects discarding resulting from minimum size regulations as well as poor fish quality (in the case of the larger, marketable cod). Discards in 1999 were estimated to be 2,630 mt, one of the highest in the data series, due to the imposition of low trip limits. Estimated discards declined to 1,170 mt in 2000 as trip limits were relaxed to 400 lbs/day in early 2000.
To further evaluate discarding in 1999 and 2000 when low trip limits were imposed, all available vessel trip report (VTR) records were examined from trips fishing in the Gulf of Maine and

reporting some catch of cod. All trips from vessels which never reported any discard were excluded from the discard analyses. The VTR data were treated in the same manner as the sea sample data except that the discard-to-kept ratios and subsequent estimates of absolute discard were derived on a monthly basis rather than a quarterly basis. This increased temporal resolution, available due to the greater quantity of VTR records, afforded a means of comparing the seasonal progression of discarding with the evolution of trip limits in 1999 and 2000. Analysis of the VTR data (Figure 2) generally confirms the seasonal patterns as well as the magnitude of the discard estimates derived from the sea sample data in 1999 and 2000 (Appendix 1: Figures 1-3). The estimated total discards of Gulf of Maine cod derived from the monthly VTR discard-to-kept ratios equaled 2,822 mt in 1999 (Table 5a) and 2,246 mt in 2000 (Table 5b).

A third approach to estimating the magnitude of 1999 and 2000 discards of Gulf of Maine cod was based on a predictive model by imposing 1999 and 2000 trip limits on 1996 and 1997 VTR data at the appropriate times of the year. Given the manner in which fishery conditions change from year to year (number of trips taken and catch rates) as well as regulatory changes over time, the primary objective was to estimate a discard-to-kept ratio rather than a direct estimate of discards. The resulting discard-to-kept ratios were then applied to observed 1999 and 2000 calendar year Gulf of Maine cod landings to provide an estimate of total discards in those years.

The predictive model incorporated information about total trip income and fishing costs, including operating costs and payments to labor, to determine which trips may no longer be profitable as a result of the trip limit. Trips that were no longer profitable were assumed to be abandoned while the remaining trips were assumed to occur while incurring discards of all cod in excess of the trip limit. That is, if the cod value ($P_{cod}*Q_{cod}$) plus income earned from all component catch ($\Sigma PiQi$) exceeds the cost of paying crew (C_{crew}) plus operating the vessel ($C_{operating}$):

$$(P_{cod} * Q_{cod} + \sum_{i} P_i Q_i) - (C_{crew} + C_{operating}) > 0 \quad (1)$$

the trip was assumed to be taken as observed. Otherwise the trip was assumed to be abandoned. Given that prices and landings are generally known, the economic relationship described in (1) will be sensitive to assumptions about crew and operating costs. Estimated operating costs for principal gear types (otter trawl, gillnet, and hook) were based on cost surveys (Georgianna and Cass 1998, Lallemand *et al.* 1998, Lallemand *et al.* 1999). Since payments to crew are based on a share system, crew income will be affected by trip limits. Thus, some minimum return to crew was assumed to be required to enable a vessel to make a trip.

The minimum crew payment was estimated using two different methods; a minimum share and a minimum payment. The minimum share method is consistent with the manner in which crew are remunerated which reflects some risk sharing between the crew and owner but could result in unrealistically low residual payments to labor. By contrast, the minimum payment approach provides an income floor below which the vessel owner may be assumed to be unable to recruit crew because they could earn more income by taking a job elsewhere. This income floor was assumed to be equal to the average wage rate for blue-collar occupations in New England ($13 per hour).

Three sensitivity trials were used for the minimum share (50%, 25%, and 10%) and one minimum payment trial ($13 per hour x 8 hours or $104 per crew per day) was conducted to test the sensitivity of the discard-to-kept ratios to crew payment assumptions.

The predictive model was applied to VTR records for calendar years 1996 and 1997 to infer what landings and discards would have been had the trip limits been implemented in those calendar years. Since these data come from observed trips the trip limit model provides an estimate of landings and total discards (discards due to the trip limit plus recorded VTR discards for other reasons). The 1996 and 1997 calendar years were selected for analysis because they represent a time period over which the Gulf of Maine cod fishery was least affected by trip limits (there were no trip limits in 1996 and the trip limits for 1997 were not binding on most occasions). By contrast, the 1998 trip limits, as well as the rolling closures, make use of data from that calendar year problematic.

The trip limit model was run separately for each of the 1996 and 1997 calendar year data and the four different sensitivity runs yielding 8 estimates for each of the 1999 and 2000 discard-to-keep ratios (Table 6a). Note that as the assumed payment necessary to attract labor to the fishery declines, formerly marginal trips become profitable resulting in higher estimated landings and discarding hence the increasing discard-to-kept ratios. Overall, the minimum payment trial results in an intermediate discard-to-kept estimate. The estimated Gulf of Maine cod discard-to-kept ratios ranged from 1.80 to 2.47 with a median value of 2.15 for calendar year 1999. Due to higher trip limits, the discard-to-kept ratios ranged between 0.72 and 0.99 with a median value of 0.83 for calendar year 2000. Applying the estimated discard-to-kept ratios to the observed landings results in a median estimate of 3,524 metric tons of discards of Gulf of Maine cod in 1999. Similarly, the median estimate of calendar year 2000 Gulf of Maine cod discards was 3,081 metric tons (Table 6b).

The estimates of discard of Gulf of Maine cod derived by each of the 3 methods are reasonably close to each other, within the range of 2,600-3,500 mt for 1999 and 1,200-3,100 mt for 2000. Each method has advantages and limitations. The sea sample data are less subjective since they are based on consistent interpretation by a small group of individuals. But these data are rather sparse, leading to considerable imprecision. The 1999 VTR data provide considerably more observations, which may increase precision, but these data may have been influenced by possible reporting bias in response to severe management actions in 1999. The third method uses VTR data from years prior to the imposition of severe trip limits, and presumably is less affected by reporting bias. However, this method relies on several assumptions regarding constancy of effort and catch rates.

While there is, at present, no objective basis to select one method over any other, all 3 suggest that minimum estimates of total discards were in the range of approximately 2,500 mt in 1999 and 1,000 mt in 2000. When these discards are added to the reported landings, the resulting total commercial catch is estimated to be 4,136 mt in 1999 (1,636 mt + 2,500 mt) and 4,730 mt in 2000 (3,730 mt + 1,000 mt). These results provide expansion factors of 2.53 in 1999 (4,136 mt/1,636 mt) and 1.27 in 2000 (4,730 mt/3,730 mt) to convert commercial landings to commercial catch.

Commercial Fishery Sampling Intensity

A summary of USA length frequency and age sampling of Gulf of Maine cod landings during 1982-2000 is presented in Table 7. USA length frequency sampling averaged one sample per 155-200 mt landed during 1983-1987 but the sampling intensity was reduced in 1990 (1 sample per 387 mt) and 1993 (1 sample per 360 mt), and the absolute level of sampling was extremely low in 1993. Overall sampling improved slightly in 1994 and 1995, but the seasonal distribution was uneven and poorly matched to the landings. Sampling improved substantially in 1996 and remained equally high in 1997, reaching all-time highs in terms of both absolute number of samples and samples per ton landed in both years.

Most of the USA samples have been taken from otter trawl landings, but sampling and the estimation of length composition is stratified by market category (scrod, market, and large). Although the length composition of cod differs among gear types (primarily between otter trawl and gillnet), the length composition of cod landings within each market category is virtually identical among gear types.

Beginning in 1998, the quality of commercial port sampling for Gulf of Maine cod has declined considerably. The total number of samples taken declined sharply in 1998 and again in 1999, a possible outcome of the very low trip limits imposed in 1999. Although the number of samples collected increased in 2000, the distribution by market category has been out of phase with actual landings. In particular, the number of 'Large' market category cod samples has diminished to the point that the representation of the older age groups may be somewhat compromised in recent years.

Of the 61 samples collected in 2000, 24 were scrod samples (39%), 36 were market (59%), and 1 was large (2%). Compared with the 2000 market category landings distribution by weight (scrod: 9%; market: 59%; large: 30%) (Table 8), sampling in 2000 over-represented the scrod category and severely under-represented the large category.

As well, the seasonal distribution of samples has become skewed such that, although there appears to have been sufficient numbers of samples taken, there has been insufficient sampling in some quarters and half-years, requiring pooling of samples on an annual basis. This approach was necessary in 1999 and 2000.

Commercial Landings Age Composition

The age composition of landings during 1982-1993 was estimated, by market category, from monthly length frequency and age samples, pooled by calendar quarter. Quarterly mean weights, by market category, were obtained by applying the NEFSC research vessel survey length-weight equation for cod:

$$ln\ Weight_{(kg,live)} = -11.7231 + 3.0521\ ln\ Length_{(cm)}$$

to the quarterly market category sample length frequencies. Computed mean weights were then

divided into quarterly market category landed weight to derive estimated numbers landed by quarter, by market category. Quarterly age/length keys were applied to the quarterly market category numbers at length distributions to provide numbers at age. These results were summed over market categories and quarters to derive the annual landings-at-age matrix (Table 9a).

Age composition of landings from 1994 through 2000 was estimated in a manner similar to that employed for the 1982-1993 estimates except that samples and landings were, at times, pooled to semi-annual or annual resolution because of the uneven distribution of length and age samples by quarter (Table 7). Semi-annual pooling was required for the 1st and 2nd quarters of 1994 because of incomplete sampling coverage of scrod and large cod landings; in 1995, samples were pooled in both semi-annual periods due to the absence of large cod samples and the sparse coverage of market cod in quarters 1 and 3. Quarterly allocation of samples to landings was achieved for all market categories in 1996 and 1997, but semi-annual and annual pooling was required in 1998 and annual pooling was required in 1999 and 2000.

Biological sampling in 2000 was especially problematic for 'Large' category cod. As only one sample was taken throughout the year, the entire representation of older age groups depended on this sample with a maximum length at just over 100 cm. To achieve greater representation of larger fish, the 'Large' category commercial port sample was augmented with length measurements of > 100 cm cod obtained from Gulf of Maine sea sample trips. The resulting 2000 age compositions obtained from the original and the augmented length data are presented in Tables 9a and 10a. It was the consensus of the SARC that the 2000 age composition based on the original port sample data be used for further analyses.

Gulf of Maine cod landings have been generally dominated by age 3 and 4 fish in numbers and by ages 3, 4, and 5 in weight. Cod from the strong 1987 year class predominated from 1990 through 1992 but, by 1993, fish from the 1990 year class accounted for the greatest proportion of the total number landed. In terms of weight, the 1993 landings were equally distributed between the 1987 and 1990 year classes. In 1993 these two year classes accounted for approximately 70% of the total number and weight landed. From 1994 through 1996, landings were dominated by age 4 cod in both number and weight. In 1997 age 5 fish were dominant in terms of both number and weight, reflecting the higher abundance of the 1992 year class. Although traditionally low in terms of their contribution to the total landings, age 10 and 11+ fish were completely absent in 1993 and 1996, and numbers of age 8 and 9 fish have also been unusually low (Table 9a). Although this pattern may be partly a result of the poor sampling of 'Large' category cod, especially in recent years, a trend towards fewer older fish in the landings has been apparent since 1991. As well, the contribution of age 2 fish to the landings has decreased in recent years.

Adjustment of the 1999 and 2000 Commercial Landings at Age

The fishery for Gulf of Maine cod was affected by management actions which occurred in 1999 and have continued into 2000. Primarily, the imposition of extremely low trip limits in 1999 are likely to have precipitated a substantial increase in the amount of cod discarded compared to previous years, as noted above. Consequently, the 1999 and 2000 estimated commercial landings at age

presented in Tables 9 and 10 do not reflect the full extent of removals from the stock by the fishery. Therefore, prior to inclusion in the VPA, the 1999 and 2000 landings estimates must be adjusted upwards at each age by the ratio of total estimated catch biomass (landings+discard) to the landed catch biomass.

This approach assumes that the age composition of the discarded component of the catch is the same as the landed component. In most discarding cases, where discards generally occur in response to mesh selectivity which is out of phase with minimum landing size regulations, it is necessary to estimate the size and age composition of the discarded component separate from the landed component. In general, the discards comprise the smaller, younger fish compared to those that are landed. However, in this case , where regulatory discards were generated as a result of extremely low trip limits, it is presumed that cod of all sizes and ages were discarded without prejudice. An examination of the 1998, 1999 and 2000 kept and discarded length composition samples from the NEFSC Sea Sample database supports this assumption. The sizes of discarded cod in 1998, when trip limits were considerably higher, were primarily below the 48 cm minimum landing size and the sizes of retained cod were approximately the same as those observed in the commercial port samples. In 1999 and 2000, however, the sizes of discarded and retained cod were generally the same, well above the minimum landing size and similar to those observed in the 1999 commercial port samples. Therefore the 1999 and 2000 commercial landings at age estimates from Table 10 were multiplied by discard adjustment factors of 2.53 and 1.27, respectively, before inclusion in the VPA catch at age matrix (see page 5).

Commercial Landings Mean Weights at Age

Mean weights at age in the catch for ages 1-11+ during 1982-2000 are given in Table 9b and, based on landings patterns, are considered mid-year values. Mean weights of age 2 and 3 cod have risen since about 1992, reflecting decreased partial recruitment of younger fish to the fishery, while those for intermediate aged fish have fluctuated without any particular trend. Mean weights for ages 9 and older fluctuate considerably and are particularly sensitive to sampling variability. Thus, it is unlikely that the apparent increases in mean weight at age for ages 10 and 11+ since the late 1980s would indicate a shift in growth or an increase in older fish in the plus group.

In 1990, mean weights at age for ages 2 and 4 were the lowest in the 9-year time series, while mean weights for ages 6, 7, and 9 were among the highest. These changes, however, may be artifacts of low sampling levels in 1990. Mean weights at ages 8 and 9 in 1993 and at ages 5 and 6 in 1995 were the highest in the series, but these anomalies are also the likely result of poor sampling. However, the generally higher mean weights at ages 2 through 4 since 1996 may be related to the required use of 152 mm (6 in.) mesh in the otter trawl fishery. Catch at age and recalculated mean weights at age for the 7+ group which are used in the VPA are given in Tables 10a and 10b.

Recreational Fishery Catches

Estimates of the recreational cod catch were derived from the Marine Recreational Fishery Statistics Survey (MRFSS) conducted annually since 1979. The Gulf of Maine cod catch was estimated assuming that catches of cod recorded by that portion of the intercept survey were removed from the ocean in statistical areas adjacent to the state or county of landing. The MRFSS database has been recently revised, resulting in adjusted catch estimates for the years 1981 through 1997. Estimates of the total Gulf of Maine cod recreational catch as well as the portion of the catch excluding those caught and released through 2000 are provided in Table 11. Information on the catch prior to 1981, which has not been revised, is included in Table 11 to provide a longer-term perspective. Further information on the details of the allocation scheme and sampling intensity are given in NEFSC (1992).

The quantity of cod retained generally exceeded 75% of the total recreational catch from 1979 through 1991, but has averaged less than 50% since 1993. The estimated total cod catch (including those caught and released) declined from over 5,000 mt in 1980 and 1981 to less than 2,000 mt between 1983 and 1986, increased to over 3,500 mt in 1990 and 1991, then fluctuated between 1,100 and 2,600 mt between 1992 and 1996 before declining sharply to 671 mt in 1997. The total catch has since increased to 2,853 mt in 2000 of which 1,147 mt was retained. The proportion of the total landings (commercial and recreational) taken by the recreational sector increased to 34 and 24 percent in 1999 and 2000, respectively. The reported total catch and retained cod from party/charter vessel VTR reports is also provided in Table 11 since 1995.

Recreational Fishery Sampling Intensity

Information on the length frequency sampling levels of Gulf of Maine cod taken in the recreational fishery is provided in Table 11. An examination of the available length frequency sampling coverage was conducted to evaluate the potential utility of these data in estimating the overall length composition of the recreational removals from the stock. Overall, sampling for cod taken by recreational gear is poor, averaging less than 1 sample per 1,000 mt removed (Table 11). Sampling of the recreational fishery improved in 1994-1996, but has been relatively low in recent years. The age composition of the 1982-1996 recreational landings was derived for the 1997 assessment (Mayo 1998) but, given the highly variable sampling, these data were not formally included in the VPA conducted in 1997 (NEFSC 1997; Mayo 1998). However, given the recent increase in the proportion of the total landings accounted by the retained recreational catch, the 1997-2000 age composition of the recreational landings was estimated for the current assessment and the 1982-2000 estimates were incorporated into the total catch at age.

Recreational Fishery Landings Age Composition

Given the limited sampling coverage in this sector of the fishery, estimation of numbers caught by length and age required that samples be pooled on an annual basis. The low inter-seasonal variability displayed by the sample length composition data supports this approach. Differences between the party/charter and private/rental fishing modes are also minimal. Therefore, estimates

of the age composition of cod retained by the recreational sector were derived from the length composition data applied to the retained numbers of cod based on pooled annual length frequency samples from Gulf of Maine trips. Only the retained numbers of cod were included because the intercept sampling may not accurately reflect the size composition of the released cod. Age-length keys obtained from sampling the commercial landings, augmented by age samples from NEFSC bottom trawl surveys for cod less than 40 cm, were applied to the numbers retained at length on an annual basis to derive the numbers retained at age (Table 12a).

During the 1980s, Gulf of Maine cod recreational landings in numbers were dominated by age 3 fish with age 2 fish next in importance. Following the increases in minimum retention size in 1989 and again in 1996, the proportion of age 2 cod declined, and the age composition of the landings from this sector now resembles that from the commercial fishery with ages 3, 4 and 5 predominant (Tables 10a and 12a). The strong 1987 year class dominated the recreational catch in 1990, 1991 and 1992, and the 1992 year class can also be tracked in the estimated catch at age between 1995 and 1999. Ages 3 and 4 cod generally predominate in terms of weight caught, although the 1987 and 1992 year classes predominated at age 5 in 1992 and 1997, respectively.

Recreational Landings Mean Weights at Age

Mean weights at age were obtained by applying the NEFSC research vessel survey length-weight equation for cod to the numbers retained at age on an annual basis:

$$ln\ Weight_{(kg,live)} = -11.7231 + 3.0521\ ln\ Length_{(cm)}$$

Mean lengths and weights at age of cod landed by the recreational sector (Table 12b) are consistently lower than those taken in the commercial fishery. This pattern persists through age 5, but for ages 6 and older, mean weights are highly variable due to the relatively poor sampling of fish at the larger sizes combined with the lack of market category stratification. Despite this variability, patterns present in the commercial landings mean weights are also evident in the recreational landings, e.g., low mean weights in 1990 and higher mean weights at age 2 in 1995 and 1996.

Total Landings Age Composition

Estimates of the age composition of total cod landings (Table 13a) were derived by combining the separate age composition estimates obtained for the commercial (Table 10a) and recreational sectors (Table 12a). Given the general similarities between the age compositions estimated for the commercial and recreational sectors, the total age composition reflects the same dominant year classes and age structure over time. In general, ages 3, 4 and 5 have predominated; the 1987 year class dominated the total landings in 1990, 1991 and 1992, and the 1992 year class can also be tracked between 1995 and 1999.

Total Landings Mean Weights at Age

Mean lengths and weights at age of cod landed by the combined commercial and recreational sectors (Table 13b) are intermediate to those obtained from the individual sectors. Mean weights at age are highly variable for the older ages due to the relatively poor sampling of fish at the larger sizes. Mean weights at age for calculating stock biomass at the beginning of the year are provided in Table 14. These values were derived from the landings mean weight at age data (Tables 9b and 13b) using procedures described by Rivard (1982).

STOCK ABUNDANCE and BIOMASS INDICES

Commercial Catch Rates

Trends in commercial landings per unit effort (LPUE) and fishing effort for the period 1965-1993 and 1994-1996 have been recently reported by Mayo (1998). Given the uncertainty in reported fishing effort since 1994, the 1994-1997 LPUE data were not formally included in the VPA conducted in 1998 (NEFSC 1998; Mayo *et al*.1998). Recent management actions, including imposition of trip limits and rolling closures also make interpretation of 1997-2000 LPUE inconsistent with previous years. Until effort units are resolved in the commercial fishery database, no further treatment of the LPUE series after 1993 will be performed. Trends in commercial LPUE through 1996 are illustrated in Figure 3.

The 1982-1993 age composition of the landings corresponding to the effort sub-fleet as presented by Mayo *et al.* (1994) was used with the updated standardized effort estimates to calculate a revised LPUE-at-age index. Numbers landed at age were estimated by applying quarterly commercial age-length keys to quarterly commercial numbers landed at length by market category. The LPUE-at-age indices were derived by dividing the estimated numbers landed at age by corresponding 1982 through 1993 standardized fishing effort. Further details regarding data selection, preparation and estimation procedures are provided in Mayo *et al.* (1994).

Research Vessel Survey Indices

Indices of cod abundance (stratified mean catch per tow in numbers) and biomass (stratified mean weight per tow in kilograms), developed from NEFSC and Commonwealth of Massachusetts Division of Marine Fisheries (MADMF) research vessel bottom trawl survey data, have been used to monitor changes and assess trends in population size and recruitment of cod populations off New England. Offshore (> 27 m) stratified random NEFSC surveys have been conducted annually in the Gulf of Maine in autumn since 1963 and in spring since 1968. Inshore areas of the Gulf of Maine (< 27 m) have been sampled during spring and autumn NEFSC and MADMF inshore bottom trawl surveys since 1978. For the NEFSC surveys, a "36 Yankee" trawl has been the standard sampling gear except during spring 1973-1981 when a modified "41 Yankee" trawl was used.

Prior to 1985, BMV oval doors (550 kg) were used in all NEFSC surveys; since 1985, Portuguese polyvalent doors (450 kg) have been used. Details on NEFSC survey sampling design and procedures are provided in Azarovitz (1981) and Clark (1981). The MADMF inshore bottom trawl sampling program is described in Howe *et al*. (1981). No adjustments in the survey catch-per-tow data for cod have been made for any of the trawl differences, but vessel and door coefficients have been applied to adjust the stratified means (number and weight per tow) as described in Table 15. Standardized catch-per-tow-at-age (number) indices are listed in Appendix 2: Table 2 and catch-per-tow-at-age indices from DMF spring and autumn surveys are listed in Appendix 2: Table 3.

NEFSC spring and autumn offshore catch per tow indices for Gulf of Maine cod have generally exhibited similar trends throughout the survey time series (Table 15, Figure 4). Number-per-tow indices declined during the mid- and late 1960s, but since 1972-1973 have fluctuated as a result of a series of recruitment pulses. Sharp increases in the number per tow indices reflect above-average recruitment of the 1971, 1973, 1977-1980, 1983, and 1985-1987 year classes at ages 1 and 2 (Appendix 2: Table 2, Figure 5). The sequential dominance of these cohorts at older ages can be discerned from number-per-tow-at-age values in both spring and autumn NEFSC surveys (Appendix 2: Table 2). The recent increases in the autumn 1994-1995 and spring 1996-1997 biomass indices may be attributed to somatic growth of fish from the 1992 year class which was the largest within the recent series of poor year classes.

Spring NEFSC number-per-tow indices have remained relatively low since 1985, below the 1981-1984 average (Table 15); spring weight-per-tow indices have also remained relatively low through 1991, but the index increased substantially in 1992, and remained relatively high in 1993, due to a large contribution from the 1987 year class (Appendix 2: Table 2). The index declined markedly in 1994, remained low in 1995, increased moderately in 1996 and remained essentially unchanged in 1997. Spring weight-per-tow indices have since declined through 2000 (Figure 4).

Autumn number- and weight-per-tow indices declined sharply in 1991 to unprecedented lows; weight-per-tow indices continued to decline to record low levels through 1993 and remained extremely low through 1998 (Figure 4), but increases were evident in 1999 and 2000. The increased abundance in 1988 and 1989, resulting from recruitment of the 1986 and 1987 year classes, became depleted by 1991, resulting in the sharp declines in the overall index. This reduction, combined with a general paucity of large fish in the surveys in recent years (Appendix 2: Table 2), resulted in the decline in the weight-per-tow indices after 1991. The recent increase in the autumn abundance and biomass indices in 1994 and 1995 reflected recruitment of the 1992 year class, but these indices had already begun to decline by 1996. Although the autumn biomass indices increased in 1999 and 2000, they still remain relatively low compared to earlier periods (Figure 4).

Overall, the 1987 year class appears to have been one of the strongest ever produced; catch-per-tow indices for this cohort at ages 1-3 in the NEFSC autumn surveys and at ages 0 and 1 in the MADMF autumn inshore surveys were nearly all record-high values (Appendix 2: Tables 2 and 3). Based on MADMF and NEFSC survey catch per tow indices, the 1992 and 1998 year classes appear to have been of moderate strength; the intervening year classes of Gulf of Maine cod, particularly the 1993, 1994, 1995, and 1996 year classes have been well below average (Figures 5 and 6).

Inshore/Offshore Biomass Comparisons

To examine changes in the distribution of cod biomass in the Gulf of Maine, the NEFSC autumn survey data were partitioned into an inshore strata set (strata: 26 and 27; area: 1,734 square miles) and an offshore strata set (strata: 28-30, 36-40; area: 16,158 square miles). The inshore strata set approximates the area in the vicinity of Massachusetts Bay up to Jeffreys Ledge which represents the core area where cod presently occur in greatest concentrations. When two or more strata sets of unequal area are compared in this manner, the stratified mean catch per tow indices must be considered to represent the density of fish (index of number per unit area) rather than actual abundance or biomass (index of population size).

To compare trends in actual abundance and biomass between regions, the indices must be weighted by the area of each strata set. This provides an index of population size within each strata set which can be directly compared on the same basiS by taking account of the area of the two regions (in this case, the inshore and offshore strata sets). Trends in the autumn NEFSC survey stratified mean weight-per-tow indices are illustrated in Figure 7 for each region and for the combined strata set (as in Figure 4). Stratified mean biomass indices from the inshore Gulf of Maine are considerably higher (generally between 20 and 60 kg/tow) than those for the offshore region (generally less than 20 kg/tow), simply indicating greater densities of cod in the two inshore strata. When area is taken into account, an opposite pattern is evident (Figure 8).

When compared in this manner, it is more readily apparent that, while biomass has declined since the 1960s and 1970s in both the inshore and the offshore regions of the Gulf of Maine, the decline has been most severe in the offshore region. This trend is also evident when trends in the proportion of total biomass from each region are compared (Figure 9). During the 1960s and 1970s, between 70 and 80 percent of the cod biomass in the Gulf of Maine was distributed in the offshore region. The offshore proportion began to decline during the early 1980s, culminating in an approximately 50:50 split during the 1990s. Since then, the proportion of cod in the offshore region appears to have increased slightly.

Concentration Indices

The Lorenz curve is an econometrics method developed to study the distribution of income among individuals (Lorenz 1905, Dagum 1985). Thompson (1976) applied the Lorenz curve in a study of the distribution of fish caught by a population of fishermen (i.e., was it true that 90 percent of the fish were caught by 10 percent of the fishermen?). Myers and Cadigan (1995) applied this method to northern cod biomass off Newfoundland using 76 strata from a 12 year research survey time series. When the technique is applied to fish distributions, the Lorenz curve simultaneously takes into account biomass and area and puts them on a comparable basis. The Lorenz curve method used by Myers and Cadigan does not fully account for strata of unequal size. Since the NEFSC survey has a wide range of strata sizes, Wigley (1996) modified the method to account for strata of unequal size.

A Lorenz curve is calculated as follows: for a set of n strata, let x_i be the biomass and a_i be the area of stratum i, i=1,2...n, ranked by mean weight per tow. The Lorenz curve is the polygon joining the points (A_h/A_n, L_h/L_n), h=(0,1,2 ... n) where $L_0 = 0$ and $L_h = \sum^h_{i=1} x_i$ is the total biomass in the h strata with the lowest biomass, and $A_0 = 0$ and $A_h = \sum^h_{i=1} a_i$ is the total area of the h strata with the lowest biomass. The x-axis of the Lorenz curve represents the cumulative percentage of area, while the y-axis depicts the cumulative percentage of biomass. If fish are evenly distributed among strata the Lorenz curve would be an identity function. If fish are unevenly distributed (i.e., concentrated) the Lorenz curve bows downward and to the right . The concentration index is derived by doubling the area between the identity function and the Lorenz curve (Dagum 1985).

The Lorenz curve method was applied to NEFSC research vessel survey data to examined the distribution of cod biomass as estimated from NEFSC autumn bottom trawl surveys in the Gulf of Maine region over a 38 year period. Lorenz curves were calculated for each NEFSC autumn bottom trawl survey between 1963 and 2000. The strata set used corresponded to that used in the stock assessment, strata 26-30, 36-40. Biomass values used in the analysis were estimates of minimum swept area biomass (kg) calculated for each stratum in each year. Cod biomass values were adjusted for differences in fishing power of the *Albatross IV* and the *Delaware II*, and for differences in the catchability of BMV doors and the polyvalent doors introduced to the survey in 1985.

Annual Lorenz curve plots (Figure 10) indicate that cod distribution in the Gulf of Maine became increasingly more evenly distributed between 1963 and the early 1980's, as indicated by the general declining trend in the concentration indices (Figure 11). However, in the second half of the time series, the concentration indices generally increase, indicating that cod biomass has become more concentrated in recent years. The 1982 concentration index is highly influenced by a one tow of cod in stratum 26.

Overall, patterns in cod distribution and concentration are consistent with the notion that, in recent years, the Gulf of Maine cod population has been primarily distributed in the inner, western regions of the Gulf of Maine. Thus, a higher proportion of the stock is now found within a relatively small area compared to earlier periods. This contraction in the overall distribution of the stock may have implications on catchability in the fishery.

MORTALITY

Total Mortality Estimates

Pooled estimates of instantaneous total mortality (Z) were calculated for 7 time periods encompassed by the NEFSC spring and autumn offshore surveys: 1964-1967, 1968-1976, 1977-1982, 1983-1987, 1988-1992, 1993-1997, and 1998-1999 (Table 16). Total mortality was calculated from NEFSC survey catch per tow at age data (Appendix 2: Table 2) for fully recruited age groups (ages 4+) by the $\log_e$ ratio of the pooled age 3+/age 4+ indices in the autumn surveys, and the pooled age 4+/age 5+ indices in the spring surveys. For example, the 1983-1987 values were derived from:

Spring: ln (Σ age 4+ for 1983-87/ Σ age 5+ for 1984-88)
Autumn: ln (Σ age 3+ for 1982-86/ Σ age 4+ for 1983-87)

Different age groups were used in the spring and autumn analyses so that Z could be evaluated over the same year classes within each time period.

Values of Z derived from the spring surveys are generally comparable to those calculated from the autumn data. Rather than selecting one survey series over the other, total mortality was calculated by taking a geometric mean of the spring and autumn estimates in each time period. The pooled estimates indicate that total mortality was relatively low (Z <= 0.50) between 1964 and 1982, but increased significantly thereafter to approximately 1.0 during 1983-1997, with an indication of a slight decline after 1997.

Estimates of total mortality were also derived on an annual basis from the spring and autumn survey data (Figure 12). These values of Z exhibit considerable inter-annual variability due primarily to year effects in the surveys. When smoothed, however, the annual estimates suggest the same pattern of increasing mortality during the1980s as indicated by the pooled analysis presented in Table 16.

Natural Mortality

Instantaneous natural mortality (M) for Gulf of Maine cod is assumed to be 0.20, the conventional value of M used for all Northwest Atlantic cod stocks (Paloheimo and Koehler 1968, Pinhorn 1975, Minet 1978).

ESTIMATION of FISHING MORTALITY RATES and STOCK SIZE

Virtual Population Analysis Calibration

The ADAPT calibration method (Parrack 1986, Gavaris 1988, Conser and Powers 1990) was used to derive estimates of terminal fishing mortality (F) in 2000. As in previous assessments, age-disaggregated analyses were performed. Several comparative ADAPT calibrations were performed, each using the same NEFSC spring and autumn (ages 2-6) and MADMF spring (ages 2-4) and autumn (age 2) survey series. Due to uncertainty in the interpretation of effort units in the 1994-1997 VTR data, USA commercial LPUE abundance indices for ages 2-6 were included only through 1993. This change effectively removed the influence of the LPUE indices on the terminal year outcome of the calibration, while preserving the historic relationship employed in the previous assessment. As in the previous assessments (see Mayo *et al.* 1998), the USA commercial LPUE indices from 1982 through 1993 were derived from the catch at age corresponding to the effort sub-fleet used in the estimation of standardized fishing effort as described by Mayo *et al.* (1994). The NEFSC and MADMF autumn indices were lagged forward by one age and one year whereby age 1-6 indices were related to age 2-7 stock sizes in the subsequent year for corresponding cohorts. All NEFSC and MADMF indices were related to January 1 stock sizes, and USA commercial LPUE indices were related to mid-year stock sizes.

The 1982-2000 commercial landings at age as provided in Table 9a include true ages 2-10 as well as the 11+ group. In recent years, however, fish beyond age 7 have been poorly represented. As reported by Mayo (1995), a calibration run employing an extended age complement (true ages 2-9) produced high coefficients of variation (CV) on the terminal year stock size estimates and variable estimates of F on ages 7-9 in most years prior to the terminal year. Therefore, as in previous assessments of this stock (Mayo *et al.* 1993; Mayo 1995, Mayo 1998, Mayo *et al.* 1998, NEFSC 2000, NEFSC 2001), all VPA formulations employed a reduced age range (ages 2-6 and 7+).

Impact of 1999 and 2000 Discards

The VPA for the current assessment includes commercial landings from1982-2000 (Table10), commercial discards from 1999 and 2000, and recreational landings from 1982-2000 (Table12). The final catch at age used in the VPA is listed in Table 13, including the discard adjustment to the 1999 and 2000 commercial landings at age. Comparative ADAPT calibrations were performed to evaluate the impact of a range of discard estimates in 1999 and 2000 on terminal year fishing mortality. A summary of each of three VPA runs (lower, middle, and upper range of discard estimates in 1999 and 2000) is provided in Table 17.

Very little difference in the overall model fit is evident among the three runs. The total sums of squares and the mean square residuals are almost identical under all scenarios, although there is a slight degradation in the coefficients of variation (CV) of the stock size estimates (2001 Ns) under the upper end discards scenario (Table 17). The major impact of the various discard scenarios occurs in the estimation of terminal year F. The effects on stock size estimates is relatively minor. Differences in fishing mortality between the lower and middle range scenarios are minor, but the estimate of the 2000 fully recruited fishing mortality is substantially greater under the upper end discards scenario.

Impact of Including Recreational Landings

The VPA formulation presented above was employed in an additional analysis to evaluate the specific impact of including (or excluding) recreational landings in the VPA. In general, inclusion of the recreational landings served to marginally increase the estimates of fully recruited F, and to substantially revise upwards the estimates of stock size. The CVs on estimates of stock size in 2001 were almost identical to those obtained from the commercial-only base formulation. The retrospective pattern, evident in the commercial-only run, remains in the commercial/recreational run. Overall, inclusion of recreational landings does not alter our perception of current stock status.

Final VPA Formulation

The ADAPT formulation employed in the final VPA calibration was the same as that used in the previous assessments (Mayo *et al.* 1998, NEFSC 2000, NEFSC 2001) except for the inclusion of 1982-2000 recreational landings at age. This analysis provided direct stock size estimates for ages 2 through 6 in 2001 and corresponding estimates of F on ages 1 through 5 in 2000. Since the age at full recruitment was defined as 4 years in the input partial recruitment vector, the terminal year

F on age 6 was estimated as the mean of the age 4 and 5 Fs; age 6 is also the oldest true age in the terminal year. In all years prior to the terminal year, F on the oldest true age (age 6) was determined from weighted estimates of Z for ages 4 through 6. In all years, the age 6 F was applied to the 7+ group. Spawning stock biomass (SSB) was calculated at spawning time (March 1) by applying a series of period-specific maturity ogives. The present analysis used a maturity schedule which reflected earlier maturation beginning in 1994.

Residuals of the observed and predicted indices derived from the final VPA formulation (Figure 13) do not indicate any consistent trends over the period of the VPA, except for the MADMF age 2 autumn index.

Virtual Population Analysis Results

A complete listing of the final ADAPT VPA calibration is given in Appendix 3, and summary results, including age-specific estimates of instantaneous fishing mortality (F), stock size, mean biomass and spawning stock biomass, are presented in Table 18. All parameter estimates were significant (Appendix 3). Coefficients of variation on the stock size estimates ranged from 0.29 (age 4) to 0.53 (age 6), while CVs on the estimates of q were between 0.15 and 0.20. Slopes of the abundance index-stock size relationships increased with age through age 6 for the NEFSC spring and autumn surveys and the USA commercial LPUE indices. The MADMF spring indices exhibited an increasing trend in q between ages 2 and 4 (Appendix 3).

Average (ages 4-5, unweighted) fishing mortality in 2000 was estimated to be 0.73 (Table 18, Figure 14), a slight decrease from 1999. The spawning stock biomass of age 1 and older cod declined from 23,900 mt in 1982 to 15,300 mt in 1987. Following the recruitment and maturation of the strong 1987 year class, SSB increased to 24,200 mt in 1990 but declined to 11,400 mt in 1993, a 3-year reduction of 53% (Table 18, Figure 15). SSB increased to 14,600 mt in 1995 due to the growth and maturation of the 1992 year class, but declined again in 1996 and reached a record-low of 9,900 mt in 1998. SSB is estimated to have increased gradually between 1998 and 2000 (Table 18). Total stock size (ages 1+) has also declined sharply in recent years from 44.6 million fish in 1988 to an average of 12.4 million fish during 1996-1998 (Table 18), a decrease of 72%, but is estimated to have increased to about 18-19 million fish in 1999 and 2000 due in large part to recruitment of the 1998 year class.

Since 1982, recruitment at age 1 has ranged from less than 3.5 million fish (1993, 1994, and 1995 year classes) to 25.2 million fish (1987 year class). Over the 1982-2000 period, geometric mean recruitment for the 1981-1999 year classes was 6.6 million fish. The 1987 year class is the highest in the 1982-2000 series and about twice the size of the next strongest year class. The1992 year class was of moderate strength, and the 1998 year class appears to be comparable (Table 18, Figure 15).

Precision of F and SSB

A bootstrap procedure (Efron 1982) was used to evaluate the precision of terminal year estimates, by generating 600 estimates of the 2000 fully recruited fishing mortality rate and spawning stock biomass. Summary statistics for the bootstrap analyses are provided in Appendix 4, and the distributions of the bootstrap estimates and the corresponding cumulative probability curves are shown in Figures 16 and 17. The cumulative probability expresses the likelihood that the fishing mortality rate was greater than a given level (Figure 16) or the likelihood that spawning stock biomass was less than a given level (Figure 17), when measurement error is considered.

Coefficients of variation for the 2001 stock size (numbers) estimates ranged from 0.29 (age 4) to 0.51 (age 2), and CVs for qs among all indices ranged from 0.14 to 0.18 (Appendix 4). The fully-recruited fishing mortality in 2000 for ages 4+ was reasonably well estimated (CV = 0.30). The mean bootstrap estimate of F (0.76) was slightly higher than the point estimate (0.73) from the VPA, and ranged from 0.41 to 2.36. The 80% probability interval ranges from 0.58 to 0.96 (Figure 16).

Although the abundance estimates for individual ages in 2001 had wide variances (CV = 0.29 to 0.51), the estimates of 2000 spawning stock biomass and mean biomass were robust (CV = 0.17 and 0.13, respectively). The bootstrap means were 2.9 - 4.6% higher than the VPA point estimates (Appendix 4). The 80% probability interval for SSB ranges from 11,200 mt to 15,600 mt (Figure 17). Despite this variability, current spawning stock biomass is estimated to have increased substantially from recent record lows. In general, estimates of stock size and fishing mortality in the present assessment are estimated with about the same precision as in the previous assessment of this stock (Mayo *et al*.1998).

Retrospective Analysis

The previous retrospective analysis for this stock was reported by Mayo *et al.* (1998). Although the formulation used in the present assessment is the same as in the previous assessment, changes in management measures for this stock during 1997-2000 may have imposed additional uncertainty in the interpretation of current stock status. Therefore, the retrospective analyses were conducted again, and the tabular results are given in Appendix 3.

Retrospective patterns with respect to terminal F are evident for Gulf of Maine cod in the most recent years (Figure 18). Mean F (ages 4-5, unweighted) in the terminal year had been generally under-estimated between 1994 and 1997 by the ADAPT calibration. The previous retrospective analysis by Mayo *et al.* (1998) indicated the same pattern, but was able to detect the opposite pattern (slight over-estimate of F) prior to 1994. Convergence of estimates is generally evident within 3 years, and often within 2 years, prior to any given terminal year. The retrospective analysis provides additional evidence that current fishing mortality on this stock, although somewhat lower than in previous years, remains relatively high. The retrospective pattern for age 1 recruits suggests that recruitment has generally been under-estimated over the past 6 years. The estimates of SSB have been relatively stable, although there was a slight tendency to under-estimate spawning biomass.

Spawning Stock and Recruitment

The relationship between spawning stock biomass and recruitment for Gulf of Maine cod was examined from two perspectives. First, a traditional spawning stock-recruitment scatterplot (Figure 19a) was constructed over the period covering the 1982-1999 year classes. In addition, a survival ratio, expressed as recruits per unit of SSB (R/SSB) was also calculated for each year class (Figure 19b). The stock-recruitment trajectory indicates the position of the most recent levels of SSB and recruitment in the lower left corner of the plot. The 1993-1997 year classes are all below average and the 1993-1995 year classes are the lowest in the series.

Survival ratios of pre-recruits up to age 1 are highest for the 1987, 1992 and 1998 year classes, the first two emerging from about average SSB and the 1998 year class from low SSB. Survival ratios were generally higher during the early-to-mid 1980s prior to the emergence of the large 1987 year class. Survival declined after the 1992 year class appeared, but increased in 1997 and 1998.

Hind-cast VPA Total Biomass Estimates

The 1982-2000 total stock biomass estimates derived from the VPA were extended back through time to 1963 utilizing NEFSC autumn research vessel survey biomass (kg/tow) indices. Estimates of the catchability coefficient (q), defined as the ratio between the survey index of total biomass and the VPA estimate of age 1+ stock biomass, were computed annually from 1982-2000. The average of these ratios was then applied to the entire 1963-2000 series of survey biomass indices to derive scaled estimates of total stock biomass. Results suggest that the total biomass of Gulf of Maine cod was likely to have been well over 100,000 mt during the 1960s and 1970s (Figure 20), and that VPA estimates beginning in 1982 may represent the condition of the stock following sharp declines in the late 1970s and early 1980s.

BIOLOGICAL REFERENCE POINTS

Yield and Spawning Stock Biomass per Recruit

Yield, total stock biomass, and spawning stock biomass per recruit analyses were performed using the method of Thompson and Bell (1934). Mean weights at age for application to the yield per recruit analysis were computed as a 17-year arithmetic average of total catch mean weights at age (Table 13b) over the 1982-1998 period. Mean weights at age for application to the SSB per recruit analysis were computed as a 17-year arithmetic average of stock mean weights at age (Table 14) over the 1982-1998 period. The 1999 and 2000 mean weights at age were excluded due to poor sampling of commercial landings during these years. The maturation ogive was the same as used in computing SSB during the 1994-2000 period in the VPA. To obtain the exploitation pattern for these analyses, a two-year geometric mean F at age was first computed over 1999 and 2000 from the final converged VPA results. These years were chosen specifically to encompass the period since enactment of the most recent increase in the minimum allowable mesh (165 mm). A smoothed exploitation pattern was then obtained by dividing the F at age by the mean unweighted F for ages 4-5, adjusted to the average partial recruitment for ages 4 and 5.

The final exploitation pattern is:

Age 1 0.000, Age 2 0.0134, Age 3 0.2867, Age 4 0.9889, Ages 5+ 1.000

This pattern is similar to that used in the 1998 assessment (Mayo *et al*.1998) for ages 1 through 3, but indicates increased selection of age 4 fish (from about 80% to 100%) compared to the 1998 assessment, possibly reflecting the inclusion of recreational data in the catch at age employed in the VPA. This partial recruitment pattern was used in yield and SSB per recruit calculations. Input data and results of the yield and SSB per recruit calculations are listed in Table 19 and are illustrated in Figure 21. The yield per recruit analyses indicate that $F_{0.1} = 0.15$ and $F_{max} = 0.27$, and SSB per recruit calculations indicate that $F_{20\%} = 0.36$. The yield per recruit reference points ($F_{0.1}$ and F_{max}), and the SSB per recruit reference point ($F_{20\%}$) are slightly lower than those reported in the 1998 assessment (Mayo *et al*.1998).

MSY-Based Reference Points

The existing estimates of B_{msy} and F_{msy} for Gulf of Maine cod were derived in 1998 from a biomass dynamics model (ASPIC; Prager 1994, 1995) integrating landings and relative biomass indices over the period 1963-1997 (Anon.1998). The biomass dynamics model analysis was conditioned on the relationship between age 1+ mean biomass derived from the 1997 VPA and biomass indices from the NEFSC spring and autumn surveys and the MADMF spring survey. Estimates of q, expressed as the ratio of the survey index to the age 1+ mean biomass, were fixed for each of the 3 surveys used to calibrate the production model. The analysis conditioned on age 1+ VPA mean biomass suggested that B_{msy} for Gulf of Maine cod was in the range of 33,000 mt and that the corresponding age 1+ F_{msy} was 0.31 (Fwb).

Because Gulf of Maine cod do not recruit to the fishery until age 2, the biomass dynamics model was re-run, conditioned on the relationship between age 2+ mean biomass derived from the current VPA and the same survey biomass indices updated through 2000. The revised analysis suggests that age 2+ B_{msy} for Gulf of Maine cod is in the range of 26,000 mt and that the corresponding age 2+ F_{msy} is 0.41 (Fwb). The modeling results indicate that stock biomass was above B_{msy} from the 1960s to the early 1980s but, as F exceeded F_{msy} in the early 1980s, stock biomass declined to low levels in the 1990s. The model further suggests that stock biomass increased sharply in 1999 and 2000, approaching B_{msy} as F declined below F_{msy}.

The rapid increase in biomass estimated by the biomass dynamics model is consistent with the recent increase in mean biomass derived from the VPA. However, the age-structured information provided by the VPA suggests that a considerable portion of the recent increase in mean biomass can be attributable to the recruitment of the 1998 year class. This effect is also reflected in the survey biomass indices which were incorporated into the production model analysis.

Age-Structured Production Model

As an alternative to the ASPIC biomass dynamics model, an age-structured production model (Sissenwine and Shepherd 1987) was developed using stock and recruitment observations from VPA and yield and biomass per recruit results. Age-structured production models are more informative than biomass dynamics models and can determine F_{msy} in the form of fully-recruited F, and can estimate SSB_{msy} as an alternative to B_{msy}. As concluded by the SAW Methods Working Group (Section D of this report), fully-recruited F_{msy} and SSB_{msy} are less sensitive to transient conditions and are directly comparable to VPA estimates of fully-recruited F and SSB. Comparison of current VPA results with reference points derived from the biomass dynamics model in Anon. (1998) is no longer appropriate, because the revised VPA includes recreational catch (1982-2000), and historical recreational catch is not available for a revised ASPIC analysis.

Age-Structured Production Model Results

A Beverton-Holt (1957) stock- recruit function was fit to the VPA estimates of SSB (in thousand mt) and age-1 recruitment (in millions) assuming a lognormal error structure:

(1) $R=(9.87 \cdot SSB)/(7.55+SSB)$

Estimates of yield, total biomass, and spawning biomass per recruit (YPR, BPR, and SPR) were derived from the Thompson-Bell (1934) dynamic pool model over a range of fully-recruited fishing mortality rates (Table 19, Figure 21). Equilibrium SSB (SSB*) was then calculated at various levels of fully-recruited fishing mortality to scale the dynamic pool estimates of SSB per recruit to absolute values:

(2) $SSB^*=(9.87 \cdot \text{SSB per recruit})-7.55$

Equilibrium recruitment (R*) was calculated as a function of SSB*, using equation 1, and equilibrium yield was calculated as the product of yield per recruit and R*.

F_{msy} was determined as the F that produced the maximum equilibrium yield (MSY), SSB_{msy} was the SSB* at F_{msy}, and B_{msy} was calculated as the product of yield per recruit and R* at F_{msy}. F on total biomass was also approximated as YPR/BPR for comparison to biomass dynamics results. Estimates of yield, F, SSB, and B from VPA were plotted with equilibrium calculations for comparison (Figure 22).

Results indicate that MSY=16,100 mt, fully-recruited F_{msy}=0.23, B_{msy}=90,300 mt, and that SSB_{msy}=78,000 mt (Figure 22). Alternative stock recruit decisions were considered for sensitivity analyses, including the use of hindcasted SSB and R observations (Brodziak et al. 2001) and assuming geometric mean recruitment. Estimates of F_{MSY} appeared to be robust to stock-recruit decisions, ranging from 0.23-0.27. However, MSY and B_{msy} were more sensitive to alternative stock recruit assumptions and were proportional to the estimate of maximum R. For comparison, F_{msy} on biomass (0.18) is substantially less than the estimate from the ASPIC biomass dynamics model, and

B_{msy} is substantially greater than that from ASPIC. However, fully-recruited F_{msy} is only slightly less than F_{max}, which was the previous overfishing definition.

Difference Between Old and New Reference Points

There are many factors contributing to differences between the existing F_{msy} and B_{msy} reference points derived from the biomass dynamics model and those derived from the present analysis based on the age-structured production model. First, the age structured approach better accounts for the productivity of the stock by specifically incorporating past and present information on the relationship between spawning stock and recruitment. In addition, the age structured approach is predicated on the yield and biomass per recruit analyses which incorporate age-specific growth and maturity information and the most appropriate exploitation pattern from the fishery. The age-aggregated approach employed in the biomass dynamics model subsumes all of the age-specific information into an estimate of a single parameter (r), the intrinsic rate of growth of the stock. This rate of increase may not always reflect the current growth potential of the stock. As noted above, the age-structured model is consistent with the assessment model because it is based on the SSB and recruitment from the current VPA, which includes recreational catch and recent discards. It is not currently possible to develop a long time series of recreational catch for a revised ASPIC analysis that could be comparable to the VPA.

The ASPIC approach was adopted by the Overfishing Definition Review Panel (Anon. 1998) as a means of applying a consistent method across as many stocks as possible, including those for which information on age structure was not yet available. In the case of the Gulf of Maine cod analysis, it was necessary to condition the biomass dynamics model (i.e., fix the estimates of q) based on the relationship between the NEFSC survey biomass indices and the corresponding VPA estimates of mean biomass in order to obtain a significant fit. This may have imposed constraints on the subsequent estimates of B_{msy} and F_{msy}.

Long-term projections, reported below, confirmed the results from the age-structured production model. The projection results indicate that long-term yield at the revised estimate of F_{MSY} (0.23) is significantly greater than the previous estimate of MSY (10,000 mt, Anon.1998) and is near the revised estimate of MSY (16,100 mt). Similarly, projected total stock biomass is significantly greater than the previous estimate of B_{msy} (33,000 mt) and close to the revised estimate of B_{msy} (90,300 mt). Furthermore, historical survey observations indicate that stock biomass exceeded the revised estimate of B_{MSY} during most of the 1960s and 1970s (Figure 20). Therefore, it appears that the previous estimates of MSY and B_{msy} were greatly underestimated (conversely it appears that F_{msy} was over-estimated), and revised reference point estimates are more consistent with long-term projections and historical observations.

CATCH and STOCK BIOMASS PROJECTIONS

Stochastic age-based projections (Brodziak and Rago MS1994) were performed over a 25-year time horizon to evaluate relative trajectories of stock biomass and catch under various fishing mortality scenarios. Recruitment was derived from the Beverton-Holt spawning stock-recruitment relationship employed in the age structured production model. Stock and catch mean weights at age, the maturity at age schedule, and the partial recruitment at age vector are the same as those employed in the yield and SSB per recruit analyses presented above. The 2001 survivors derived from 600 bootstrap iterations of the final VPA formulation were employed as the initial population vector. The projection was performed at four fishing mortality rates: $F_{0.1}$ (0.15), F_{msy} (0.23), F_{max} (0.27) and F_{sq} (0.73). Fully recruited fishing mortality in 2001 was assumed equal to that in 2000 (0.73) under all F scenarios. Short-term forecasts of 2002 catch and corresponding 2003 SSB were derived from the first two years of the long-term projections. All input data are provided in Table 20.

Short-Term Projection Results

The forecast for 2002 and 2003 is summarized in Table 20 and Figure 23. The results suggest that if the current fishing mortality rate is reduced to F_{max} or less in 2002, SSB will continue to increase in 2003. However, if F in 2002 remains at or near the 2000 F, SSB in 2003 will not increase beyond that projected for 2002.

Long-Term Projection Results

The long-term projections (Table 21; Figures 24 and 25) suggest that fishing at F_{msy} (0.23) will result in the total stock biomass stabilizing at about 92,000 mt providing total catches of about 15,000 mt per year. If F is not reduced from the current level (0.73), neither total stock biomass nor spawning stock biomass are likely to increase appreciably above the existing level. Because the spawning stock-recruit relationship for this stock is relatively flat across most observed levels of SSB (Figure 22), recruitment is estimated to be only slightly impaired at this high fishing mortality rate. Given the recent trends in observed recruitment at low SSB, however, this outcome is both unlikely and optimistic.

CONCLUSIONS

The Gulf of Maine cod stock remains at a low biomass level, although there are indications of a recent increase in total biomass and spawning stock biomass in 1999 and 2000 . Fully recruited fishing mortality appears to have declined only slightly in 2000 (0.73), indicating that F continues to remain very high relative to fully recruited F reference points ($F_{0.1}$ = 0.15; F_{msy} = 0.23; F_{max} = 0.27). Spawning stock biomass (SSB) declined from over 24,000 mt in 1990 to a low of 9,900 mt in 1998, but increased to 13,100 mt in 2000.

The 1987 year class has been the strongest in the VPA assessment period (1982-2000), but research vessel survey results suggest that even stronger year classes occurred during the 1970s. Year classes

subsequent to 1987 have been poor except for those from 1992 and 1998. The 1993, 1994, and 1995 year classes are among the poorest in the VPA time series. Survival ratios (R/SSB) declined through 1998 but now appear to be increasing.

Total (age 1+) stock biomass in 2001 is slightly above 1/4 of the revised B_{msy} reference point (90,300 mt) and fully recruited F in 2000 is about 3 times greater than the revised F_{msy} reference point (0.23). A substantial retrospective pattern has existed in the VPA results for this stock whereby fully recruited F has generally been underestimated in the terminal year since 1994. In the retrospective analysis of the present assessment, F_{1998} and F_{1999} appear to have been slightly overestimated, while terminal Fs from 1994-1997 were underestimated.

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Table 1. A brief chronology of management measures affecting Gulf of Maine cod.

1973
Total Allowable Catch (TAC) limits implemented by the International Commission for the Northwest Atlantic Fisheries (ICNAF) for Division 5Y (Gulf of Maine) cod.
Minimum codend mesh size at 4 ½" (114 mm).

1977
Fishery Conservation and Management Act (FCMA) implemented. Management under the auspices of the New England Fishery Management Council.

1977-1982
Management of groundfish resources under the Fishery Management Plan (FMP) for Atlantic groundfish.
Carried forward TACs; implemented by vessel tonnage class and calendar quarter with trip limits.
Minimum codend mesh size increased to 5 1/8" (130 mm).

1982-1985
Management of groundfish resources under the "Interim" Plan for Atlantic groundfish.
Eliminated direct catch controls; primary tools for fishery management were minimum mesh sizes and minimum landing sizes.

1983
Minimum codend mesh size increased to 5 ½" (140 mm).

1986
Northeast Multi-species FMP implemented . Amendments 1-4 retained indirect controls, including minimum mesh and minimum fish landing sizes.

1989
Minimum fish size = 19" (48 cm) for commercial and recreational sectors.

1994
January 1 Amendment 5
50% reduction in F and effort over 5-7 years.
Days at Sea (DAS) monitoring
Implemented a Mandatory Reporting Scheme

May 1 Amendment 5 (again)
Minimum codend mesh size increased to 6" (152 mm), diamond or square.

1996
May 1 Amendment 7
Established rebuilding program based on Fmax target fishing mortality
Established Target TACs
Accelerated Days at Sea reductions
Established Framework Adjustment Process and the Multi-species Monitoring Committee to permit annual adjustments to management measures
Minimum fish size increased to 20" (51 cm) for recreational sector.

Table 1 (Continued).

1997
May 1 Framework 20
Target TAC: 2,605 mt
Gulf of Maine cod trip limit: 1,000 or 1,500 lbs/day
Minimum fish size increased to 21" (53 cm) for recreational sector.

1998
May 1 Framework 25
Target TAC: 1,800 mt with trigger provision
Gulf of Maine cod trip limit 700 lbs/day
Series of 1-month rolling closures from Massachusetts Bay to Penobscot Bay.
Year-round closure of portions of Jeffreys Ledge and Stellwagen Bank (WGOM Closed Area)

June 25 Framework trigger pulled
Gulf of Maine cod trip limit: 400 lbs/day

1999
February 1 Framework 26
Additional month-block (30x30 minutes) closures implemented for February and April

May 1 Framework 27
Target TAC: 1,300 mt with trigger provision
Gulf of Maine cod trip limit: 200 lbs/day
Minimum square mesh increased to 6.5" (165 mm).

May 28 Framework trigger pulled
Gulf of Maine cod trip limit: 30 lbs/day

August 3 Interim Rule
Gulf of Maine cod trip limit: 100 lbs/day

2000
January 5 Framework 31
Gulf of Maine cod trip limit: 400 lbs/day- 4,000 maximum/trip.
Additional month-block (30x30 minutes) closures implemented for February

May 1 Framework 33
Target TAC: 1,900 mt with trigger provision
Continuation of most Framework 27 and 31 measures
Year-round closure of WGOM area extended until April, 2002.

November 1 Framework trigger pulled
One-month closure of Cashes Ledge

2001
January 1 Framework trigger pulled
Additional month-block (30x30 minutes) closures implemented for January

May 1 Annual Adjustment
Target TAC: 1,118 mt
Continuation of most Framework 27 and 31, and 33 measures.

Table 2. Commercial landings (metric tons, live) of Atlantic cod the Gulf of Maine (NAFO Division 5Y), 1960 - 2000.[1]

	Gulf of Maine				
Year	USA	Canada	USSR	Other	Total
1960	3448	129	-	-	3577
1961	3216	18	-	-	3234
1962	2989	83	-	-	3072
1963	2595	3	133	-	2731
1964	3226	25	-	-	3251
1965	3780	148	-	-	3928
1966	4008	384	-	-	4392
1967	5676	297	-	-	5973
1968	6360	61	-	-	6421
1969	8157	59	-	268	8484
1970	7812	26	-	423	8261
1971	7380	119	-	163	7662
1972	6776	53	11	77	6917
1973	6069	68	-	9	6146
1974	7639	120	-	5	7764
1975	8903	86	-	26	9015
1976	10172	16	-	-	10188
1977	12426	-	-	-	12426
1978	12426	-	-	-	12426
1979	11680	-	-	-	11680
1980	13528	-	-	-	13528
1981	12534	-	-	-	12534
1982	13582	-	-	-	13582
1983	13981	-	-	-	13981
1984	10806	-	-	-	10806
1985	10693	-	-	-	10693
1986	9664	-	-	-	9664
1987	7527	-	-	-	7527
1988	7958	-	-	-	7958
1989	10397	-	-	-	10397
1990	15154	-	-	-	15154
1991	17781	-	-	-	17781
1992	10891	-	-	-	10891
1993	8287	-	-	-	8287
1994*	7877	-	-	-	7877
1995*	6798	-	-	-	6798
1996*	7194	-	-	-	7194
1997*	5421	-	-	-	5421
1998*	4156	-	-	-	4156
1999*	1636	-	-	-	1636
2000*	3730	-	-	-	3730

* Provisional

[1] USA 1960-1993 landings from NMFS, NEFSC Detailed Weighout Files and Canvass data.
[2] USA 1994-2000 landings estimated by prorating NMFS, NEFSC Detailed Weighout data by Vessel Trip Reports.

Table 3. Distribution of USA commercial landings (metric tons, live) of Atlantic cod from the Gulf of Maine (Area 5Y), by gear type, 1965 - 2000. The percentage of total USA commercial landings of Atlantic cod from the Gulf of Maine, by gear type, is also presented for each year. Data only reflect Gulf of Maine 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	2480	501	462	168	1	3612	68.7	13.9	12.8	4.6	-	100.0
1966	2549	830	308	150	4	3841	66.4	21.6	8.0	3.9	0.1	100.0
1967	4312	734	206	274	<1	5526	78.0	13.3	3.7	5.0	-	100.0
1968	4143	1377	213	339	4	6076	68.2	22.7	3.5	5.6	-	100.0
1969	6553	851	258	162	4	7828	83.7	10.9	3.3	2.1	-	100.0
1970	5967	951	407	178	9	7512	79.4	12.7	5.4	2.4	0.1	100.0
1971	5117	1043	927	98	8	7193	71.1	14.5	12.9	1.4	0.1	100.0
1972	4004	1492	1234	54	2	6786	59.0	22.0	18.2	0.8	-	100.0
1973	3542	1182	1305	23	9	6061	58.4	19.5	21.5	0.4	0.2	100.0
1974	5056	1412	904	36	17	7425	68.1	19.0	12.2	0.5	0.2	100.0
1975	6255	1480	920	12	8	8675	72.1	17.1	10.6	0.1	0.1	100.0
1976	6701	2511	621	4	41	9878	67.8	25.4	6.3	0.1	0.4	100.0
1977	8415	2872	534	6	166 [a]	11993	70.2	23.9	4.5	-	1.4	100.0
1978	7958	3438	393	10	91 [b]	11890	66.9	28.9	3.3	0.1	0.8	100.0
1979	7567	2900	334	19	167 [c]	10987	68.9	26.4	3.0	0.2	1.5	100.0
1980	8420	3733	251	48	61	12513	67.3	29.8	2.0	0.4	0.5	100.0
1981	7937	4102	276	23	45	12383	64.1	33.1	2.2	0.2	0.4	100.0
1982	9758	3453	188	46	34	13479	72.4	25.6	1.4	0.3	0.3	100.0
1983	9975	3744	77	4	67	13867	71.9	27.0	0.6	-	0.5	100.0
1984	6646	3985	22	3	69	10725	62.0	37.2	0.2	-	0.6	100.0
1985	7119	3090	55	6	326 [d]	10596	67.2	29.1	0.5	0.1	3.1	100.0
1986	6664	2692	56	12	180 [e]	9604	69.4	28.0	0.6	0.1	1.9	100.0
1987	4356	2994	70	13	68	7501	58.1	39.9	0.9	0.2	0.9	100.0
1988	4513	3308	68	27	22	7938	56.9	41.7	0.8	0.3	0.3	100.0
1989	6152	4000	72	36	119 [f]	10379	59.3	38.5	0.7	0.4	1.1	100.0
1990	10420	4343	126	20	186 [g]	15095	69.0	28.8	0.8	0.1	1.2	100.0
1991	13049	4158	212	59	266 [h]	17744	73.5	23.4	1.2	0.3	1.5	100.0
1992	7344	3081	359	94	14	10891	67.4	28.3	3.3	0.9	0.1	100.0
1993	4876	3130	236	16	29	8287	58.8	37.8	2.8	0.2	0.3	100.0
1994	4205	3317	338	[i]	17	7877	53.4	42.1	4.3	[i]	0.2	100.0
1995	3450	3050	281	[i]	17	6798	50.8	44.9	4.1	[i]	0.3	100.0
1996	4012	2825	335	[i]	22	7194	55.8	39.3	4.7	[i]	0.3	100.0
1997	2798	2175	426	[i]	22	5421	51.6	40.1	7.9	[i]	0.4	100.0
1998	2329	1431	381	[i]	15	4156	56.0	34.4	9.2	[i]	0.4	100.0
1999	838	494	302	[l]	2	1630	51.2	30.2	18.5	[l]	0.1	100.0
2000	2007	1393	309	[l]	20	3730	53.8	37.4	8.3	[l]	0.5	100.0

[a] Of 166 mt landed, 107 mt were by mid-water pair trawl and 42 mt were by drifiting gill nets.
[b] Of 91 mt landed, 56 mt were by Danish seine and 27 mt were by drifting gill nets.
[c] Of 167 mt landed, 199 mt were by drifting gill nets and 38 mt were by Danish seine.
[d] Of 326 mt landed, 268 mt were by longline and 37 mt were by Danish seine.
[e] Of 181 mt landed, 152 mt were by longline and 23 mt were by Danish seine.
[f] Of 199 mt landed, 75 mt were by longline and 27 mt were by Danish seine.
[g] Of 186 mt landed, 159 mt were by longline and 16 mt were by Danish seine.
[h] Of 266 mt landed, 245 mt were by longline and 9 mt were by Danish seine.
[i] Handline and line trawl combined.

Table 4. Discard and total catch estimates (metric tons, live) for Gulf of Maine cod by otter trawl, shrimp trawl, and sink gillnet gear derived from 1989-2000 NEFSC Sea Sample data.

		Discard Estimates				
Year	Total Landings	Included Landings	Discard Estimate	Discard to Landings Ratio	Total Discard	Total Catch
1989	10397	10182	1513	0.1486	1545	11942
1990	15154	14827	3521	0.2375	3598	18752
1991	17781	17374	1025	0.0590	1049	18830
1992	10891	10511	582	0.0554	603	11494
1993	8287	8058	320	0.0397	329	8616
1994	7877	7522	228	0.0303	239	8116
1995	6798	6500	408	0.0627	426	7224
1996	7194	6837	189	0.0277	199	7393
1997	5421	4974	164	0.0330	179	5600
1998	4156	3760	139	0.0370	154	4310
1999	1636	1332	2141	1.6074	2630	4266
2000	3730	3401	1067	0.3137	1170	4900

Table 5a. 1999 Discard estimation procedure for Gulf of Maine cod based on 1999 VTR records.

D/K Ratio	Month of the Year 1	2	3	4	5	6	7	8	9	10	11	12	Total
Trawls	0.164	0.149	0.149	0.176	0.785	8.403	5.706	0.820	1.153	1.227	2.548	2.157	
Gillnets	0.428	0.006	0.041	0.019	1.135	10.731	13.596	3.718	4.393	6.027	7.216	3.136	
Other	0.114	0.052	0.318	0.011	0.042	3.651	4.837	0.014	0.016	0.028	0.208	0.208	
Total													
Landings	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Trawls	141.6	68.1	112.5	112.5	185.4	44.9	20.5	22.2	21.1	18.9	30.3	57.8	835.8
Gillnets	81.1	36.2	30.3	111.4	109.8	29.2	38.9	36.2	38.9	31.4	24.3	38.4	606.1
Other	38.9	17.3	30.3	26.5	23.2	2.7	3.8	4.9	9.2	9.2	11.4	16.8	194.1
Total	261.7	121.6	173.0	250.3	318.4	76.8	63.3	63.3	69.2	59.5	66.0	113.0	1636.0
Disc	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Trawls	23.2	10.2	16.8	19.8	145.5	377.1	117.2	18.2	24.3	23.2	77.1	124.8	977.4
Gillnets	34.7	0.2	1.3	2.1	124.6	313.3	529.2	134.7	171.0	189.0	175.6	120.4	1795.9
Other	4.5	0.9	9.6	0.3	1.0	9.9	18.3	0.1	0.1	0.1	0.3	3.5	48.6
Total	62.4	11.3	27.7	22.1	271.0	700.2	664.8	152.9	195.4	212.3	253.0	248.6	2821.9
Catch	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Trawls	164.9	78.3	129.3	132.2	330.9	421.9	137.8	40.3	45.4	42.1	107.4	182.6	1813.2
Gillnets	115.8	36.4	31.5	113.4	234.3	342.5	568.2	170.9	209.9	220.3	199.9	158.8	2402.0
Other	43.4	18.2	39.9	26.8	24.2	12.6	22.1	4.9	9.3	9.3	11.7	20.3	242.7
Total	324.1	132.9	200.7	272.5	589.5	777.0	728.0	216.2	264.6	271.8	319.0	361.6	4457.9

Table 5b. Discard estimation procedure for Gulf of Maine cod based on 2000 VTR records.

					Month of the Year							
D/K Ratio	1	2	3	4	5	6	7	8	9	10	11	12	Total
Trawls	1.223	0.506	0.555	0.193	0.389	0.346	0.581	0.285	0.414	0.476	0.426	0.345	
Gillnets	0.816	0.258	0.282	0.447	0.287	0.876	1.039	0.567	1.764	0.674	1.127	0.694	
Other	0.242	0.056	0.041	0.183	0.164	0.017	0.233	0.556	0.554	0.200	0.088	0.117	
Total													
Landings	1	2	3	4	5	6	7	8	9	10	11	12	Total
Trawls	170.6	92.1	90.2	58.4	398.1	215.9	133.6	77.6	57.0	68.7	170.1	340.2	1872.5
Gillnets	58.9	25.7	69.6	55.6	169.6	357.5	253.7	192.5	108.9	116.4	115.0	121.5	1644.9
Other	30.4	15.9	20.1	8.9	30.8	22.0	7.9	4.2	14.0	9.8	4.2	44.4	212.6
Total	259.8	133.6	179.9	122.9	598.6	595.3	395.3	274.3	179.9	194.9	289.3	506.1	3730.0
Disc	1	2	3	4	5	6	7	8	9	10	11	12	Total
Trawls	208.6	46.5	50.1	11.3	155.0	74.6	77.6	22.1	23.6	32.7	72.4	117.4	891.8
Gillnets	48.0	6.6	19.6	24.9	48.8	313.2	263.7	109.1	192.1	78.4	129.5	84.3	1318.2
Other	7.4	0.9	0.8	1.6	5.1	0.4	1.8	2.3	7.8	2.0	0.4	5.2	35.6
Total	264.0	54.1	70.5	37.8	208.8	388.2	343.1	133.5	223.4	113.1	202.3	206.8	2245.6
Catch	1	2	3	4	5	6	7	8	9	10	11	12	Total
Trawls	379.2	138.6	140.3	69.7	553.1	290.5	211.2	99.7	80.6	101.4	242.5	457.6	2764.3
Gillnets	106.9	32.3	89.3	80.5	218.4	670.6	517.4	301.7	301.0	194.8	244.5	205.8	2963.1
Other	37.7	16.8	20.9	10.5	35.9	22.3	9.8	6.5	21.8	11.8	4.6	49.6	248.2
Total	523.9	187.7	250.4	160.7	807.4	983.5	738.4	407.9	403.3	308.0	491.6	712.9	5975.6

Table 6a. Estimated Discard-to-Kept Ratios (discarded pounds to landed pounds).				
	Calendar Year 1999		Calendar Year 2000	
Sensitivity Trial	1996 Data	1997 Data	1996 Data	1997 Data
Minimum Share = 50%	1.80	1.95	0.73	0.72
Minimum Share = 25%	2.27	2.25	0.92	0.84
Minimum Share = 10%	2.47	2.34	0.99	0.87
Minimum Payment	2.00	2.05	0.81	0.78

Table 6b. Estimated Discards of Gulf of Maine Cod (metric tons).				
	Calendar Year 1999		Calendar Year 2000	
Sensitivity Trial	1996 Data	1997 Data	1996 Data	1997 Data
Minimum Share = 50%	2949	3194	2707	2701
Minimum Share = 25%	3719	3686	3432	3133
Minimum Share = 10%	4038	3832	3682	3253
Minimum Payment	3270	3362	3028	2919

Table 7. USA sampling of commercial Atlantic cod landings from the Gulf of Maine cod stock (NAFO Division 5Y), 1982 - 2000.

	Number of Samples				Number of Samples, by Market Category & Quarter														Annual Sampling Intensity			
	Length Samples		Age Samples		Scrod					Market					Large					No. of Tons Landed/Sample			
Year	No.	No. Fish Measured	No.	No. Fish Aged	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Scrod	Market	Large	Σ
1982	48	3848	48	866	6	7	6	6	**25**	4	3	7	4	**18**	0	2	1	2	**5**	134	348	792	266
1983	71	5241	67	1348	14	10	10	4	**38**	4	10	6	2	**22**	1	3	5	2	**11**	106	294	318	197
1984	55	3925	55	1224	7	5	6	7	**25**	4	3	5	6	**18**	1	6	3	2	**12**	85	319	245	193
1985	69	5426	66	1546	5	6	7	5	**23**	8	6	7	4	**25**	7	5	3	6	**21**	95	229	132	155
1986	53	3970	51	1160	5	5	6	3	**19**	5	6	8	2	**21**	1	5	4	3	**13**	124	242	170	182
1987	43	3184	42	939	4	4	3	4	**15**	5	5	3	5	**18**	4	2	3	1	**10**	83	224	225	175
1988	34	2669	33	741	4	3	4	4	**15**	1	5	3	5	**14**	1	2	2	0	**5**	147	271	391	234
1989	32	2668	32	714	3	3	3	3	**12**	4	1	5	4	**14**	2	2	1	1	**6**	209	430	311	325
1990	39	2982	38	789	3	7	3	5	**18**	4	7	4	3	**18**	0	2	1	0	**3**	300	378	966	387
1991	56	4519	56	1152	2	10	4	3	**19**	5	11	11	3	**30**	0	3	3	1	**7**	250	313	519	318
1992	51	4086	51	1002	2	8	6	3	**19**	6	7	7	3	**23**	3	1	1	4	**9**	104	232	375	214
1993	23	1753	23	447	3	3	3	1	**10**	1	2	4	1	**8**	1	1	2	1	**5**	177	453	527	360
1994	30	2696	33	665	0	2	2	4	**8**	1	4	4	6	**15**	0	2	3	2	**7**	180	284	272	263
1995	31	2568	32	662	4	2	2	4	**12**	2	7	1	2	**12**	0	5	0	2	**7**	133	300	202	219
1996	77	7027	71	1483	6	5	7	9	**27**	7	9	10	12	**38**	1	3	3	5	**12**	62	116	79	93
1997	78	6657	74	1521	7	10	3	9	**29**	11	9	9	7	**36**	1	8	2	2	**13**	37	91	71	69
1998	46	4205	46	912	4	7	0	3	**14**	8	9	9	3	**29**	0	0	2	1	**3**	53	81	321	90
1999	15	1305	16	350	6	0	1	0	**7**	4	2	0	0	**6**	2	0	0	0	**2**	36	144	245	109
2000	61	4687	57	1300	12	5	3	4	**24**	12	14	4	6	**36**	0	0	0	1	**1**	14	62	1131	61

Source: 1982-1985 from Serchuk and Wigley (Woods Hole Lab. Ref 86-12); 1986-2000 from NEFSC files.

Table 8. Percentage (by weight) of USA commercial Atlantic cod landings from the Gulf of Maine (NAFO Division 5Y), by market category, 1964 - 2000.

	Gulf of Maine			
Year	Large	Market	Scrod	Total [a]
1964	29	59	12	100
1965	39	54	7	100
1966	42	48	10	100
1967	41	41	17	100
1968	47	43	9	100
1969	35	55	9	100
1970	43	52	6	100
1971	52	42	6	100
1972	58	35	7	100
1973	52	36	11	100
1974	39	33	28	100
1975	32	42	26	100
1976	29	45	20	100
1977	33	42	22	100
1978	38	44	17	100
1979	37	49	14	100
1980	36	45	19	100
1981	29	45	22	100
1982	29	45	24	100
1983	25	45	28	100
1984	26	51	19	100
1985	25	51	20	100
1986	22	51	23	100
1987	29	52	16	100
1988	26	45	23	100
1989	17	55	23	100
1990	34	43	19	100
1991	26	51	20	100
1992	31	49	18	100
1993	32	44	21	100
1994	24	54	18	100
1995	21	53	23	100
1996	13	61	23	100
1997	17	60	20	100
1998	23	57	18	100
1999	29	53	16	100
2000	30	59	9	100

[a] Includes landings of 'mixed' cod.

Table 9a. Commercial landings at age (thousands of fish; metric tons) of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2000.

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
Commercial Landings at Age in Numbers (000's)												
1982	30	1380	1633	1143	633	69	91	61	41	4	33	5118
1983	-	866	2357	1058	638	422	47	61	23	9	15	5496
1984	4	446	1240	1500	437	194	74	19	15	11	17	3957
1985	-	407	1445	991	630	128	78	32	4	11	11	3737
1986	-	84	2164	813	250	177	39	24	20	4	8	3583
1987	2	216	595	1109	277	66	51	9	8	8	3	2344
1988	-	160	1443	953	406	43	9	17	1	2	1	3035
1989	-	337	1583	1454	449	81	35	6	3	5	7	3960
1990	-	205	3425	2064	430	157	27	30	10	15	17	6380
1991	-	344	934	4161	851	143	41	30	6	1	1	6512
1992	-	313	530	484	2018	202	62	7	12	3	-	3631
1993	-	76	1487	641	129	457	28	6	2	-	-	2825
1994	-	29	1016	1135	288	72	54	17	13	1	1	2626
1995	-	218	880	1153	194	12	8	22	3	1	-	2491
1996	-	65	584	1738	347	45	5	2	3	-	-	2789
1997	-	53	438	435	832	68	4	1	1	1	1	1834
1998	-	94	390	542	165	193	8	1	1	1	-	1395
1999	-	-	178	192	90	27	28	6	2	-	-	523
2000	-	42	239	569	141	64	8	7	3	-	-	1074
2000a	-	42	233	523	112	34	5	32	30	9	1	1020
Commercial Landings at Age in Weight (Tons)												
1982	24	1595	2717	3160	3019	461	813	608	531	41	613	13582
1983	-	1009	3913	2619	2410	2518	271	643	227	102	269	13981
1984	3	516	2071	4080	1607	1145	603	186	193	152	250	10816
1985	-	513	2523	2816	2814	705	615	363	51	141	152	10693
1986	-	110	3976	2375	1153	1072	296	243	253	54	132	9664
1987	2	283	1001	3641	1340	451	455	88	116	110	40	7527
1988	-	203	2715	2311	2097	295	85	191	11	36	14	7958
1989	-	420	2811	4351	1737	325	323	67	43	87	163	10397
1990	-	219	5794	4687	1834	1200	290	354	153	214	350	15095
1991	-	388	1463	10455	3520	1045	399	369	93	32	17	17781
1992	-	480	1019	1313	6175	1011	594	88	161	49	-	10891
1993	-	99	2809	1611	561	2819	281	79	27	-	-	8286
1994	-	43	1975	3576	991	442	451	218	156	20	6	7877
1995	-	361	1689	3200	997	96	92	291	45	27	-	6798
1996	-	110	1247	4131	1267	333	49	18	39	-	-	7194
1997	-	92	977	1308	2658	316	36	15	7	10	2	5421
1998	-	120	816	1614	693	812	67	13	12	13	-	4157
1999	-	-	315	520	361	155	203	54	28	-	-	1636
2000	-	68	578	1962	621	366	45	55	36	-	-	3730
2000a	-	68	541	1690	443	180	25	294	345	125	20	3730

a 2000 Estimates include additional length data from sea sample trips.

Table 9b. Mean weight (kg) and mean length (cm) at age of commercial landings of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2000.

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11+	Average
Commercial Landings Mean Weight(kg) at Age												
1982	0.801	1.156	1.664	2.764	4.770	6.739	8.944	9.931	12.922	10.618	18.456	2.654
1983	-	1.164	1.660	2.475	3.778	5.962	5.808	10.522	10.089	10.898	17.813	2.544
1984	0.589	1.159	1.670	2.721	3.677	5.898	8.119	9.595	12.889	13.951	15.028	2.731
1985	-	1.260	1.746	2.840	4.466	5.525	7.901	11.218	11.420	13.386	14.523	2.861
1986	-	1.304	1.837	2.923	4.619	6.067	7.669	10.030	12.463	12.907	16.554	2.698
1987	1.028	1.313	1.684	3.283	4.831	6.824	8.878	10.023	13.752	14.738	14.596	3.212
1988	-	1.268	1.881	2.426	5.166	6.767	9.932	11.126	14.960	15.763	20.356	2.622
1989	-	1.247	1.776	2.993	3.864	4.872	9.267	11.938	14.806	18.196	21.521	2.626
1990	-	1.071	1.692	2.271	4.265	7.645	10.734	11.758	15.015	14.784	20.295	2.366
1991	-	1.130	1.568	2.512	4.136	7.309	9.642	12.322	15.547	24.328	21.885	2.731
1992	-	1.533	1.922	2.714	3.061	5.000	9.566	12.462	13.449	16.631	-	2.999
1993	-	1.293	1.889	2.513	4.356	6.174	9.999	13.869	17.544	-	-	2.933
1994	-	1.450	1.943	3.151	3.444	6.132	8.321	12.628	12.052	21.532	19.369	3.000
1995	-	1.652	1.921	2.775	5.142	8.290	10.755	12.914	16.433	21.504	-	2.728
1996	-	1.687	2.136	2.376	3.648	7.376	10.440	11.928	13.471	-	-	2.580
1997	-	1.733	2.233	3.007	3.193	4.649	8.543	13.439	14.787	16.075	21.356	2.958
1998	-	1.277	2.089	2.979	4.191	4.211	8.538	11.747	19.369	20.847	-	2.980
1999	-	-	1.774	2.704	4.020	5.727	7.254	9.231	12.542	-	-	3.128
2000	-	1.627	2.415	3.447	4.399	5.702	5.551	8.344	10.952	-	-	3.474
2000a	-	1.627	2.323	3.233	3.971	5.298	5.115	9.297	11.340	13.830	17.514	3.657
Commercial Landings Mean Length (cm) at Age												
1982	43.2	48.3	53.8	63.4	76.8	86.1	94.6	97.9	107.4	101.0	120.7	59.9
1983	-	48.6	53.8	61.4	70.8	82.4	80.5	98.8	97.5	100.0	118.7	59.8
1984	39.0	48.4	54.1	63.4	69.7	81.8	91.5	96.7	106.9	109.6	112.0	61.6
1985	-	49.8	55.1	64.6	74.9	80.3	90.8	101.9	103.1	108.2	109.7	62.8
1986	-	50.3	55.9	65.0	75.4	82.6	89.9	98.7	105.8	107.5	116.2	61.6
1987	47.0	50.4	54.4	67.8	76.9	86.5	93.8	98.7	109.5	111.7	111.3	65.4
1988	-	50.1	56.4	61.1	78.7	86.4	98.6	102.3	113.0	114.8	125.0	61.4
1989	-	49.8	55.5	65.7	71.5	76.7	95.8	103.4	112.6	120.4	126.8	61.7
1990	-	47.5	54.8	60.0	73.7	90.0	100.9	104.0	111.8	112.6	124.6	59.2
1991	-	47.7	52.6	61.8	72.6	88.6	97.2	105.0	113.3	132.5	128.0	62.2
1992	-	53.1	56.6	62.9	65.6	77.0	97.3	106.1	109.1	117.0	-	64.3
1993	-	50.5	56.8	61.7	74.2	83.7	98.6	110.0	119.1	-	-	63.5
1994	-	52.4	57.2	66.6	68.1	82.7	92.0	106.4	104.9	127.3	123.0	64.4
1995	-	54.4	56.9	63.4	78.6	92.5	101.1	107.2	116.1	127.2	-	62.3
1996	-	54.6	58.8	60.7	69.3	88.9	99.9	104.8	108.7	-	-	61.8
1997	-	55.0	59.7	65.4	66.4	74.9	93.3	108.7	112.2	115.6	127.0	64.7
1998	-	50.1	58.4	65.1	72.9	72.7	92.9	102.2	123.0	126.0	-	64.4
1999	-	-	55.5	63.4	71.7	80.8	88.3	96.2	106.6	-	-	64.9
2000	-	54.1	60.8	66.2	74.6	82.1	81.3	93.3	102.0	-	-	68.3
2000a	-	54.1	60.2	64.8	72.2	80.0	79.1	96.7	103.2	110.1	119.0	68.6

a 2000 Estimates include additional length data from sea sample trips.

Table 10a. Commercial landings at age (thousands of fish; metric tons)of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2000. (Partial Input data for Virtual Population Analysis).

	Age							
Year	1	2	3	4	5	6	7+	Total
Commercial Landings at Age in Numbers (000's)								
1982	30	1380	1633	1143	633	69	230	5118
1983	-	866	2357	1058	638	422	155	5496
1984	4	446	1240	1500	437	194	136	3957
1985	-	407	1445	991	630	128	136	3737
1986	-	84	2164	813	250	177	95	3583
1987	2	216	595	1109	277	66	79	2344
1988	-	160	1443	953	406	43	30	3035
1989	-	337	1583	1454	449	81	56	3960
1990	-	205	3425	2064	430	157	99	6380
1991	-	344	934	4161	851	143	79	6512
1992	-	313	530	484	2018	202	84	3631
1993	-	76	1487	641	129	457	36	2825
1994	-	29	1016	1135	288	72	86	2626
1995	-	218	880	1153	194	12	34	2491
1996	-	65	584	1738	347	45	10	2789
1997	-	53	438	435	832	68	8	1834
1998	-	94	390	542	165	193	10	1395
1999	-	-	178	192	90	27	36	523
2000	-	42	239	569	141	64	18	1074
2000a	-	42	233	523	112	34	77	1020
Commercial Landings at Age in Weight (Tons)								
1982	24	1595	2717	3160	3019	461	2606	13582
1983	-	1009	3913	2619	2410	2518	1512	13981
1984	3	516	2071	4080	1607	1145	1384	10816
1985	-	513	2523	2816	2814	705	1322	10693
1986	-	110	3976	2375	1153	1072	978	9664
1987	2	283	1001	3641	1340	451	809	7527
1988	-	203	2715	2311	2097	295	337	7958
1989	-	420	2811	4351	1737	325	683	10397
1990	-	219	5794	4687	1834	1200	1361	15095
1991	-	388	1463	10455	3520	1045	910	17781
1992	-	480	1019	1313	6175	1011	892	10891
1993	-	99	2809	1611	561	2819	387	8286
1994	-	43	1975	3576	991	442	851	7877
1995	-	361	1689	3200	997	96	455	6798
1996	-	110	1247	4131	1267	333	106	7194
1997	-	92	977	1308	2658	316	70	5421
1998	-	120	816	1614	693	812	104	4157
1999	-	-	315	520	361	155	285	1636
2000	-	68	578	1962	621	366	136	3730
2000a	-	68	542	1690	443	180	809	3730

a 2000 Estimates include additional length data from sea sample trips.

Table 10b. Mean weight (kg) and mean length (cm) at age of commercial landings of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2000. (Partial Input data for Virtual Population Analysis)

Year	Age 1	2	3	4	5	6	7+	Average
Commercial Landings Mean Weight (kg) at Age								
1982	0.801	1.156	1.664	2.764	4.770	6.739	11.330	2.654
1983	-	1.164	1.660	2.475	3.778	5.962	9.755	2.544
1984	0.589	1.159	1.670	2.721	3.677	5.898	10.176	2.731
1985	-	1.260	1.746	2.840	4.466	5.525	9.721	2.861
1986	-	1.304	1.837	2.923	4.619	6.067	10.295	2.698
1987	1.028	1.313	1.684	3.283	4.831	6.824	10.241	3.212
1988	-	1.268	1.881	2.426	5.166	6.767	11.233	2.622
1989	-	1.247	1.776	2.993	3.864	4.872	12.200	2.626
1990	-	1.071	1.692	2.271	4.265	7.645	13.747	2.366
1991	-	1.130	1.568	2.512	4.136	7.309	11.449	2.731
1992	-	1.533	1.922	2.714	3.061	5.000	10.614	2.999
1993	-	1.293	1.889	2.513	4.353	6.174	11.063	2.933
1994	-	1.450	1.943	3.151	3.444	6.132	10.018	3.000
1995	-	1.652	1.921	2.775	5.142	8.290	12.969	2.728
1996	-	1.687	2.136	2.376	3.648	7.376	11.647	2.580
1997	-	1.733	2.233	3.007	3.193	4.649	12.479	2.958
1998	-	1.277	2.089	2.979	4.191	4.211	10.262	2.980
1999	-	-	1.774	2.704	4.020	5.727	7.901	3.128
2000	-	1.627	2.415	3.447	4.399	5.702	7.553	3.474
2000a	-	1.627	2.323	3.233	3.971	5.298	10.491	3.657
Commercial Landings Mean Length (cm) at Age								
1982	43.2	48.3	53.8	63.4	76.8	86.1	101.6	59.9
1983	-	48.6	53.8	61.4	70.8	82.4	95.1	59.8
1984	39.0	48.4	54.1	63.4	69.7	81.8	98.0	61.6
1985	-	49.8	55.1	64.6	74.9	80.3	96.7	62.8
1986	-	50.3	55.9	65.0	75.4	82.6	98.4	61.6
1987	47.0	50.4	54.4	67.8	76.9	86.5	98.4	65.4
1988	-	50.1	56.4	61.1	78.7	86.4	103.1	61.4
1989	-	49.8	55.5	65.7	71.5	76.7	103.6	61.7
1990	-	47.5	54.8	60.0	73.7	90.0	108.8	59.2
1991	-	47.7	52.6	61.8	72.6	88.6	102.2	62.2
1992	-	53.1	56.6	62.9	65.6	77.0	100.4	64.3
1993	-	50.5	56.8	61.7	74.2	83.7	101.6	63.5
1994	-	52.4	57.2	66.6	68.1	82.7	97.6	64.4
1995	-	54.4	56.9	63.4	78.6	92.5	107.1	62.3
1996	-	54.6	58.8	60.7	69.3	88.9	103.5	61.8
1997	-	55.0	59.7	65.4	66.4	74.9	104.6	64.7
1998	-	50.1	58.4	65.1	72.9	72.7	97.7	64.4
1999	-	-	55.5	63.4	71.7	80.8	90.7	64.9
2000	-	54.1	60.8	66.2	74.6	82.1	89.5	68.3
2000a	-	54.1	60.2	64.8	72.2	80.0	100.0	68.6

a 2000 Estimates include additional length data from sea sample trips.

Table 11. Estimated number (000's) and weight (metric tons, live) of Atlantic cod caught by marine recreational fishermen from the Gulf of Maine stock, 1979 - 2000.[1]

Year	Total Cod Caught		Total Cod Retained (excluding those caught and released)				
	No. of Cod (000's)	Wt. of Cod (mt)	No. of Cod (000's)	Wt. of Cod (mt)	Sample Mean Weight (kg)	Number Measured	Percent of Total Landings
1979	2698	3466	not estimated		------- not estimated ------		
1980	2254	6860	not estimated		------- not estimated ------		
1981	2933	5944	2738	5549	1.595	380	30.7
1982	1833	2138	1736	2025	1.121	377	13.0
1983	1455	1388	1237	1180	1.323	882	7.8
1984	1098	1705	905	1405	1.520	596	11.5
1985	1671	1964	1471	1729	1.238	295	13.9
1986	1114	967	993	862	1.942	75	8.2
1987	2625	2317	2054	1813	1.738	320	19.4
1988	1487	2114	1300	1848	2.049	407	18.8
1989	1769	2690	1193	1814	1.736	404	14.9
1990	1725	3882	1247	2806	1.964	206	15.6
1991	1770	3635	1419	2914	2.004	370	14.1
1992	585	1154	332	655	2.001	922	5.7
1993	1564	2378	772	1174	1.831	290	12.4
1994	VTR P/C	1424	2578	VTR P/C	516	934	1.844	750	10.6
1995	393	1206	1799	247	517	771	1.716	1028	10.2
1996	278	812	2112	174	351	913	2.099	1068	11.3
1997	208	434	671	123	161	250	2.692	525	4.4
1998	299	331	1245	119	219	824	2.507	580	16.5
1999	226	539	1680	143	264	823	3.448	212	33.5
2000	241	1211	2853	160	487	1147	2.733	144	23.5

[1] 1981-2000 from Revised Marine Recreational Fishery Statistics Survey database expanded catch estimates.
2 VTR P/C are estimates of the number of cod caught and retained derived from VTR records of Part/Charter vessels.

Table 12a. Recreational landings at age (thousands of fish; metric tons) of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2000. (Partial input data for Virtual Population Analysis)

	Age							
Year	1	2	3	4	5	6	7+	Total
Recreational Landings at Age in Numbers (000's)								
1982	58	615	717	243	84	6	12	1735
1983	14	471	539	126	47	26	14	1237
1984	20	367	332	136	32	11	6	904
1985	49	582	666	131	35	5	1	1469
1986	26	124	586	116	25	20	95	992
1987	39	691	823	416	53	13	18	2053
1988	6	360	697	196	28	8	4	1299
1989	5	193	701	244	36	10	5	1194
1990	7	89	770	309	58	10	6	1249
1991	5	103	415	787	95	8	6	1419
1992	-	37	70	42	166	14	2	331
1993	1	76	511	146	11	24	3	772
1994	1	28	364	93	27	2	2	517
1995	-	61	272	171	10	2	-	516
1996	-	21	104	205	21	1	-	352
1997	-	8	56	31	62	4	-	161
1998	-	16	95	74	15	18	1	219
1999	1	8	113	81	39	10	13	264
2000	-	44	182	212	32	15	2	487
Recreational Landings at Age in Weight (Tons)								
1982	26	556	1018	559	373	33	132	2697
1983	6	412	751	272	158	173	168	1940
1984	9	304	480	332	103	47	78	1353
1985	18	494	899	305	115	20	5	1856
1986	11	103	970	304	99	114	1247	2848
1987	11	634	1184	1111	224	96	189	3449
1988	1	310	1049	425	107	26	26	1944
1989	3	208	1111	628	124	61	43	2178
1990	1	80	1147	727	212	66	63	2296
1991	1	119	582	1749	287	48	34	2820
1992	-	56	130	119	509	69	19	902
1993	1	73	841	292	33	108	41	1389
1994	-	35	593	214	56	7	17	922
1995	-	91	443	331	36	4	-	905
1996	-	32	193	406	54	7	3	695
1997	-	13	111	74	149	12	1	360
1998	-	27	207	195	51	59	5	544
1999	-	10	238	260	178	58	82	827
2000	-	69	371	603	118	96	9	1265

Table 12b. Mean weight (kg) and mean length (cm) at age of recreational landings of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2000. (Partial input data for Virtual Population Analysis)

	Age							
Year	1	2	3	4	5	6	7+	Average
Recreational Landings Mean Weight (kg) at Age								
1982	0.452	0.904	1.420	2.297	4.417	5.542	10.872	1.554
1983	0.410	0.874	1.394	2.159	3.350	6.635	12.136	1.568
1984	0.450	0.827	1.447	2.432	3.236	4.215	11.892	1.497
1985	0.371	0.848	1.349	2.330	3.298	3.780	5.2091	1.263
1986	0.413	0.832	1.655	2.630	3.884	5.600	12.995	2.871
1987	0.269	0.918	1.439	2.672	4.252	7.134	10.283	1.680
1988	0.184	0.860	1.504	2.165	3.816	3.443	6.067	1.497
1989	0.615	1.081	1.586	2.575	3.498	6.285	7.851	1.824
1990	0.148	0.900	1.489	2.354	3.640	6.587	13.783	1.838
1991	0.171	1.156	1.403	2.223	3.013	5.696	5.696	1.987
1992	0.456	1.495	1.858	2.832	3.074	4.820	7.221	2.725
1993	0.582	0.959	1.645	2.001	3.131	4.566	11.797	1.799
1994	0.183	1.240	1.632	2.302	2.046	4.613	8.947	1.783
1995	-	1.501	1.627	1.931	3.404	1.871	6.062	1.754
1996	0.582	1.541	1.853	1.979	2.706	7.829	12.378	1.974
1997	0.327	1.585	1.989	2.376	2.410	3.104	9.111	2.235
1998	0.456	1.724	2.183	2.640	3.376	3.261	3.526	2.482
1999	0.335	1.204	2.105	3.225	4.572	5.698	6.598	3.131
2000	-	1.571	2.036	2.841	3.652	6.543	4.271	2.598
Recreational Landings Mean Length (cm) at Age								
1982	33.9	42.9	50.2	59.0	74.1	79.9	98.4	49.9
1983	33.5	42.9	50.1	57.9	67.1	84.5	101.2	49.9
1984	34.2	42.0	50.5	60.1	66.1	71.0	100.1	49.3
1985	32.0	42.4	49.3	60.0	67.0	70.1	78.9	47.5
1986	33.7	41.6	53.3	62.0	70.8	80.4	113.4	59.1
1987	27.8	43.4	50.5	62.5	72.3	86.0	98.6	51.3
1988	26.2	42.8	51.3	58.2	69.9	66.2	81.3	50.5
1989	38.4	46.2	52.5	61.6	67.8	83.9	97.5	54.2
1990	23.7	43.1	51.1	59.8	69.7	84.4	110.0	53.9
1991	24.9	47.0	50.4	58.5	64.5	80.0	80.9	55.8
1992	35.0	51.3	54.7	63.1	64.9	75.4	86.6	61.6
1993	38.0	44.3	53.2	56.6	64.9	72.8	103.1	53.9
1994	26.3	48.2	53.2	59.1	57.2	71.7	95.1	54.4
1995	-	51.8	53.2	55.9	67.1	55.1	83.0	54.2
1996	38.0	52.3	55.4	56.6	62.0	90.1	106.3	56.4
1997	32.4	52.3	56.9	60.0	64.4	72.8	95.7	60.6
1998	35.0	54.3	58.6	62.2	67.1	65.9	68.6	60.7
1999	33.0	47.4	57.8	66.6	74.4	80.0	84.5	64.9
2000	-	52.6	57.0	63.5	68.8	83.5	72.1	61.1

Table 13a. Total (commercial and recreational)landings at age (thousands of fish; metric tons) of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2000. (Input data for Virtual Population Analysis)

	Age							
Year	1	2	3	4	5	6	7+	Total
Total Landings at Age in Numbers (000's)								
1982	88	1995	2350	1386	717	75	242	6853
1983	14	1337	2896	1184	685	448	169	6733
1984	24	813	1572	1636	469	205	142	4861
1985	49	989	2111	1122	665	133	137	5206
1986	26	208	2750	929	275	197	190	4575
1987	41	907	1418	1525	330	79	97	4397
1988	6	520	2140	1149	434	51	34	4334
1989	5	530	2284	1698	485	91	61	5154
1990	7	294	4195	2373	488	167	105	7629
1991	5	447	1349	4948	946	151	85	7931
1992	-	350	600	526	2184	218	86	3962
1993	1	152	1998	787	140	481	39	3597
1994	1	57	1380	1228	315	74	88	3143
1995	-	279	1152	1324	204	14	34	3007
1996	-	86	688	1943	368	46	10	3141
1997	-	61	494	466	894	72	8	1995
1998	-	110	485	616	180	211	11	1614
1999[1]	1	8	563	566	267	78	104	1586
2000[2]	-	97	485	934	211	96	25	1849
Total Landings at Age in Weight (Tons)								
1982	50	2151	3735	3719	3392	494	2738	16279
1983	6	1421	4664	2891	2568	2691	1680	15921
1984	12	820	2551	4412	1710	1192	1462	12169
1985	18	1007	3442	3121	2929	725	1327	12549
1986	11	213	4946	2679	1252	1186	2225	12512
1987	13	917	2185	4752	1564	547	998	10976
1988	1	513	3764	2736	2204	321	363	9902
1989	3	628	3922	4979	1861	386	726	12575
1990	1	299	6941	5414	2046	1266	1424	17391
1991	1	507	2045	12204	3807	1093	944	20601
1992	-	536	1149	1432	6684	1080	911	11793
1993	1	172	3650	1903	594	2927	428	9675
1994	-	78	2568	3790	1047	449	868	8799
1995	-	452	2132	3531	1033	100	455	7703
1996	-	142	1440	4537	1321	340	109	7889
1997	-	105	1088	1382	2807	328	71	5781
1998	-	147	1023	1809	744	871	109	4701
1999[1]	-	10	1036	1573	1093	449	801	4963
2000[2]	-	156	1103	3090	905	559	181	5996

1. Includes 2,500 mt of estimated discards
2. Includes 1,000 mt of estimated discards.

Table 13b. Mean weight (kg) and mean length (cm) at age of total landings (commercial and recreational) of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2000. (Input data for Virtual Population Analysis)

	Age							
Year	1	2	3	4	5	6	7+	Average
Total Landings Mean Weight (kg) at Age								
1982	0.568	1.078	1.589	2.683	4.731	6.587	11.314	2.375
1983	0.429	1.063	1.610	2.442	3.749	6.007	9.941	2.365
1984	0.500	1.009	1.623	2.697	3.646	5.815	10.296	2.503
1985	0.367	1.018	1.621	2.782	4.405	5.451	9.686	2.410
1986	0.423	1.024	1.799	2.884	4.553	6.020	11.711	2.735
1987	0.317	1.011	1.541	3.116	4.739	6.924	10.289	2.496
1988	0.167	0.987	1.759	2.381	5.078	6.294	10.676	2.285
1989	0.600	1.185	1.717	2.932	3.837	4.242	11.902	2.440
1990	0.143	1.017	1.655	2.282	4.193	7.581	13.562	2.280
1991	0.171	1.134	1.516	2.466	4.024	7.238	11.106	2.598
1992	0.468	1.531	1.915	2.722	3.060	5.000	10.593	2.977
1993	1.000	1.132	1.627	2.418	4.243	6.085	10.974	2.690
1994	0.468	1.368	1.861	3.086	3.324	6.068	9.864	2.800
1995	0.468	1.620	1.851	2.667	5.064	7.143	13.382	2.562
1996	0.468	1.651	2.093	2.335	3.590	7.391	10.900	2.512
1997	0.468	1.721	2.202	2.966	3.140	4.556	8.875	2.898
1998	0.466	1.336	2.109	2.937	4.133	4.128	9.909	2.913
1999	0.331	1.250	1.841	2.776	4.100	5.736	7.702	3.129
2000	0.468	1.600	2.274	3.310	4.291	5.811	7.307	3.243
Total Landings Mean Length (cm) at Age								
1982	37.1	46.6	52.7	62.6	76.5	85.6	101.4	57.4
1983	33.5	46.6	53.1	61.0	70.5	82.5	95.6	58.0
1984	28.5	45.5	53.3	63.1	69.5	81.2	98.1	59.3
1985	32.0	45.4	53.3	64.1	74.5	79.9	96.6	58.5
1986	33.7	45.1	55.3	64.6	75.0	82.4	105.9	61.1
1987	26.4	45.1	52.1	66.4	76.2	86.4	98.4	58.8
1988	26.2	45.0	54.7	60.6	78.1	83.2	100.5	58.1
1989	38.4	48.5	54.6	65.1	71.2	77.5	103.1	60.0
1990	23.7	46.2	54.1	60.0	73.2	89.7	108.9	58.3
1991	24.9	47.5	51.9	61.3	71.8	88.1	100.7	61.1
1992	31.3	52.9	56.4	62.9	65.5	76.9	100.1	64.1
1993	38.0	47.4	55.9	60.8	73.5	83.2	101.7	61.4
1994	26.3	50.3	56.1	66.0	67.2	82.4	97.5	62.8
1995	31.2	53.8	56.0	62.4	78.0	87.2	107.1	60.9
1996	31.2	54.0	58.3	60.3	68.9	88.9	103.5	61.2
1997	31.2	54.6	59.4	65.0	66.3	74.8	104.6	64.4
1998	35.0	50.7	58.4	64.8	72.4	72.1	95.1	63.9
1999	33.0	47.4	56.0	63.9	72.1	80.7	89.9	64.9
2000	31.2	53.4	59.4	65.6	73.7	82.3	88.1	66.4

Table 14. Mean weight at age (kg) at the beginning of the year (January 1) for Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2001. Values derived from total landings (commercial and recreational) mean weight-at-age data (mid-year) using procedures described by Rivard (1980).

	Age										
Year	1	2	3	4	5	6	7	8	9	10	11+
1982	0.415	0.882	1.282	2.270	4.199	5.582	8.246	9.853	14.071	11.713	18.456
1983	0.280	0.777	1.317	1.970	3.172	5.331	6.256	9.701	10.010	11.867	17.813
1984	0.350	0.658	1.313	2.084	2.984	4.669	6.957	7.465	11.646	11.864	15.028
1985	0.220	0.713	1.279	2.125	3.447	4.458	6.826	9.544	10.468	13.135	14.523
1986	0.274	0.613	1.353	2.162	3.559	5.150	6.509	8.902	11.824	12.141	16.554
1987	0.180	0.654	1.256	2.368	3.697	5.615	7.339	8.767	11.744	13.553	14.596
1988	0.063	0.559	1.334	1.915	3.978	5.461	8.233	9.939	12.245	14.723	20.356
1989	0.461	0.445	1.302	2.271	3.023	4.641	7.919	10.889	12.835	16.499	21.521
1990	0.051	0.781	1.400	1.979	3.506	5.393	7.232	10.438	13.388	14.795	20.295
1991	0.057	0.403	1.242	2.020	3.030	5.509	8.586	11.501	13.520	19.112	21.885
1992	0.301	0.512	1.474	2.031	2.747	4.486	8.362	10.962	12.873	16.08	18.479
1993	0.855	0.728	1.672	2.152	3.398	4.315	7.071	11.518	14.786	14.856	18.479
1994	0.252	1.170	1.451	2.374	2.835	5.074	7.168	11.237	12.929	19.436	19.369
1995	0.249	0.871	1.591	2.228	3.953	4.873	8.121	10.366	14.405	16.099	18.479
1996	0.244	0.879	1.841	2.079	3.094	6.118	9.303	11.326	13.190	16.422	18.479
1997	0.277	0.897	1.907	2.492	2.708	4.044	7.938	11.845	13.281	14.716	21.356
1998	0.286	0.791	1.905	2.543	3.501	3.600	6.300	10.018	16.134	17.557	18.479
1999	0.151	0.765	1.568	2.420	3.470	4.869	5.527	8.878	12.138	17.829	18.479
2000	0.301	0.728	1.686	2.469	3.451	4.881	5.412	8.212	10.231	13.170	17.514
2001	0.226	0.728	3.518	3.067	4.438	5.335	6.082	4.834	10.525	12.569	17.514
Avg 1982-1998	0.283	0.725	1.466	2.180	3.343	4.960	7.551	10.251	12.903	14.975	18.479
Avg 1996-1998	0.269	0.856	1.884	2.371	3.101	4.587	7.847	11.063	14.202	16.232	19.438

Table 15. Standardized stratified mean catch per tow in numbers and weight (kg) for Atlantic cod from NEFSC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine (Strata 26-30 and 36-40), 1963 - 2000 [a,b]

	Gulf of Maine [c]			
	Spring		Autumn	
Year	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	5.92	17.9
1964	-	-	4.00	22.8
1965	-	-	4.49	12.0
1966	-	-	3.78	12.9
1967	-	-	2.56	9.2
1968	5.44	17.9	4.39	19.4
1969	3.25	13.2	2.76	15.4
1970	2.21	11.1	4.90	16.4
1971	1.43	7.0	4.37	16.5
1972	2.06	8.0	9.31	13.0
1973	7.54	18.8	4.46	8.7
1974	2.91	7.4	4.33	9.0
1975	2.51	6.0	6.15	8.6
1976	2.78	7.6	2.15	6.7
1977	3.88	8.5	3.08	10.2
1978	2.06	7.7	5.75	12.9
1979	4.27	9.5	3.49	17.5
1980	2.15	6.2	7.04	14.2
1981	4.86	10.8	2.42	8.1
1982	3.75	8.6	7.77	16.1
1983	3.91	10.5	4.22	8.8
1984	3.40	5.8	2.42	8.8
1985	2.52	7.7	2.92	8.5
1986	1.96	3.6	1.95	5.1
1987	1.68	3.0	2.98	3.4
1988	3.13	3.3	5.90	6.6
1989	2.26	2.5	4.65	4.6
1990	2.36	3.1	2.99	4.9
1991	2.39	2.9	1.25	2.8
1992	2.41	8.7	1.43	2.4
1993	2.50	5.9	1.23	1.0
1994	1.27	2.4	2.14	2.7
1995	1.91	2.4	2.01	3.7
1996	2.46	5.4	1.32	2.4
1997	2.19	5.6	0.87	1.9
1998	1.71	4.2	0.84	1.5
1999	2.30	5.1	1.81	3.5
2000	3.08	3.2	2.60	4.7

[a] During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portugeuse 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).

[b] 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 differences.

[c] In the Gulf of Maine, spring surveys during 1980-1982, 1989-1991 and 1994, and autumn surveys during 1977-1978, 1980, 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 ALBTATROSS IV equivalents. Conversion coefficients 0.79 (number) and 0.67 (weight) were used in this standardization (NEFSC 1991).

Table 16. Estimates of instantaneous total mortality (Z) and fishing mortality (F)[1] for Gulf of Maine Atlantic cod, 1964 - 2000, derived from NEFSC offshore spring and autumn bottom trawl survey data.[2]

Time Period	Gulf of Maine					
	Spring		Autumn		Geometric Mean	
	Z	F	Z	F	Z	F
1964-1967	-	-	0.39	0.19	0.39	0.19
1968-1976	0.36	0.16	0.44	0.24	0.40	0.20[3]
1977-1982	0.56	0.36	0.44	0.37	0.50	0.30[4]
1983-1987	0.93	0.73	1.12	0.92	1.02	0.82
1988-1992	1.24	1.04	0.86	0.66	1.03	0.83[5]
1993-1997	0.73	0.53	1.05	0.85	0.88	0.68
1998-1999	0.81	0.61	N/a	N/a	0.81	0.61

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

[2] Estimates derived from:

Spring: ln (Σ age 4+ for year i to j/ Σ age 5+ for years i+1 to j+1).
Autumn: ln (Σ age 3+ for years i-1 to j-1/ Σ age 4+ for years i to j).

[3] Excludes autumn 1967-1968 data (3+/4+) since these gave large negative Z value.

[4] Excludes autumn 1976-1977 data (3+/4+) since these gave large negative Z value.

[5] Excludes spring 1991-1992 data (4+/5+) since these gave unreasonably low Z value.

Table 17. Comparative VPA Results for Gulf of Maine Cod Assuming 3 Discard scenarios in 1999 and 2000.

Discard Option 1: Lower End of Range

1999 Discards = 2,000 mt
2000 Discards = 1,000 mt

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 133.743222421604
Mean Square Residuals: 0.45184

	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 2	4.61E+03	2.26E+03	2.04E+00	0.49
N 3	6.28E+03	1.97E+03	3.18E+00	0.31
N 4	2.01E+03	5.86E+02	3.44E+00	0.29
N 5	8.10E+02	3.29E+02	2.46E+00	0.41
N 6	1.85E+02	8.97E+01	2.06E+00	0.49

Discard Option 2: Middle of the Range.

1999 Discards = 2,500 mt
2000 Discards = 1,000 mt

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 134.032264575886
Mean Square Residuals: 0.45281

	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 2	4.63E+03	2.27E+03	2.04E+00	0.49
N 3	6.31E+03	1.99E+03	3.18E+00	0.31
N 4	2.02E+03	5.89E+02	3.44E+00	0.29
N 5	8.03E+02	3.30E+02	2.43E+00	0.41
N 6	1.76E+02	8.79E+01	2.01E+00	0.50

Discard Option 3: Upper End of Range

1999 Discards = 3,000 mt
2000 Discards = 2,000 mt

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 134.72526691389
Mean Square Residuals: 0.45515

	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 2	4.67E+03	2.30E+03	2.03E+00	0.49
N 3	6.36E+03	2.01E+03	3.17E+00	0.32
N 4	1.99E+03	5.94E+02	3.36E+00	0.30
N 5	7.32E+02	3.29E+02	2.23E+00	0.45
N 6	1.56E+02	8.42E+01	1.86E+00	0.54

Table 17 (Continued).

STOCK NUMBERS (Jan 1) in thousands - D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

Lower End of Range

Ages	1996	1997	1998	1999	2000	2001
1+	12303	11878	12375	18196	19150	14007

Middle of Range

Ages	1996	1997	1998	1999	2000	2001
1+	12480	12095	12571	18399	19200	14048

Upper End of Range

Ages	1996	1997	1998	1999	2000	2001
1+	12766	12566	13007	18842	19464	14004

FISHING MORTALITY - D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

Lower End of Range

Ages	1996	1997	1998	1999	2000
4,5	1.01	0.89	0.73	0.70	0.71

Middle of Range

Ages	1996	1997	1998	1999	2000
4,5	1.01	0.88	0.70	0.77	0.73

Upper End of Range

Ages	1996	1997	1998	1999	2000
4,5	1.00	0.85	0.67	0.80	0.87

Table 18. Final VPA Results for Gulf of Maine Cod, 1982-2000

STOCK NUMBERS (Jan 1) in thousands - D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

	1982	1983	1984	1985	1986	1987	1988
1	7769	7539	10464	7004	10161	12538	25198
2	10891	6281	6160	8545	5690	8296	10228
3	5359	7112	3933	4307	6101	4471	5971
4	3026	2262	3202	1797	1616	2507	2377
5	1796	1223	780	1142	456	483	673
6	170	822	382	214	333	125	97
7	541	305	260	216	315	150	63
1+	29552	25543	25180	23227	24674	28569	44607

	1989	1990	1991	1992	1993	1994	1995
1	4302	4021	6992	6411	9327	3325	3386
2	20625	3518	3286	5720	5249	7635	2721
3	7903	16406	2614	2286	4367	4160	6200
4	2953	4404	9637	920	1328	1767	2157
5	907	881	1459	3413	277	375	336
6	158	303	280	338	818	100	22
7	104	188	155	132	65	116	53
1+	36951	29721	24421	19219	21430	17478	14876

	1996	1997	1998	1999	2000	2001
1	3020	4745	4498	9549	5656	00
2	2773	2473	3885	3683	7817	4630
3	1975	2192	1969	3081	3008	6312
4	4033	995	1348	1174	2013	2024
5	568	1544	393	546	449	803
6	90	132	455	159	206	176
7	19	14	23	209	53	102
1+	12480	12095	12571	18399	19200	14048

Table 18 (Continued).

FISHING MORTALITY - D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

	1982	1983	1984	1985	1986	1987	1988
1	0.01	0.00	0.00	0.01	0.00	0.00	0.00
2	0.23	0.27	0.16	0.14	0.04	0.13	0.06
3	0.66	0.60	0.58	0.78	0.69	0.43	0.50
4	0.71	0.86	0.83	1.17	1.01	1.12	0.76
5	0.58	0.96	1.09	1.03	1.10	1.41	1.25
6	0.67	0.92	0.90	1.16	1.06	1.20	0.87
7	0.67	0.92	0.90	1.16	1.06	1.20	0.87
F(4,5)	0.64	0.91	0.96	1.10	1.05	1.26	1.01
F(wb)	0.47	0.60	0.51	0.59	0.54	0.49	0.38

	1989	1990	1991	1992	1993	1994	1995
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.03	0.10	0.16	0.07	0.03	0.01	0.12
3	0.38	0.33	0.84	0.34	0.70	0.46	0.23
4	1.01	0.91	0.84	1.00	1.06	1.46	1.13
5	0.89	0.95	1.26	1.23	0.82	2.62	1.11
6	1.01	0.94	0.91	1.22	1.05	1.70	1.17
7	1.01	0.94	0.91	1.22	1.05	1.70	1.17
F(4,5)	0.95	0.93	1.05	1.11	0.94	2.04	1.12
F(wb)	0.30	0.49	0.78	0.53	0.40	0.44	0.41

	1996	1997	1998	1999	2000
1	0.00	0.00	0.00	0.00	0.00
2	0.03	0.03	0.03	0.00	0.01
3	0.49	0.29	0.32	0.23	0.20
4	0.76	0.73	0.70	0.76	0.72
5	1.26	1.02	0.71	0.78	0.73
6	0.83	0.92	0.72	0.78	0.73
7	0.83	0.92	0.72	0.78	0.73
F(4,5)	1.01	0.88	0.70	0.77	0.73
F(wb)	0.50	0.40	0.32	0.30	0.23

MEAN BIOMASS (using catch mean weights at age)

	1982	1983	1984	1985	1986	1987	1988
1	3975	2928	4736	2321	3890	3596	3813
2	9560	5331	5225	7385	5177	7148	8899
3	5705	7889	4426	4451	7270	5108	7540
4	5340	3399	5389	2721	2706	4345	3632
5	5895	2709	1597	2891	1164	1138	1804
6	747	2966	1346	640	1139	464	373
7	4089	1821	1624	1148	2097	829	415
1+	35312	27044	24343	21557	23444	22628	26477

	1989	1990	1991	1992	1993	1994	1995
1	2338	521	1083	2719	8453	1410	1436
2	21846	3095	3125	7675	5302	9429	3772
3	10275	21056	2459	3378	5250	5676	9327
4	5022	6083	14785	1457	1824	2660	3177
5	2114	2197	3085	5558	737	416	946
6	389	1374	1224	902	2841	272	87
7	718	1519	1040	745	408	510	387
1+	42702	35845	26800	22434	24814	20372	19133

Table 18 (Continued).

	1996	1997	1998	1999	2000	
1	1281	2013	1908	2864	2399	
2	4080	3806	4632	4167	11260	
3	2992	3822	3242	4619	5647	
4	6054	1922	2606	2093	4358	
5	1074	2800	1068	1429	1252	
6	417	362	1230	580	779	
7	132	77	152	1023	252	
1+	16028	14802	14838	16775	25946	00

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

	1982	1983	1984	1985	1986	1987	1988
1	218	143	248	60	108	87	61
2	2326	1174	993	2765	1608	2465	2629
3	3630	5002	2764	4445	6762	4801	6729
4	5197	3283	4945	3039	2857	4768	3877
5	6421	3100	1821	3204	1308	1365	2102
6	820	3633	1483	763	1390	554	442
7	5296	2513	2229	1672	2991	1221	567
1+	23908	18848	14484	15947	17024	15262	16406

	1989	1990	1991	1992	1993	1994	1995
1	77	22	42	205	848	32	33
2	4241	732	349	784	1029	3279	854
3	8868	11771	1527	1723	3516	4815	8171
4	5481	5872	13262	1238	1876	3149	3810
5	2284	2372	3221	6871	738	665	1066
6	599	1327	1255	1173	2808	370	87
7	1012	2104	1430	1101	580	831	567
1+	22561	24200	21088	13096	11396	13141	14587

	1996	1997	1998	1999	2000
1	29	51	50	56	66
2	891	812	1123	1035	2087
3	2887	3431	3063	4005	4225
4	7074	2102	2919	2395	4221
5	1379	3411	1182	1610	1325
6	465	444	1407	656	860
7	177	106	199	1364	331
1+	12901	10357	9943	11121	13114

Table 19. Yield and spawning stock biomass per recruit estimates and input data for Gulf of Maine cod.

```
   The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
    PC Ver.2.0 [Method of Thompson and Bell (1934)] 1-Jan-1999
              ---------------------------------------
              Run Date: 28- 6-2001;  Time: 10:23:22.61
 GULF OF MAINE COD (5Y) -  2001 UPDATED AVE WTS, FPAT AND MAT VECTORS
```

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: 11
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
==> yrcodgma.dat

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Stock
1	.0000	1.0000	.0400	.441	.283
2	.0134	1.0000	.3800	1.229	.725
3	.2867	1.0000	.8900	1.782	1.466
4	.9889	1.0000	.9900	2.694	2.180
5	1.0000	1.0000	1.0000	4.089	3.343
6	1.0000	1.0000	1.0000	6.031	4.960
7	1.0000	1.0000	1.0000	9.003	7.551
8	1.0000	1.0000	1.0000	11.615	10.251
9	1.0000	1.0000	1.0000	14.175	12.903
10	1.0000	1.0000	1.0000	16.411	14.975
11+	1.0000	1.0000	1.0000	18.479	18.479

Summary of Yield per Recruit Analysis for:
GULF OF MAINE COD (5Y) - 2001 UPDATED AVE WTS, FPAT AND MAT VECTORS

```
 Slope of the Yield/Recruit Curve at F=0.00: -->   27.9322
   F level at slope=1/10 of the above slope (F0.1): ----->    .153
     Yield/Recruit corresponding to F0.1: ----->    1.6797
   F level to produce Maximum Yield/Recruit (Fmax): ----->    .267
     Yield/Recruit corresponding to Fmax: ----->    1.8015
   F level at 20 % of Max Spawning Potential (F20): ----->    .363
     SSB/Recruit corresponding to F20: -------->    5.6681
```

Listing of Yield per Recruit Results for:
GULF OF MAINE COD (5Y) - 2001 UPDATED AVE WTS, FPAT AND MAT VECTORS

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.00	.00000	.00000	5.5167	30.0615	3.8396	28.3409	100.00
	.05	.11706	.97975	4.9338	21.7023	3.2551	20.0950	70.90
	.10	.19534	1.44901	4.5447	16.5838	2.8643	15.0665	53.16
	.15	.25146	1.67194	4.2664	13.2304	2.5843	11.7852	41.58
F0.1	.15	.25406	1.67973	4.2535	13.0825	2.5714	11.6408	41.07
	.20	.29373	1.76902	4.0573	10.9224	2.3736	9.5355	33.65
	.25	.32676	1.79997	3.8943	9.2722	2.2090	7.9325	27.99
Fmax	.27	.33641	1.80149	3.8469	8.8186	2.1610	7.4929	26.44
	.30	.35333	1.79603	3.7637	8.0552	2.0767	6.7541	23.83
	.35	.37519	1.77411	3.6565	7.1343	1.9679	5.8648	20.69
F20%	.36	.38029	1.76668	3.6315	6.9303	1.9426	5.6681	20.00
	.40	.39351	1.74357	3.5669	6.4217	1.8768	5.1784	18.27
	.45	.40912	1.70964	3.4908	5.8596	1.7992	4.6381	16.37
	.50	.42259	1.67520	3.4254	5.4087	1.7323	4.2053	14.84
	.55	.43435	1.64181	3.3686	5.0413	1.6740	3.8532	13.60
	.60	.44472	1.61027	3.3186	4.7380	1.6225	3.5626	12.57
	.65	.45394	1.58092	3.2743	4.4844	1.5768	3.3199	11.71
	.70	.46220	1.55386	3.2348	4.2700	1.5358	3.1147	10.99
	.75	.46966	1.52903	3.1992	4.0868	1.4989	2.9394	10.37
	.80	.47643	1.50633	3.1670	3.9290	1.4653	2.7882	9.84
	.85	.48261	1.48560	3.1378	3.7917	1.4347	2.6567	9.37
	.90	.48828	1.46666	3.1110	3.6714	1.4067	2.5413	8.97
	.95	.49351	1.44936	3.0865	3.5653	1.3808	2.4393	8.61
	1.00	.49835	1.43352	3.0638	3.4710	1.3569	2.3486	8.29

Table 20a. Starting conditions and input data for short-term (2001-2003) and long-term (2001-2025) stochastic stock biomass and catch projections for Gulf of Maine cod.

Input for Projections:

Number of Years: 3; Initial Year: 2001; Final Year: 2003
Number of Ages : 7; Age at Recruitment: 1; Last Age: 7
Natural Mortality is assumed Constant over time at: .200
Proportion of F before spawning: .1667
Proportion of M before spawning: .1667
Last age is a PLUS group;

Age-specific Input data for Projection # 1

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Stock
1	.0010	1.0000	.0400	0.441	0.283
2	.0134	1.0000	.3800	1.229	0.725
3	.2867	1.0000	.8900	1.782	1.466
4	1.0000	1.0000	.9900	2.694	2.180
5	1.0000	1.0000	1.0000	4.089	3.343
6	1.0000	1.0000	1.0000	6.031	4.960
7+	1.0000	1.0000	1.0000	10.881	10.881

Table 20b. Results of short-term stochastic stock biomass and catch projections for Gulf of Maine cod.

Projections for 2001-2003; F(2001)=0.73, Basis: Status quo 2000 point estimate.
Recruitment (age 1) 2001 and 2002 year classes derived from Beverton-Holts spawning stock-recruitment relationship based on 1981-1999 year classes.

SSB was estimated to be 13,100 t in 2000.

2001				2002		2003
F	Catch	SSB	F	Catch	SSB	SSB
0.73	7540	18210	$F_{0.1}$ =0.15	2619	21339	29819
0.73	7540	18210	F_{msy} =0.23	3884	21122	28153
0.73	7540	18210	F_{max} =0.27	4482	21015	27374
0.73	7540	18210	F_{SQ} =0.73	10107	19862	20401

Table 21. Long-term (25 yr) Projections for Gulf of Maine cod at F0.1 (0.15), Fmsy (0.23) and Fmax (0.27).

A) F0.1 = 0.15

PROJECTION RUN: GM Cod F0.1 25 yr projection
INPUT FILE: gmc2001mod5.in
OUTPUT FILE: gmc2001mod5_F01.out
RECRUITMENT MODEL: 5
NUMBER OF SIMULATIONS: 100

F-BASED PROJECTIONS
TIME-VARYING F

YEAR	F
2001	0.730
2002	0.150
2003	0.150
2004	0.150
2005	0.150
2006	0.150
2007	0.150
2008	0.150
2009	0.150
2010	0.150
2011	0.150
2012	0.150
2013	0.150
2014	0.150
2015	0.150
2016	0.150
2017	0.150
2018	0.150
2019	0.150
2020	0.150
2021	0.150
2022	0.150
2023	0.150
2024	0.150
2025	0.150

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2001	12.397	13.705	14.578	16.323	18.210	20.442	22.278	23.559	27.247
2002	14.141	16.331	17.389	19.059	21.339	24.107	26.764	28.120	31.894
2003	21.298	23.704	25.015	27.087	29.819	33.068	36.313	38.050	42.339
2004	28.288	31.246	32.752	35.553	39.049	42.958	46.889	49.369	54.707
2005	37.130	40.900	42.899	46.704	51.394	56.591	61.670	65.011	72.334
2006	42.726	47.054	49.427	53.691	58.943	64.873	70.803	74.464	82.868
2007	49.741	54.075	56.505	60.864	66.118	72.062	77.897	81.714	89.707
2008	54.106	58.988	61.735	66.724	72.684	79.418	86.107	90.334	99.409
2009	58.281	63.596	66.501	71.888	78.380	85.547	92.755	97.432	106.650
2010	62.379	67.842	70.975	76.586	83.416	90.955	98.410	103.306	113.095
2011	65.782	71.580	74.800	80.635	87.742	95.516	103.260	108.446	118.213
2012	68.706	74.659	77.968	83.999	91.278	99.290	107.195	112.334	122.463
2013	71.004	77.136	80.524	86.698	94.103	102.236	110.348	115.427	126.060
2014	72.983	79.115	82.648	88.784	96.288	104.609	112.722	117.933	128.586
2015	74.684	80.698	84.263	90.465	98.054	106.421	114.597	119.894	130.496
2016	75.712	81.900	85.502	91.744	99.415	107.781	115.961	121.203	131.929
2017	76.708	82.924	86.460	92.794	100.514	108.842	117.100	122.351	132.953
2018	77.442	83.650	87.220	93.605	101.306	109.682	118.078	123.300	133.940
2019	78.078	84.175	87.783	94.260	101.951	110.303	118.783	124.111	134.857
2020	78.301	84.668	88.256	94.707	102.464	110.815	119.242	124.453	135.459
2021	78.750	85.087	88.614	95.070	102.831	111.231	119.625	124.930	135.835
2022	78.917	85.276	88.961	95.390	103.080	111.512	119.894	125.364	136.318
2023	79.225	85.615	89.163	95.583	103.287	111.723	120.182	125.668	136.640
2024	79.481	85.722	89.296	95.726	103.428	111.909	120.423	125.786	137.046
2025	79.584	85.928	89.436	95.833	103.584	112.097	120.425	125.875	136.951

PERCENTILES OF TOTAL JANUARY 1 STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2001	16.976	19.063	19.892	21.970	24.424	27.174	29.536	31.219	35.279
2002	19.197	21.392	22.507	24.480	27.054	30.064	32.968	34.695	38.753
2003	26.874	29.583	31.037	33.601	36.812	40.495	44.077	46.357	51.159
2004	35.066	38.422	40.217	43.501	47.532	52.011	56.418	59.285	65.393
2005	45.691	50.077	52.454	56.778	62.088	67.973	73.754	77.477	85.465
2006	52.471	57.414	60.175	65.057	71.017	77.710	84.422	88.624	97.959
2007	60.604	65.699	68.387	73.397	79.372	86.073	92.689	96.979	106.093
2008	65.992	71.506	74.744	80.463	87.322	94.981	102.707	107.591	118.017
2009	70.880	76.841	80.250	86.439	93.849	102.047	110.266	115.564	125.960
2010	75.360	81.629	85.201	91.616	99.401	107.956	116.491	122.036	133.111
2011	79.137	85.670	89.283	95.952	104.020	112.782	121.631	127.450	138.541
2012	82.167	88.909	92.692	99.538	107.772	116.824	125.749	131.457	142.792
2013	84.692	91.534	95.417	102.342	110.687	119.849	128.893	134.657	146.269
2014	86.715	93.614	97.538	104.469	112.948	122.244	131.263	137.211	149.056
2015	88.299	95.234	99.223	106.213	114.774	124.039	133.237	139.043	150.888
2016	89.460	96.497	100.452	107.478	116.120	125.482	134.559	140.496	152.513
2017	90.423	97.471	101.468	108.531	117.183	126.479	135.760	141.710	153.493
2018	91.251	98.131	102.185	109.347	118.019	127.323	136.609	142.522	154.377
2019	91.801	98.672	102.774	109.974	118.606	127.925	137.359	143.204	155.109
2020	91.987	99.110	103.177	110.408	119.086	128.439	137.736	143.568	155.560
2021	92.271	99.550	103.515	110.745	119.419	128.747	138.156	144.001	156.056
2022	92.574	99.761	103.804	111.072	119.641	129.033	138.326	144.435	156.725
2023	92.858	100.093	104.066	111.192	119.849	129.264	138.560	144.662	156.808
2024	93.145	100.252	104.145	111.381	119.977	129.412	138.848	144.740	157.222
2025	93.202	100.354	104.318	111.460	120.146	129.645	138.921	144.856	157.002

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2001	4.869	5.651	5.970	6.730	7.540	8.371	9.204	9.823	10.962
2002	1.709	1.947	2.070	2.307	2.619	2.939	3.275	3.458	4.087
2003	2.477	2.832	3.027	3.332	3.722	4.207	4.717	4.968	5.549
2004	3.633	4.068	4.259	4.596	5.058	5.580	6.096	6.417	7.106
2005	4.765	5.282	5.550	6.058	6.690	7.402	8.101	8.568	9.551
2006	5.538	6.102	6.425	6.997	7.717	8.519	9.328	9.834	10.996
2007	6.454	7.028	7.368	7.964	8.693	9.525	10.348	10.884	12.058
2008	7.043	7.707	8.089	8.764	9.594	10.540	11.477	12.102	13.371
2009	7.634	8.346	8.763	9.500	10.398	11.407	12.415	13.061	14.384
2010	8.172	8.938	9.376	10.152	11.106	12.160	13.225	13.898	15.301
2011	8.657	9.467	9.904	10.709	11.707	12.799	13.886	14.598	15.977
2012	9.073	9.890	10.348	11.181	12.195	13.323	14.436	15.169	16.604
2013	9.381	10.224	10.694	11.553	12.585	13.727	14.856	15.606	17.091
2014	9.648	10.497	10.986	11.846	12.889	14.053	15.193	15.939	17.447
2015	9.867	10.728	11.212	12.077	13.135	14.296	15.450	16.201	17.705
2016	10.041	10.883	11.381	12.251	13.324	14.501	15.649	16.403	17.900
2017	10.136	11.011	11.514	12.398	13.471	14.638	15.810	16.557	18.038
2018	10.281	11.127	11.623	12.511	13.587	14.758	15.927	16.665	18.168
2019	10.346	11.203	11.692	12.597	13.672	14.852	16.032	16.790	18.288
2020	10.391	11.252	11.769	12.656	13.743	14.913	16.107	16.837	18.385
2021	10.435	11.315	11.817	12.709	13.799	14.971	16.148	16.918	18.425
2022	10.466	11.354	11.849	12.751	13.835	15.019	16.181	16.960	18.504
2023	10.498	11.393	11.897	12.780	13.861	15.036	16.223	17.002	18.556
2024	10.548	11.417	11.909	12.797	13.882	15.063	16.271	17.019	18.611
2025	10.563	11.426	11.924	12.804	13.897	15.078	16.282	17.033	18.616

Table 21 (Continued).

B) Fmsy = 0.23

PROJECTION RUN: GM Cod Fmsy 25 yr projection
INPUT FILE: gmc2001mod5.in
OUTPUT FILE: gmc2001mod5_Fmsy.out
RECRUITMENT MODEL: 5
NUMBER OF SIMULATIONS: 100

F-BASED PROJECTIONS
TIME-VARYING F

YEAR	F
2001	0.730
2002	0.230
2003	0.230
2004	0.230
2005	0.230
2006	0.230
2007	0.230
2008	0.230
2009	0.230
2010	0.230
2011	0.230
2012	0.230
2013	0.230
2014	0.230
2015	0.230
2016	0.230
2017	0.230
2018	0.230
2019	0.230
2020	0.230
2021	0.230
2022	0.230
2023	0.230
2024	0.230
2025	0.230

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2001	12.397	13.705	14.578	16.323	18.210	20.442	22.278	23.559	27.247
2002	14.001	16.165	17.214	18.870	21.122	23.859	26.506	27.866	31.562
2003	20.161	22.434	23.655	25.610	28.153	31.195	34.270	35.911	39.813
2004	25.737	28.334	29.699	32.220	35.368	38.889	42.428	44.709	49.617
2005	32.202	35.437	37.195	40.462	44.538	49.033	53.443	56.370	62.517
2006	36.023	39.534	41.589	45.178	49.617	54.622	59.663	62.815	70.053
2007	40.691	44.313	46.319	50.016	54.474	59.497	64.495	67.813	74.554
2008	43.427	47.457	49.743	53.875	58.852	64.446	70.019	73.615	80.985
2009	46.132	50.389	52.771	57.219	62.532	68.430	74.340	78.163	85.661
2010	48.599	53.082	55.588	60.111	65.699	71.811	77.945	81.830	89.800
2011	50.703	55.321	57.898	62.615	68.320	74.591	80.909	84.991	92.817
2012	52.335	57.114	59.743	64.589	70.397	76.817	83.165	87.276	95.551
2013	53.702	58.539	61.226	66.118	72.014	78.514	85.002	89.077	97.665
2014	54.779	59.638	62.422	67.261	73.211	79.853	86.256	90.475	98.825
2015	55.710	60.465	63.258	68.173	74.165	80.800	87.351	91.539	99.930
2016	56.226	61.068	63.882	68.871	74.914	81.509	88.064	92.273	100.642
2017	56.792	61.637	64.406	69.408	75.522	82.052	88.692	92.793	101.151
2018	57.126	61.977	64.766	69.811	75.869	82.530	89.096	93.281	101.737
2019	57.383	62.167	65.069	70.134	76.245	82.832	89.501	93.757	102.336
2020	57.508	62.459	65.261	70.357	76.462	83.095	89.772	94.006	102.591
2021	57.638	62.650	65.462	70.518	76.670	83.310	89.847	94.151	102.624
2022	57.812	62.707	65.644	70.648	76.720	83.418	90.024	94.322	103.158
2023	58.032	62.932	65.700	70.756	76.821	83.430	90.210	94.492	103.164
2024	58.130	62.965	65.735	70.798	76.881	83.593	90.301	94.586	103.420
2025	58.132	63.086	65.791	70.837	76.953	83.678	90.320	94.609	103.336

PERCENTILES OF TOTAL JANUARY 1 STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2001	16.976	19.063	19.892	21.970	24.424	27.174	29.536	31.219	35.279
2002	19.197	21.392	22.507	24.480	27.054	30.064	32.968	34.695	38.753
2003	25.873	28.449	29.843	32.299	35.382	38.893	42.338	44.528	49.146
2004	32.564	35.584	37.271	40.272	44.003	48.122	52.219	54.878	60.616
2005	40.586	44.471	46.586	50.414	55.095	60.320	65.458	68.775	75.728
2006	45.280	49.516	51.939	56.187	61.312	67.126	72.886	76.571	84.687
2007	50.931	55.251	57.589	61.926	67.105	72.923	78.644	82.420	90.302
2008	54.382	59.142	61.804	66.678	72.538	79.037	85.606	89.693	98.359
2009	57.610	62.631	65.436	70.609	76.804	83.684	90.511	94.981	103.585
2010	60.365	65.589	68.571	73.838	80.328	87.395	94.454	98.977	107.888
2011	62.698	68.046	71.041	76.522	83.149	90.361	97.600	102.203	111.193
2012	64.451	69.991	73.017	78.583	85.325	92.693	99.901	104.606	113.962
2013	65.912	71.469	74.583	80.185	86.941	94.405	101.750	106.482	116.200
2014	66.966	72.549	75.739	81.347	88.205	95.748	103.049	107.813	117.080
2015	67.817	73.399	76.634	82.270	89.171	96.681	104.071	108.795	118.426
2016	68.304	74.046	77.227	82.940	89.861	97.392	104.790	109.637	119.128
2017	68.915	74.558	77.743	83.450	90.460	97.899	105.367	110.151	119.464
2018	69.338	74.857	78.069	83.874	90.794	98.341	105.831	110.598	120.155
2019	69.438	75.050	78.349	84.154	91.108	98.630	106.222	110.970	120.581
2020	69.533	75.297	78.560	84.354	91.337	98.863	106.317	111.121	120.793
2021	69.800	75.527	78.742	84.500	91.494	99.006	106.521	111.303	120.929
2022	69.895	75.599	78.824	84.647	91.508	99.123	106.598	111.530	121.424
2023	69.991	75.772	78.933	84.672	91.603	99.173	106.752	111.602	121.353
2024	70.162	75.827	78.938	84.761	91.643	99.298	106.814	111.616	121.639
2025	70.186	75.857	79.034	84.774	91.723	99.412	106.875	111.683	121.398

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2001	4.869	5.651	5.970	6.730	7.540	8.371	9.204	9.823	10.962
2002	2.531	2.887	3.066	3.421	3.884	4.357	4.859	5.132	6.054
2003	3.473	3.954	4.256	4.663	5.214	5.891	6.615	6.958	7.773
2004	4.890	5.462	5.710	6.160	6.761	7.447	8.125	8.540	9.432
2005	6.123	6.759	7.107	7.752	8.561	9.467	10.365	10.965	12.248
2006	6.872	7.573	7.974	8.685	9.593	10.594	11.606	12.248	13.749
2007	7.785	8.498	8.915	9.653	10.568	11.613	12.649	13.351	14.819
2008	8.330	9.145	9.609	10.436	11.467	12.635	13.807	14.567	16.145
2009	8.887	9.750	10.258	11.152	12.249	13.475	14.699	15.493	17.089
2010	9.396	10.307	10.820	11.758	12.910	14.180	15.468	16.290	17.972
2011	9.829	10.785	11.303	12.261	13.450	14.771	16.067	16.940	18.606
2012	10.187	11.148	11.696	12.678	13.883	15.225	16.565	17.410	19.177
2013	10.439	11.434	11.980	12.993	14.208	15.574	16.916	17.795	19.587
2014	10.647	11.660	12.230	13.232	14.469	15.850	17.202	18.085	19.850
2015	10.858	11.838	12.416	13.416	14.666	16.038	17.418	18.309	20.079
2016	10.994	11.961	12.542	13.563	14.816	16.205	17.572	18.464	20.234
2017	11.059	12.057	12.642	13.677	14.934	16.314	17.701	18.583	20.349
2018	11.162	12.147	12.724	13.763	15.022	16.405	17.780	18.643	20.469
2019	11.197	12.195	12.769	13.827	15.081	16.476	17.867	18.764	20.586
2020	11.228	12.230	12.824	13.863	15.135	16.513	17.931	18.808	20.637
2021	11.270	12.288	12.854	13.900	15.182	16.572	17.954	18.857	20.631
2022	11.295	12.307	12.884	13.932	15.192	16.597	17.966	18.871	20.718
2023	11.336	12.330	12.920	13.953	15.213	16.603	17.998	18.922	20.782
2024	11.331	12.358	12.921	13.962	15.219	16.624	18.032	18.917	20.807
2025	11.351	12.356	12.931	13.964	15.234	16.637	18.046	18.950	20.813

Table 21 (Continued).

C) Fmax = 0.27

PROJECTION RUN: GM Cod Fmax 25 yr projection
INPUT FILE: gmc2001mod5.in
OUTPUT FILE: gmc2001mod5_Fmax.out
RECRUITMENT MODEL: 5
NUMBER OF SIMULATIONS: 100

F-BASED PROJECTIONS
TIME-VARYING F

YEAR	F
2001	0.730
2002	0.270
2003	0.270
2004	0.270
2005	0.270
2006	0.270
2007	0.270
2008	0.270
2009	0.270
2010	0.270
2011	0.270
2012	0.270
2013	0.270
2014	0.270
2015	0.270
2016	0.270
2017	0.270
2018	0.270
2019	0.270
2020	0.270
2021	0.270
2022	0.270
2023	0.270
2024	0.270
2025	0.270

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2001	12.397	13.705	14.578	16.323	18.210	20.442	22.278	23.559	27.247
2002	13.930	16.082	17.126	18.774	21.015	23.733	26.374	27.740	31.398
2003	19.630	21.841	23.017	24.917	27.374	30.319	33.307	34.906	38.655
2004	24.591	27.017	28.323	30.737	33.724	37.077	40.459	42.640	47.337
2005	30.100	33.099	34.752	37.808	41.623	45.816	49.939	52.718	58.389
2006	33.134	36.428	38.326	41.661	45.781	50.429	55.119	58.070	64.756
2007	36.975	40.364	42.219	45.625	49.773	54.470	59.129	62.207	68.593
2008	39.185	42.891	44.992	48.794	53.386	58.554	63.712	67.047	73.854
2009	41.355	45.268	47.432	51.511	56.379	61.807	67.206	70.708	77.619
2010	43.352	47.427	49.675	53.802	58.901	64.490	70.099	73.634	80.923
2011	44.991	49.182	51.519	55.772	60.978	66.699	72.455	76.168	83.409
2012	46.256	50.542	52.922	57.321	62.584	68.442	74.183	77.925	85.460
2013	47.264	51.647	54.077	58.480	63.819	69.729	75.625	79.279	87.149
2014	48.075	52.499	54.989	59.372	64.771	70.741	76.582	80.398	88.000
2015	48.771	53.087	55.632	60.043	65.478	71.482	77.406	81.203	88.740
2016	49.222	53.525	56.084	60.574	66.046	72.006	77.940	81.751	89.277
2017	49.571	53.953	56.450	60.971	66.493	72.390	78.366	82.132	89.806
2018	49.912	54.196	56.726	61.266	66.741	72.757	78.700	82.545	90.132
2019	50.041	54.334	56.962	61.494	67.026	73.000	79.061	82.906	90.621
2020	50.100	54.576	57.082	61.652	67.180	73.182	79.211	83.047	90.817
2021	50.256	54.724	57.262	61.792	67.327	73.336	79.251	83.171	90.867
2022	50.355	54.768	57.384	61.887	67.365	73.388	79.372	83.233	91.272
2023	50.548	54.901	57.402	61.948	67.416	73.424	79.552	83.392	91.276
2024	50.561	54.903	57.416	61.983	67.453	73.521	79.613	83.474	91.430
2025	50.585	54.985	57.471	62.004	67.527	73.577	79.600	83.473	91.375

PERCENTILES OF TOTAL JANUARY 1 STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2001	16.976	19.063	19.892	21.970	24.424	27.174	29.536	31.219	35.279
2002	19.197	21.392	22.507	24.480	27.054	30.064	32.968	34.695	38.753
2003	25.402	27.906	29.278	31.684	34.698	38.138	41.517	43.667	48.197
2004	31.418	34.307	35.922	38.821	42.415	46.386	50.342	52.909	58.528
2005	38.355	42.022	44.038	47.662	52.098	57.037	61.926	65.068	71.726
2006	42.240	46.247	48.495	52.472	57.307	62.775	68.192	71.694	79.282
2007	46.915	50.961	53.208	57.259	62.120	67.619	73.051	76.579	84.026
2008	49.761	54.197	56.679	61.222	66.679	72.723	78.829	82.651	90.602
2009	52.376	57.047	59.660	64.426	70.152	76.551	82.853	87.011	94.925
2010	54.653	59.415	62.128	66.984	72.984	79.484	86.002	90.168	98.450
2011	56.472	61.340	64.109	69.115	75.214	81.863	88.490	92.760	100.917
2012	57.795	62.836	65.630	70.764	76.921	83.657	90.270	94.546	103.323
2013	58.873	64.029	66.842	71.957	78.128	84.980	91.674	96.000	104.978
2014	59.746	64.789	67.678	72.831	79.085	86.000	92.639	97.057	105.399
2015	60.354	65.453	68.387	73.515	79.807	86.691	93.473	97.771	106.474
2016	60.711	65.891	68.800	74.011	80.361	87.165	93.991	98.373	107.075
2017	61.139	66.290	69.181	74.399	80.780	87.598	94.383	98.736	107.314
2018	61.442	66.483	69.441	74.710	81.004	87.874	94.711	99.088	107.942
2019	61.557	66.629	69.604	74.924	81.235	88.114	95.036	99.317	108.163
2020	61.541	66.836	69.780	75.047	81.417	88.280	95.098	99.459	108.340
2021	61.808	66.973	69.899	75.132	81.504	88.389	95.211	99.595	108.346
2022	61.857	67.009	69.959	75.220	81.516	88.437	95.232	99.750	108.890
2023	61.910	67.143	70.059	75.241	81.562	88.462	95.401	99.849	108.737
2024	62.050	67.156	70.030	75.315	81.604	88.591	95.442	99.854	108.976
2025	62.070	67.191	70.077	75.303	81.631	88.644	95.470	99.868	108.720

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
2001	4.869	5.651	5.970	6.730	7.540	8.371	9.204	9.823	10.962
2002	2.921	3.333	3.539	3.949	4.482	5.028	5.613	5.928	6.986
2003	3.896	4.436	4.777	5.231	5.857	6.622	7.418	7.815	8.750
2004	5.391	6.009	6.280	6.774	7.426	8.169	8.906	9.358	10.326
2005	6.595	7.271	7.646	8.340	9.213	10.184	11.156	11.807	13.217
2006	7.286	8.035	8.457	9.220	10.191	11.267	12.356	13.045	14.687
2007	8.141	8.910	9.353	10.139	11.117	12.241	13.361	14.112	15.683
2008	8.654	9.516	10.008	10.881	11.977	13.218	14.457	15.272	16.945
2009	9.167	10.072	10.611	11.557	12.712	14.007	15.309	16.153	17.865
2010	9.638	10.586	11.132	12.112	13.322	14.662	16.026	16.891	18.675
2011	10.037	11.027	11.569	12.574	13.817	15.209	16.572	17.478	19.254
2012	10.356	11.343	11.924	12.948	14.212	15.614	17.015	17.913	19.765
2013	10.587	11.601	12.173	13.229	14.495	15.934	17.341	18.250	20.163
2014	10.750	11.805	12.397	13.439	14.730	16.165	17.577	18.525	20.358
2015	10.941	11.953	12.554	13.597	14.900	16.334	17.778	18.720	20.591
2016	11.061	12.062	12.664	13.727	15.027	16.478	17.911	18.851	20.720
2017	11.110	12.140	12.744	13.821	15.135	16.573	18.017	18.949	20.791
2018	11.194	12.222	12.818	13.900	15.207	16.652	18.087	19.006	20.915
2019	11.226	12.261	12.856	13.945	15.258	16.716	18.175	19.107	21.019
2020	11.242	12.287	12.900	13.979	15.301	16.749	18.228	19.154	21.094
2021	11.299	12.338	12.928	14.012	15.344	16.797	18.233	19.186	21.064
2022	11.306	12.353	12.955	14.039	15.356	16.819	18.247	19.206	21.113
2023	11.333	12.375	12.988	14.061	15.365	16.816	18.272	19.243	21.187
2024	11.352	12.399	12.983	14.060	15.368	16.840	18.312	19.244	21.244
2025	11.369	12.398	12.989	14.058	15.383	16.848	18.314	19.286	21.236

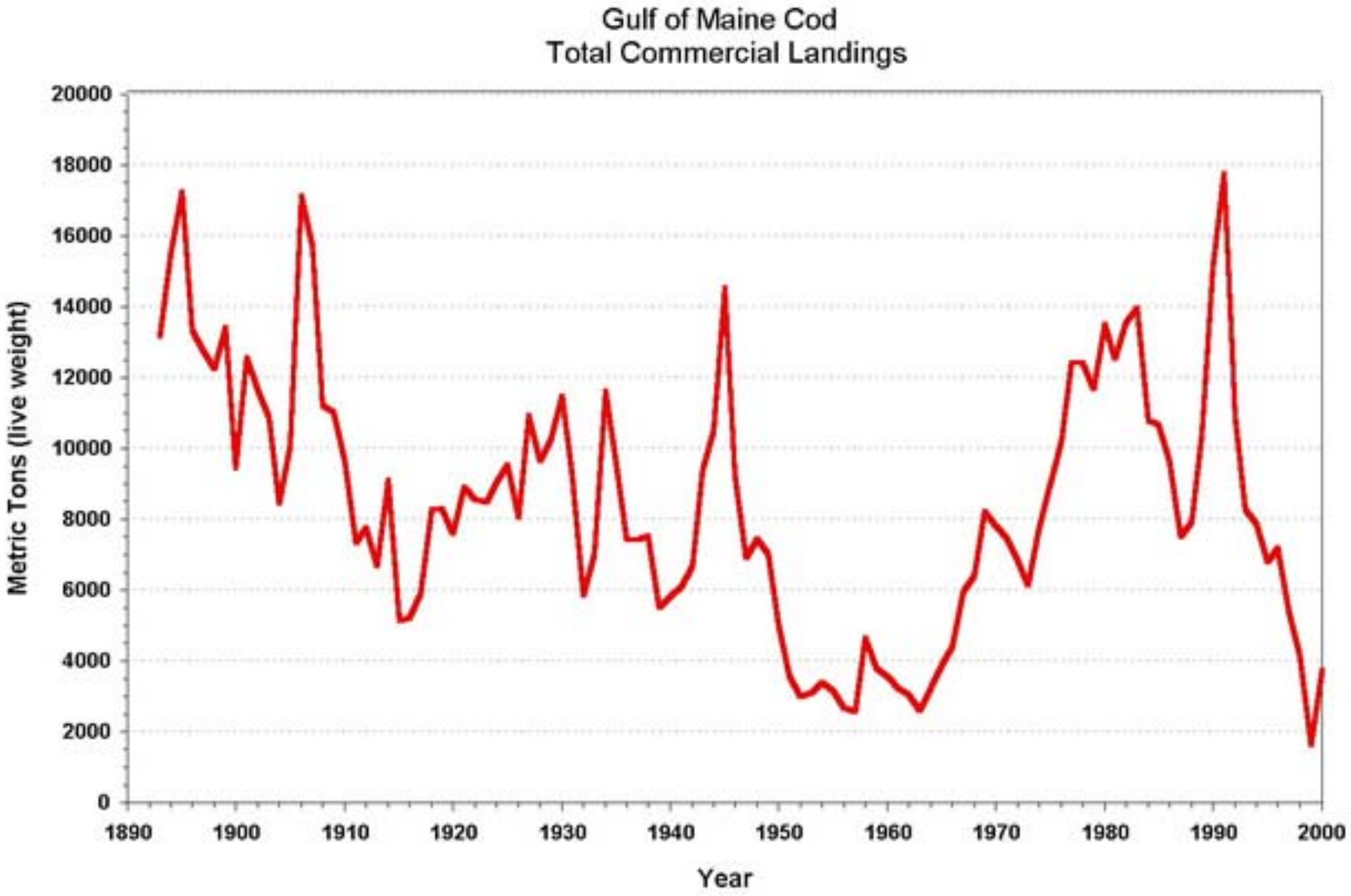


Figure 1. Total commercial landings of Gulf of Maine cod (NAFO Div. 5Y), 1893-2000.

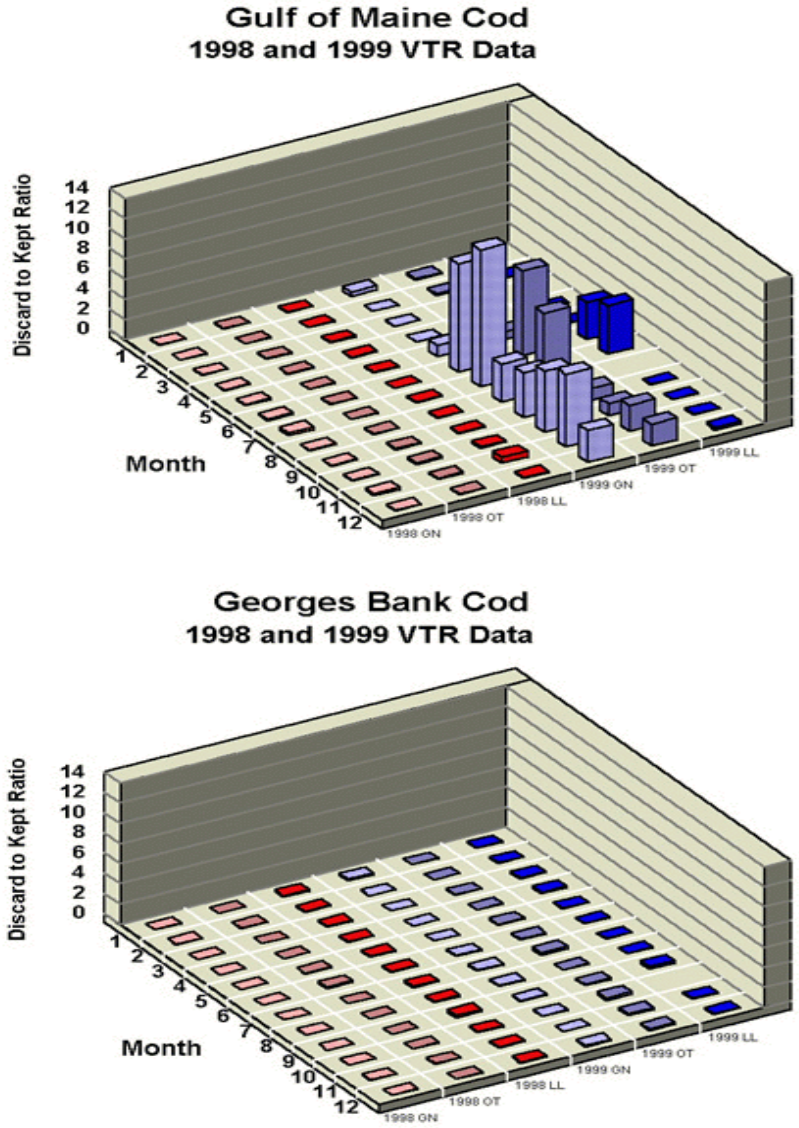
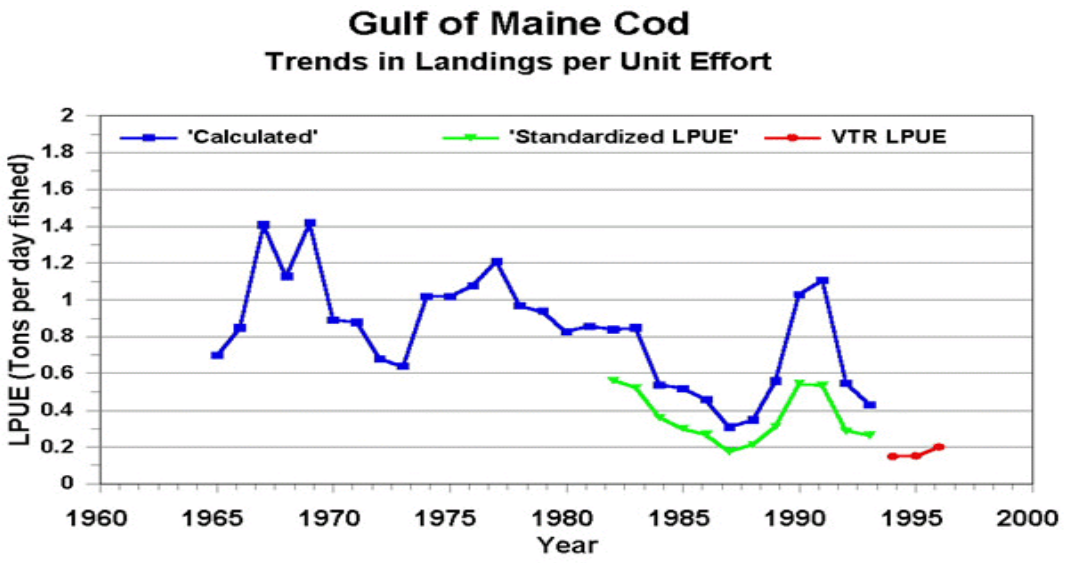


Figure 2. Discard to kept ratios based of 1998 and 1999 VTR data for Gulf of Maine and Georges Bank cod.



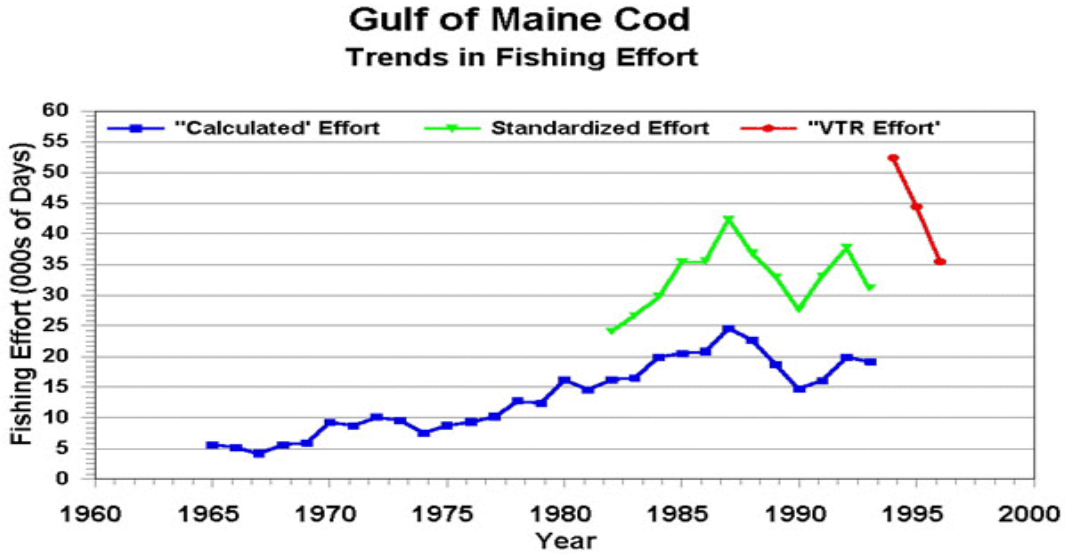


Figure 3. (a) Trends in LPUE for Gulf of Maine cod, 1964-1996.
(b) Trends in fishing effort for Gulf of Maine cod, 1964-1996.

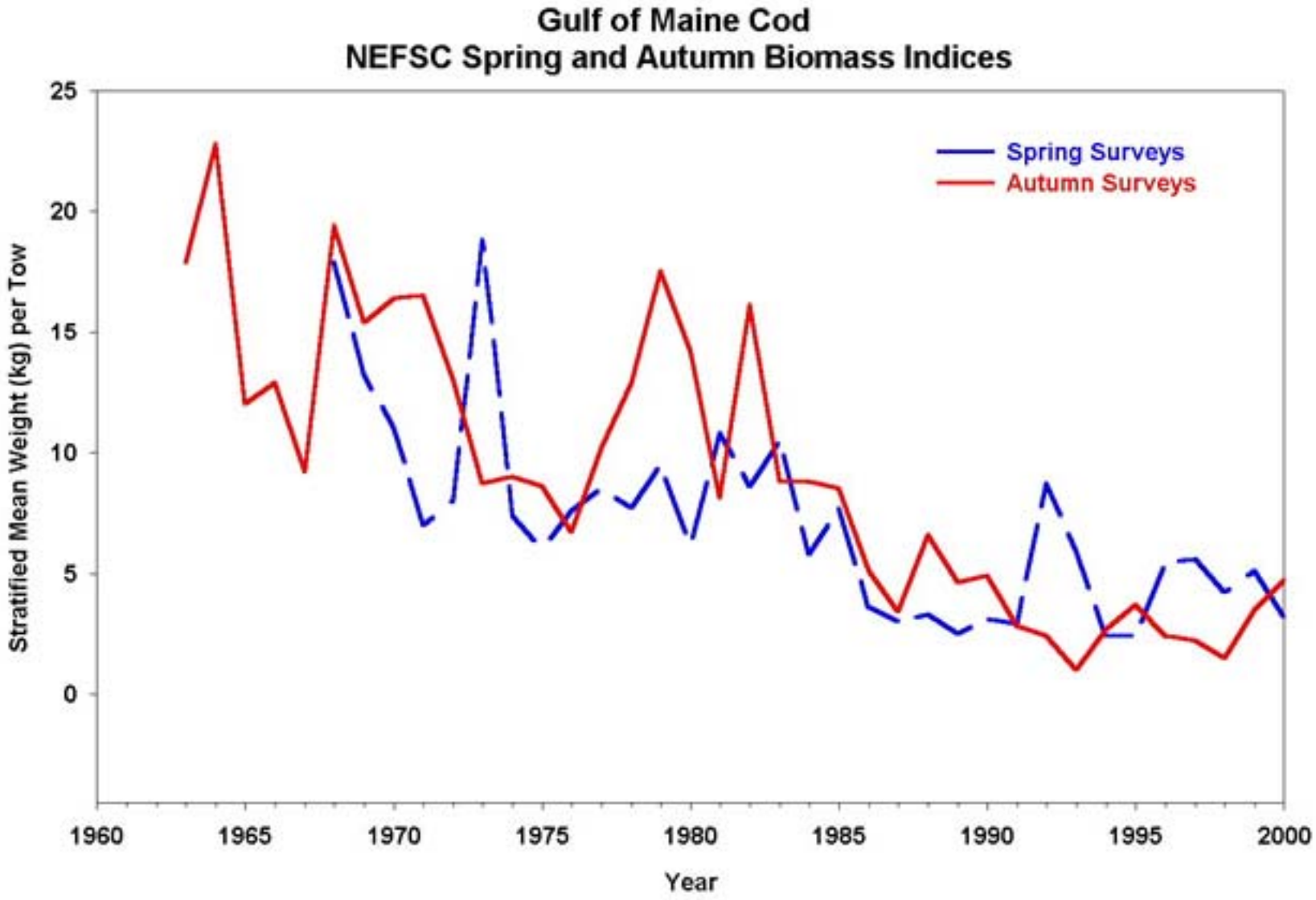
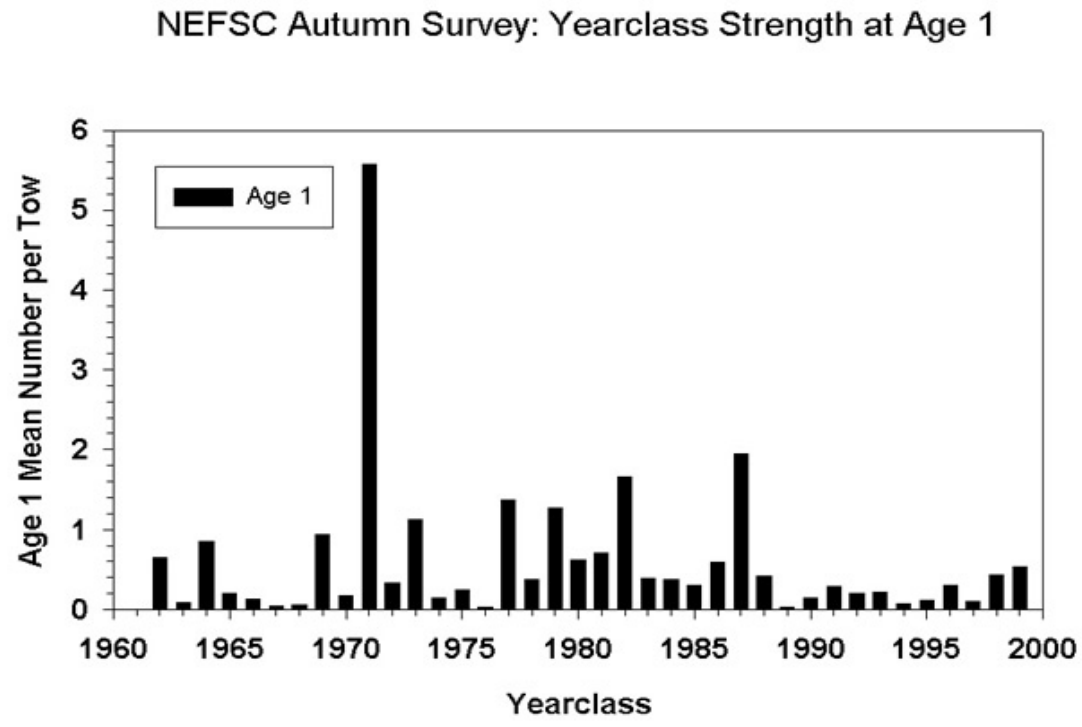


Figure 4. Biomass indices (stratified mean weight per tow) for Gulf of Maine cod from NEFSC autumn bottom trawl surveys.



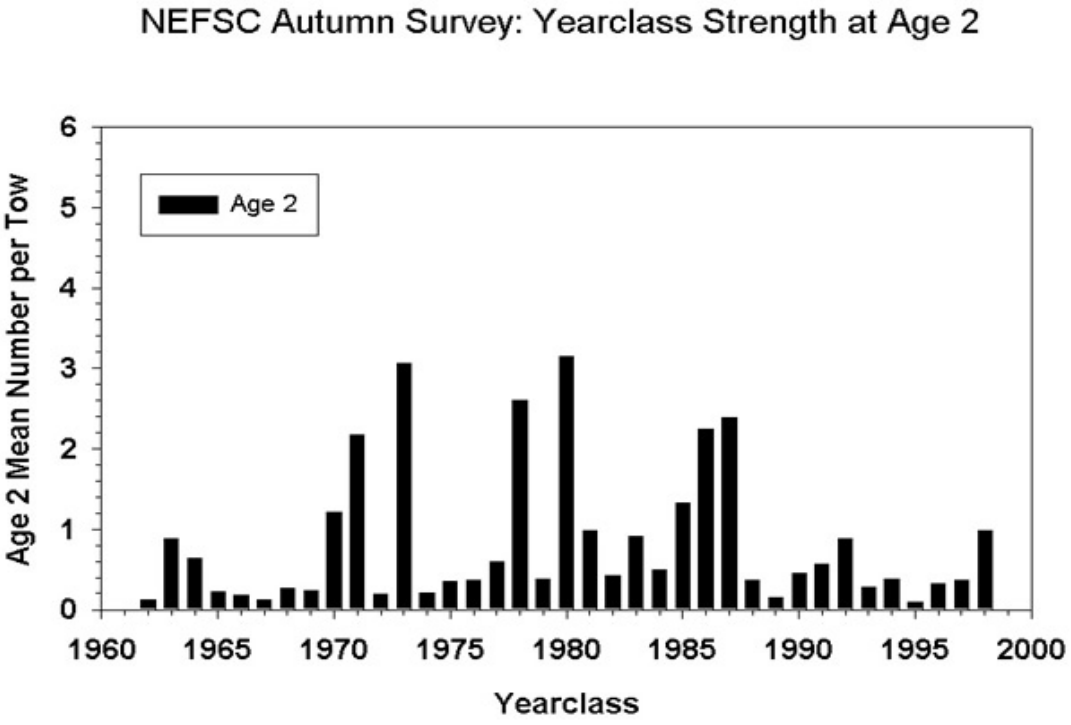
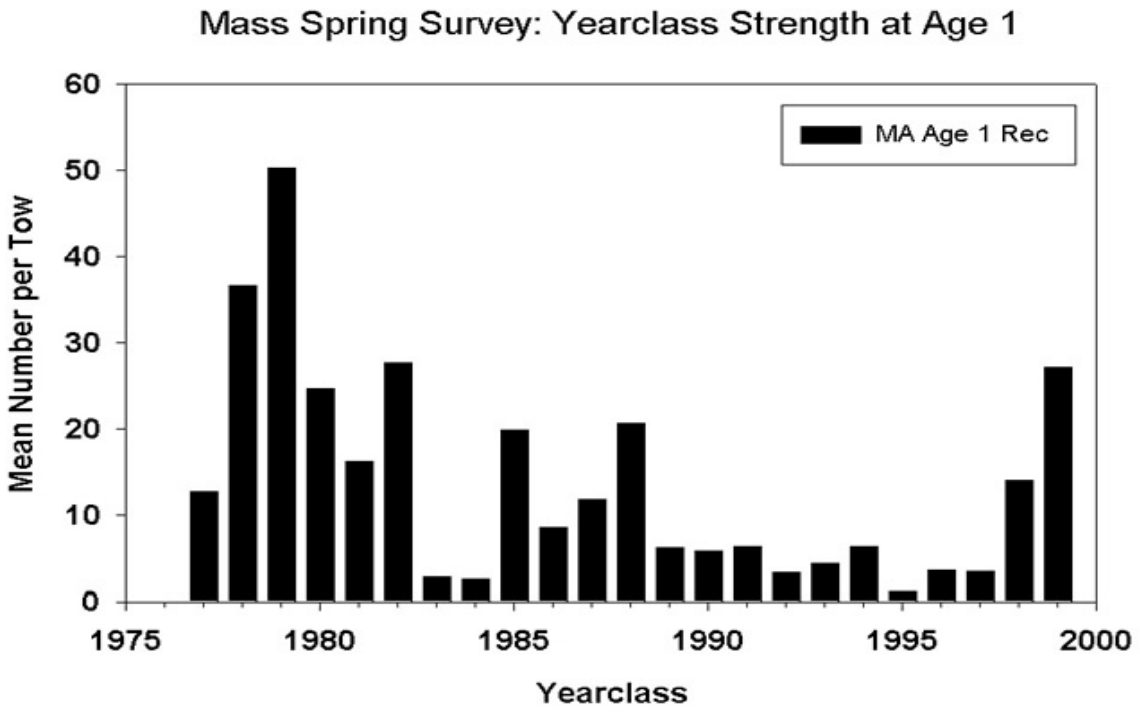


Figure 5. Recruitment indices at age 1 and 2 for Gulf of Maine cod from NEFSC autumn bottom trawl surveys.



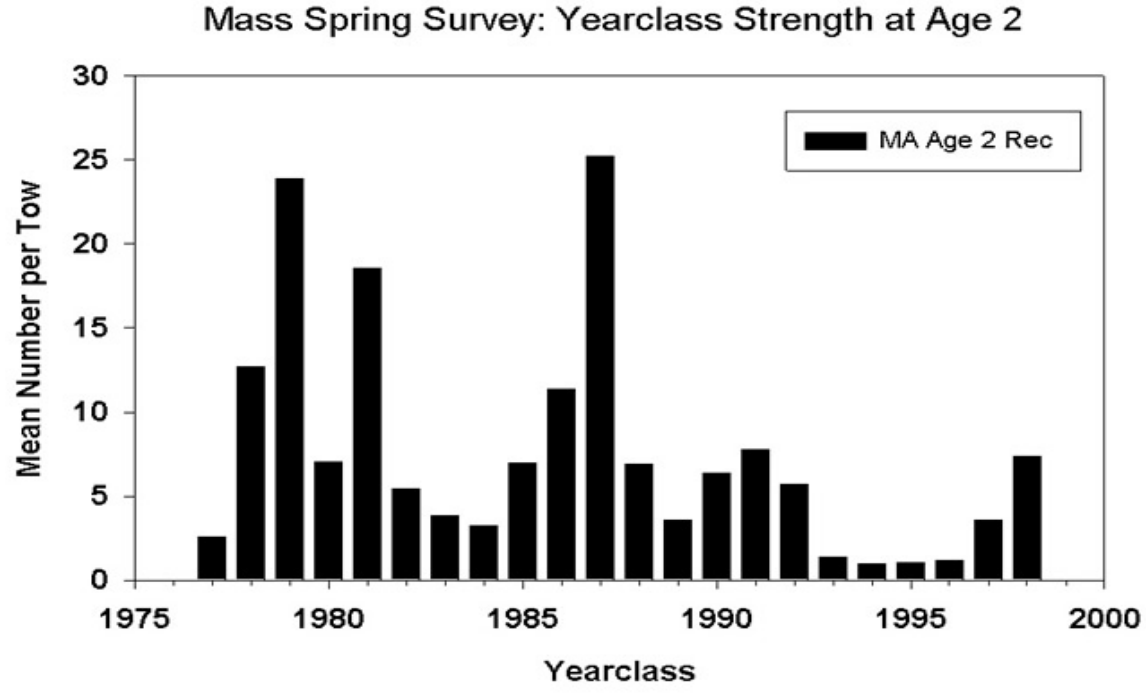


Figure 6. Recruitment indices at age 1 and 2 for Gulf of Maine cod from MA DMF autumn bottom trawl surveys.

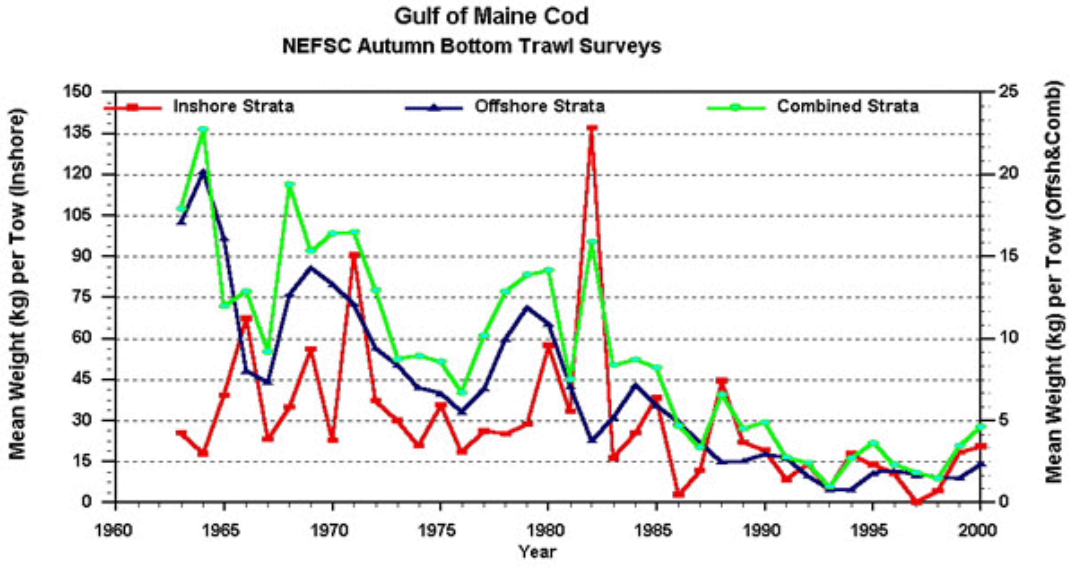


Figure 7. Biomass indices (Stratified mean weight per tow) for Gulf of Maine cod based on inshore (strata 26 and 27), offshore (strata 28-30 and 36-40), and combined regions from NEFSC autumn bottom trawl surveys.

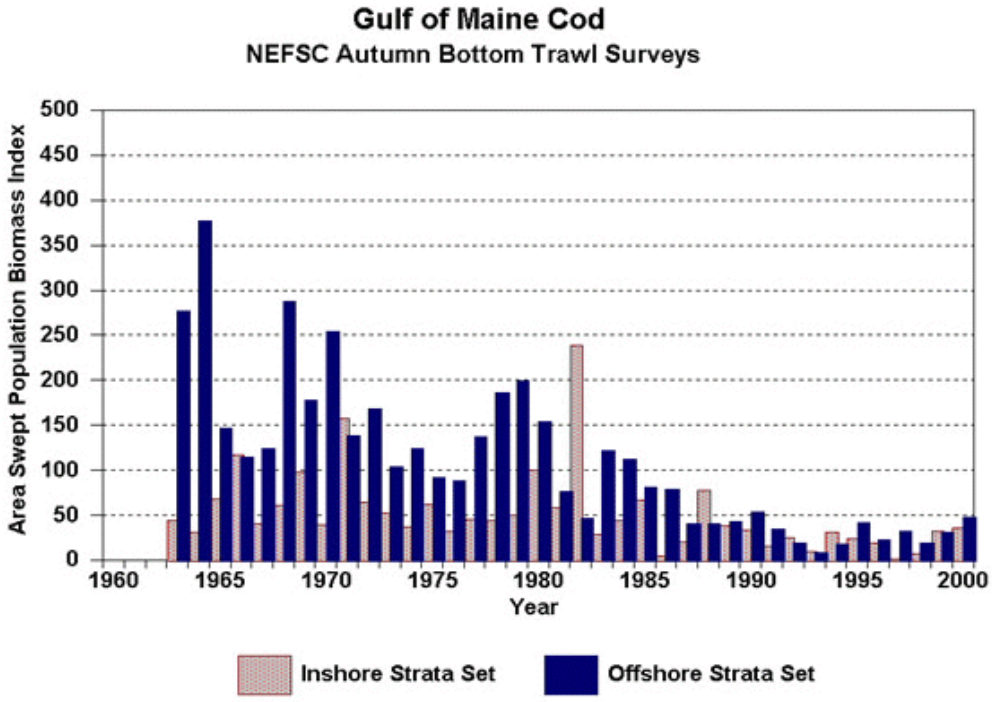


Figure 8. Swept area weighted biomass indices (Stratified mean weight per tow) for Gulf of Maine cod based on inshore (strata 26 and 27) and offshore (strata 28-30 and 36-40) regions from NEFSC autumn bottom trawl surveys.

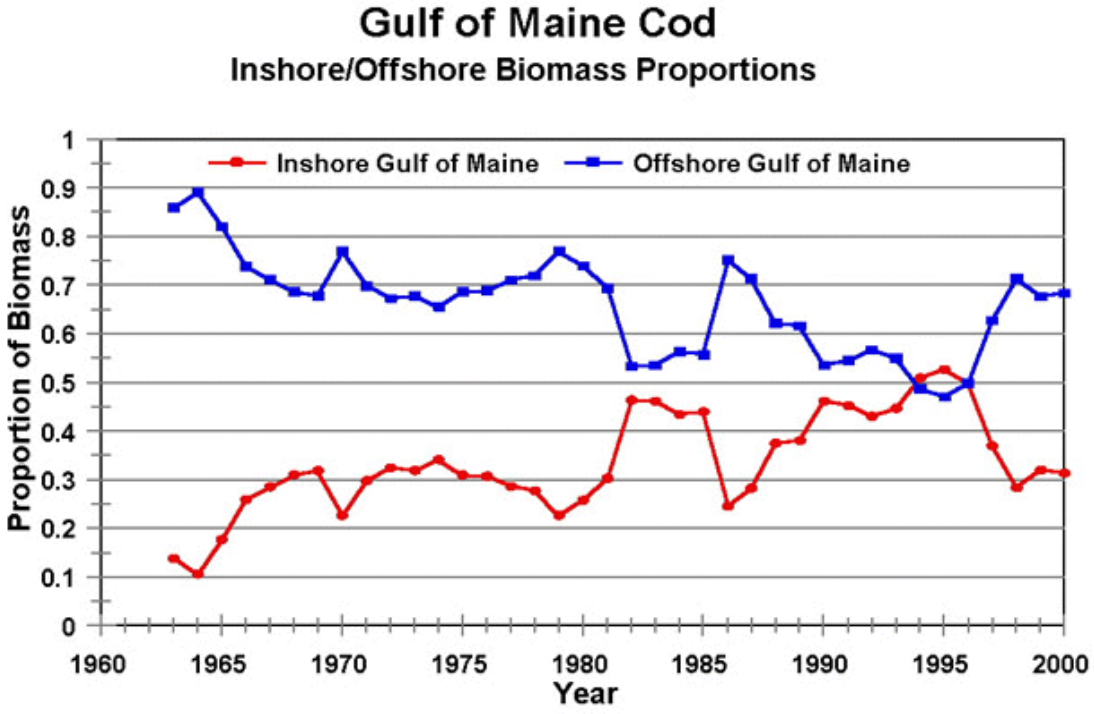


Figure 9. Proportion of biomass of Gulf of Maine cod from inshore (strata 26 and 27) and offshore (strata 28-30, 36-40) regions from NEFSC autumn bottom trawl surveys (4-year running average).

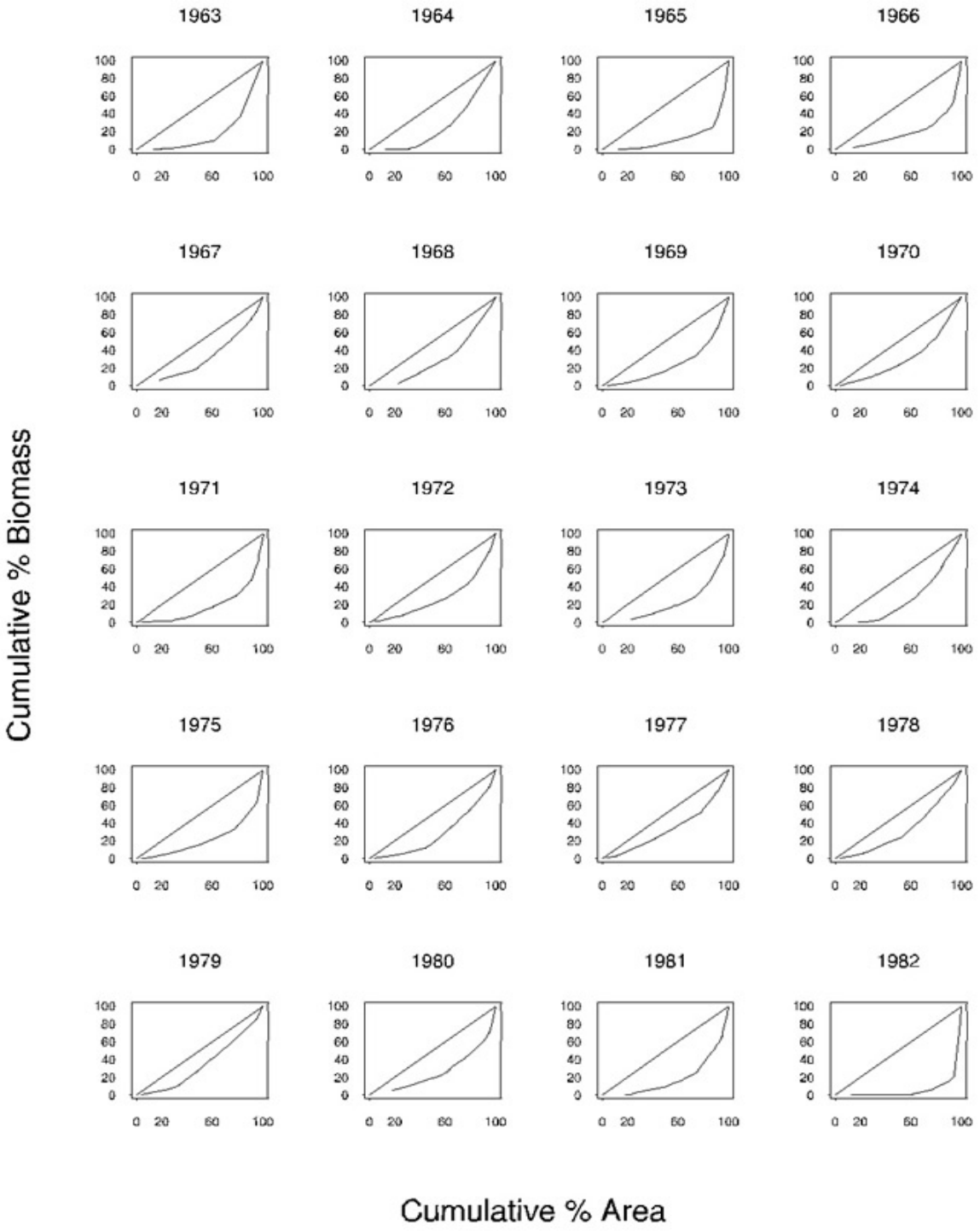


Figure 10. Lorenz curves for Gulf of Maine cod from NEFSC autumn bottom trawl survey biomass indices, strata 26-30 and 36-40.

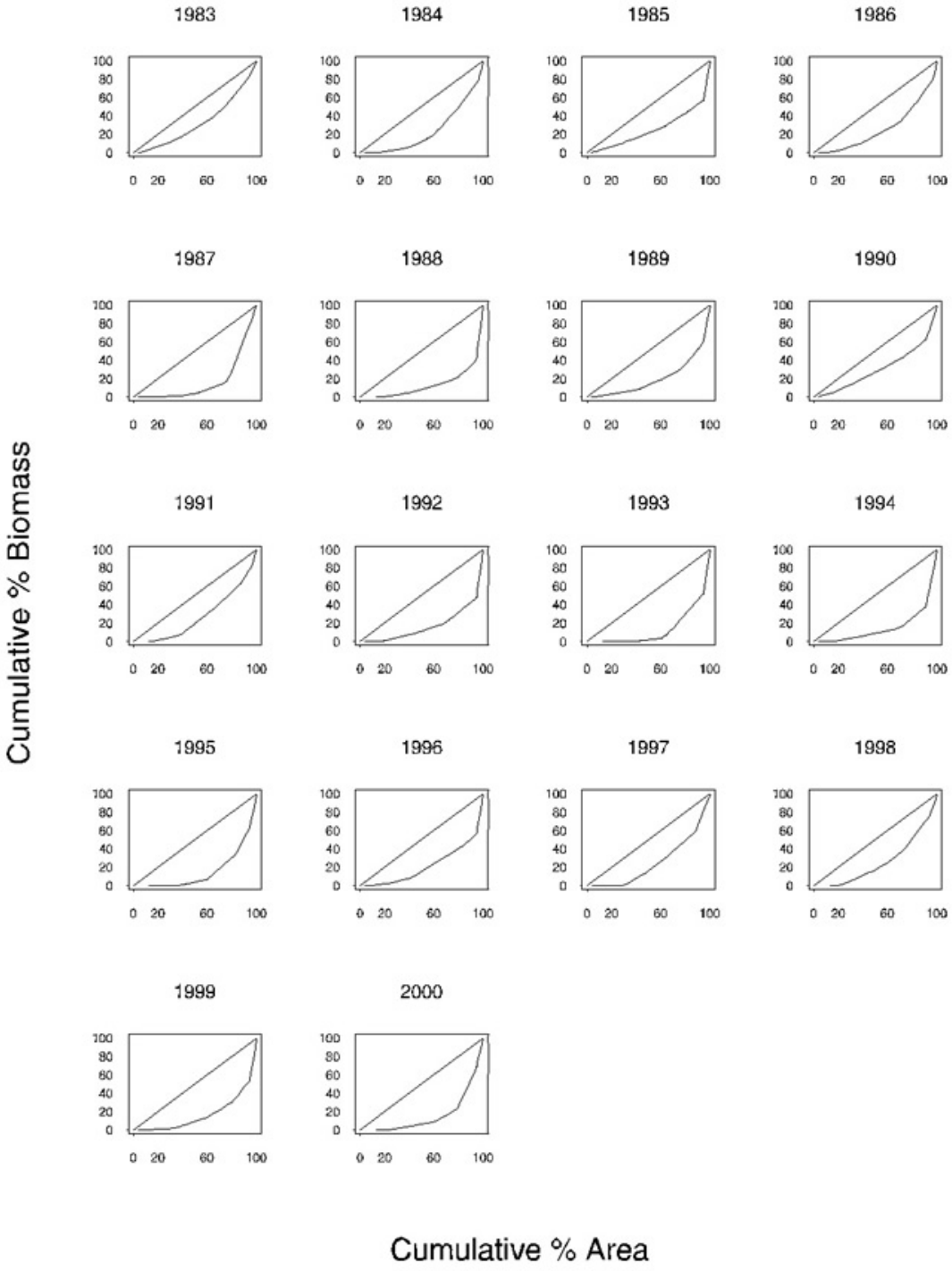


Figure 10 (Continued).

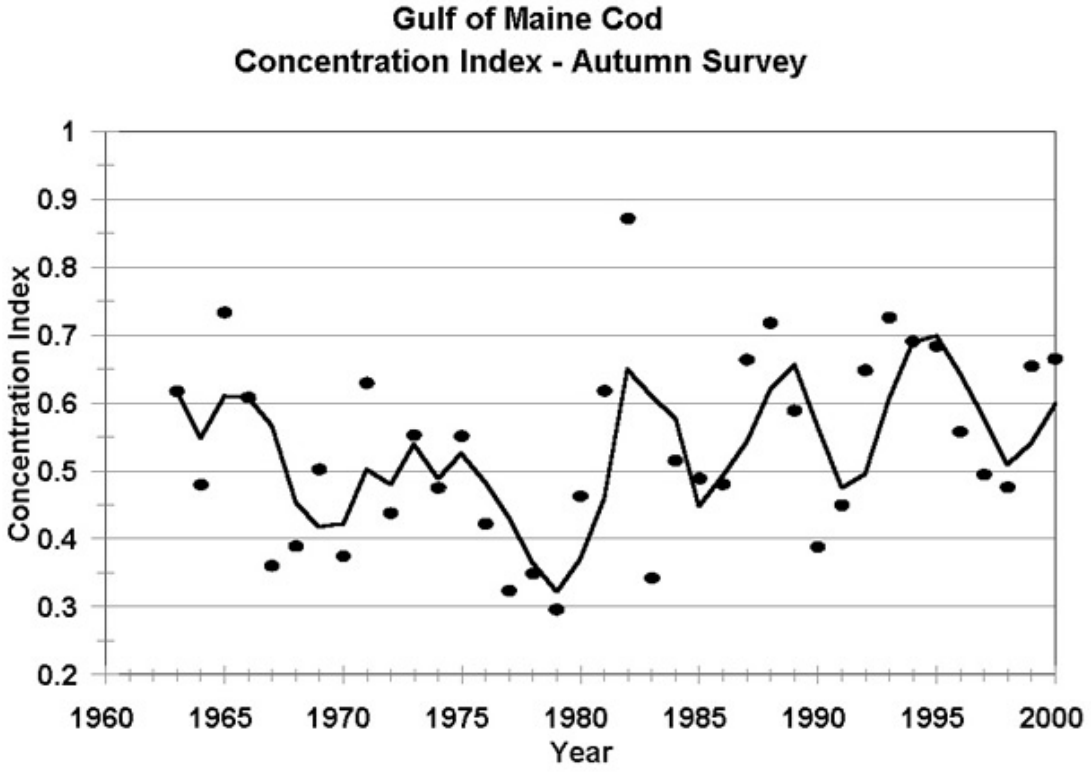


Figure 11. Concentration Index for Gulf of Maine cod derived from Lorenz curves from NEFSC autumn bottom trawl survey biomass indices, strata 26-30 and 36-40.

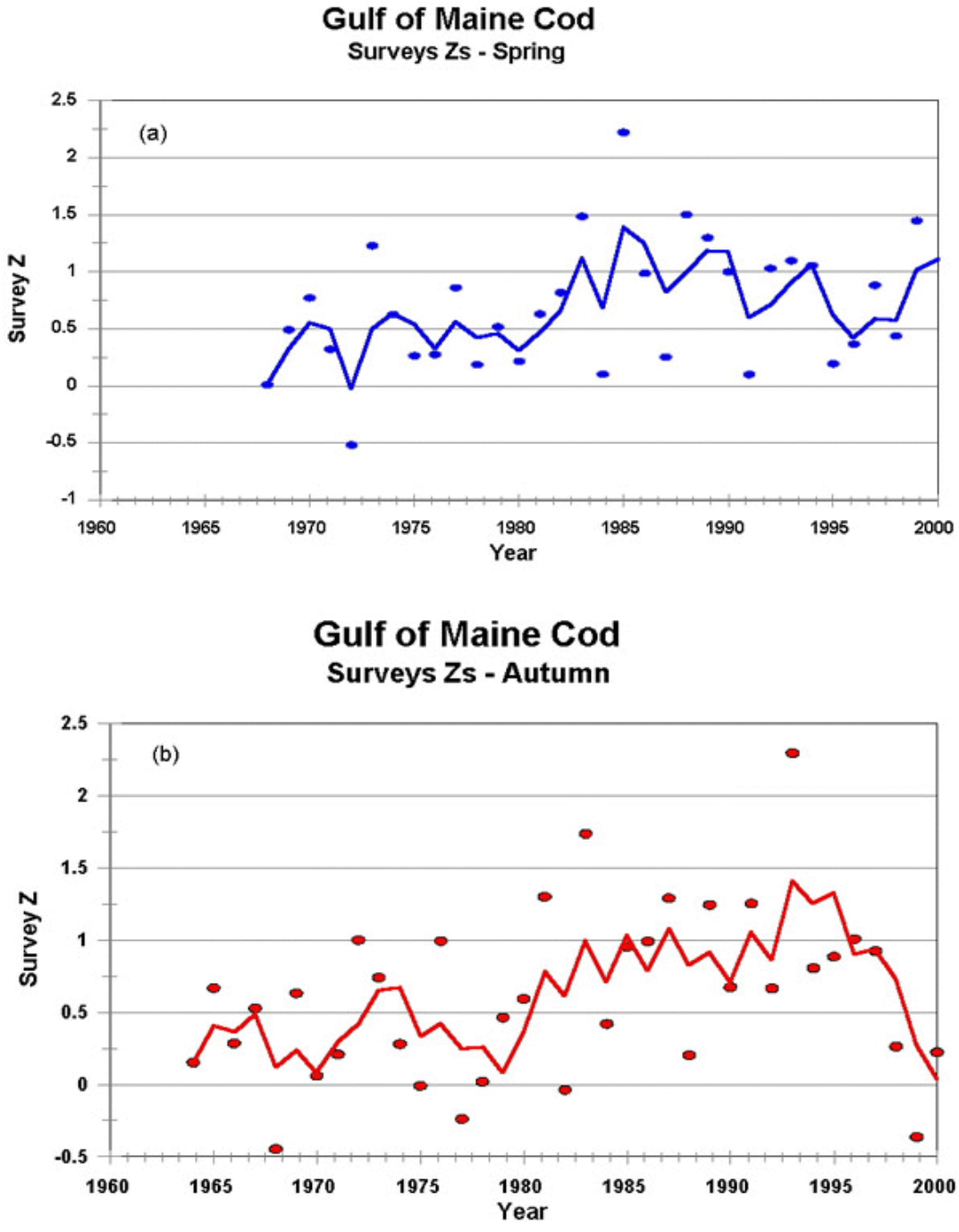
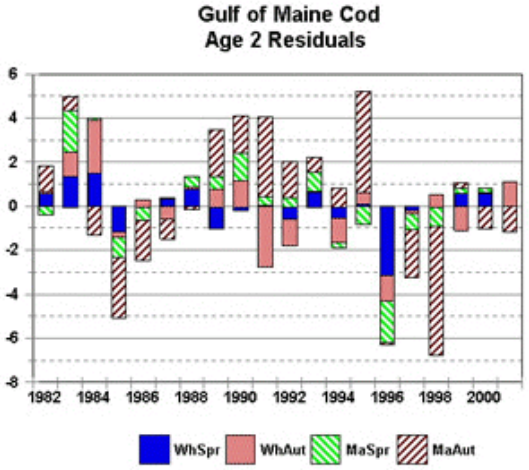
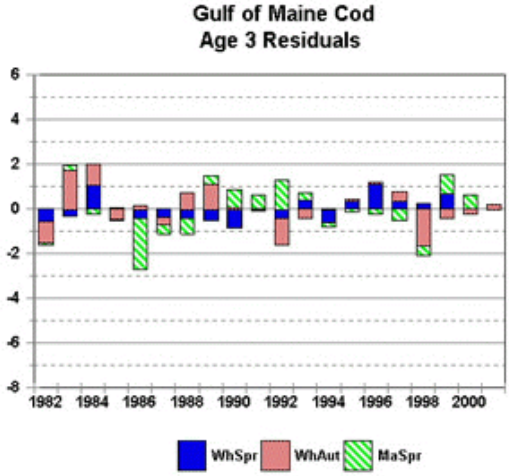
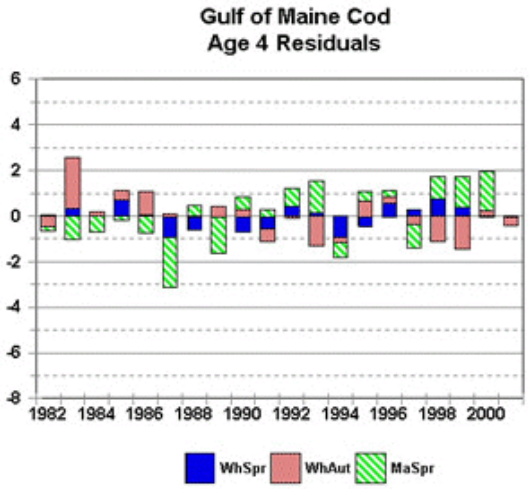
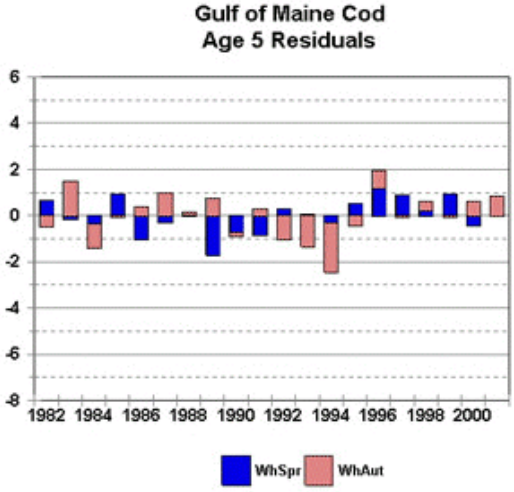


Figure 12. Annual estimates of total instantaneous mortality (Z) for Gulf of Maine cod (points) and 3-year running average (line) from (a) NEFSC spring and (b) NEFSC autumn bottom trawl surveys.









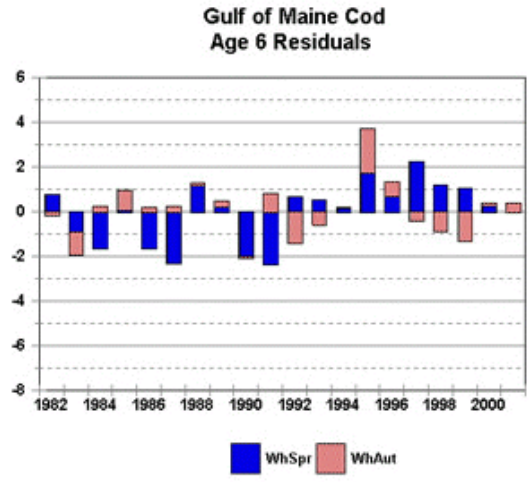


Figure 13. Residual plots from VPA calibration for Gulf of Maine cod.

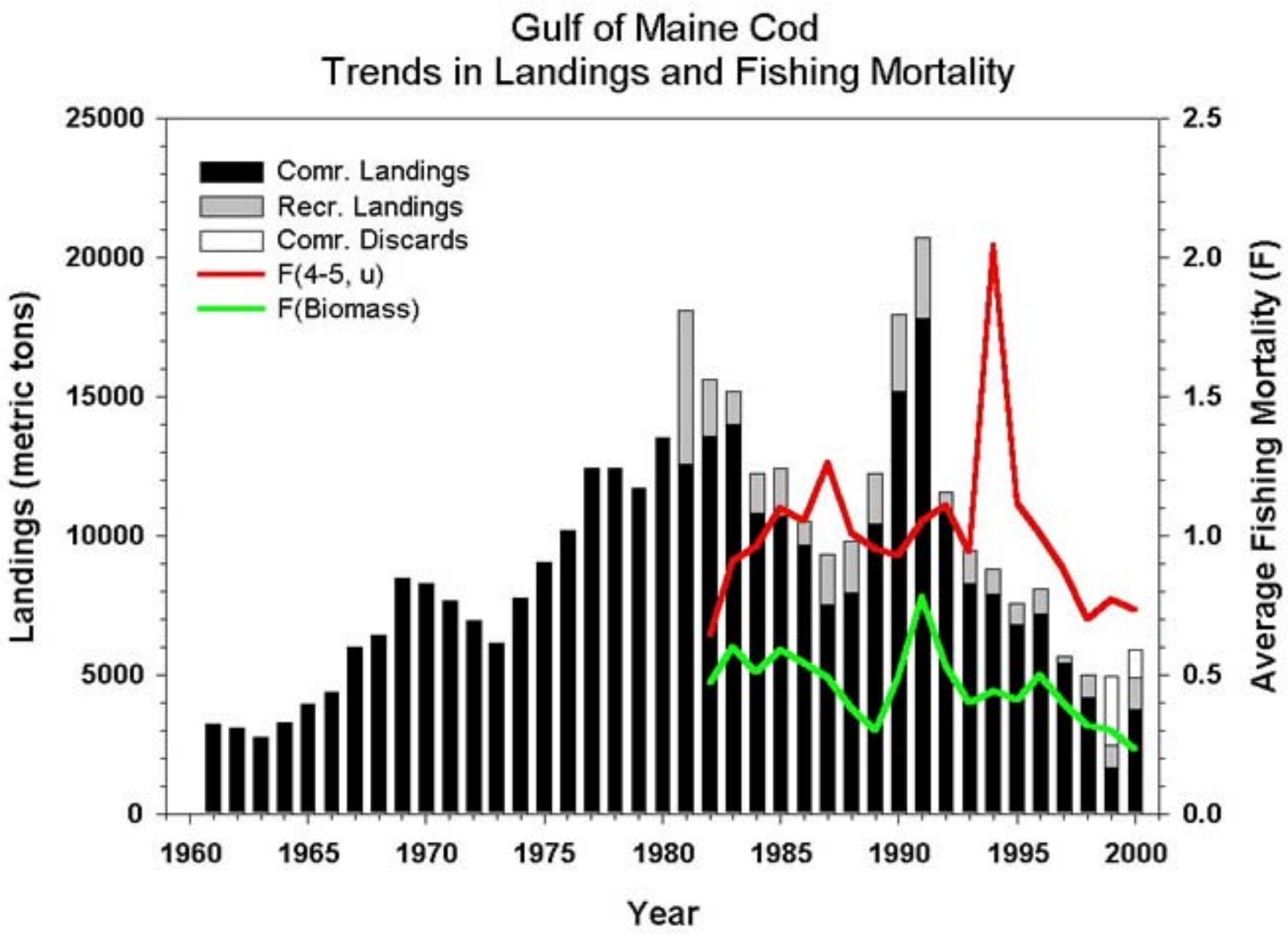


Figure 14. Trends in landings and fishing mortality for Gulf of Maine cod.

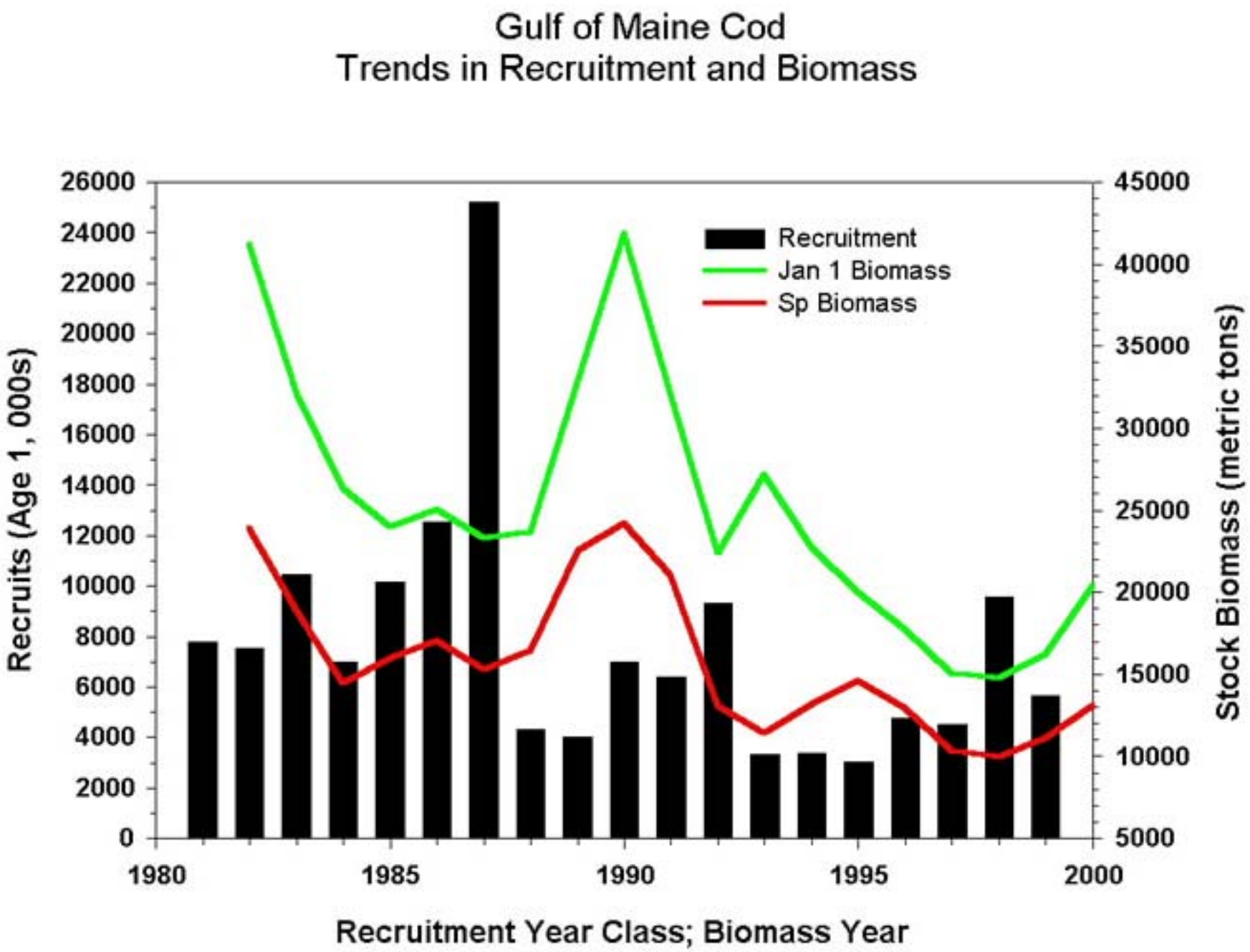


Figure 15. Trends in recruitment (age 1) and biomass for Gulf of Maine cod.

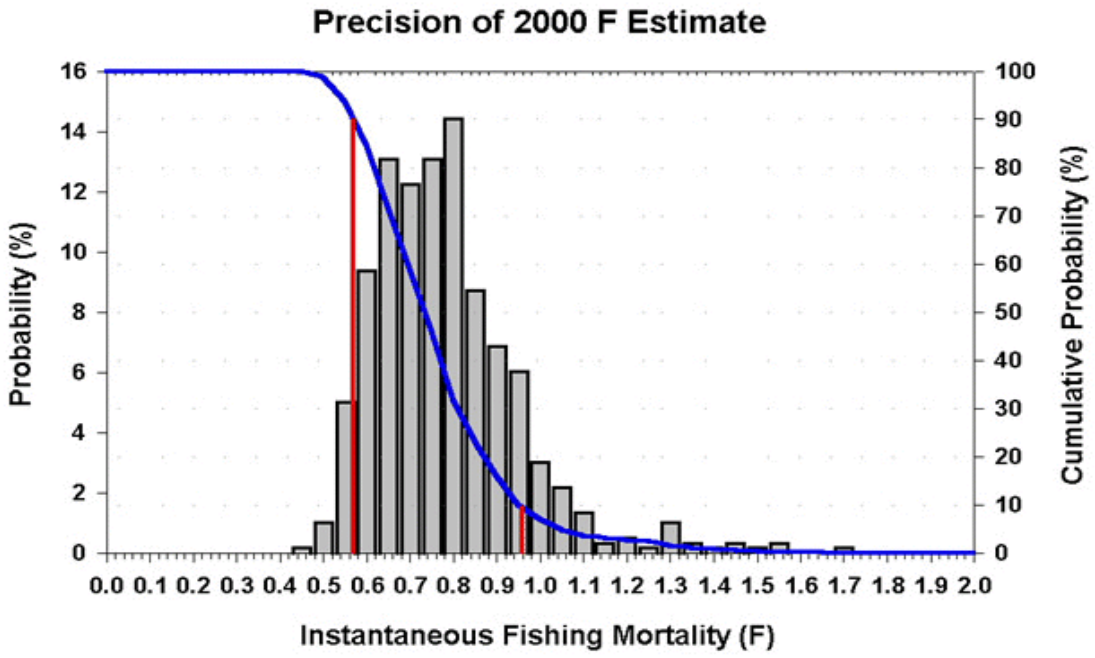


Figure 16. Precision of the estimated fully recruited fishing mortality in 2000 based on 600 bootstrap realizations of the VPA for Gulf of Maine cod.

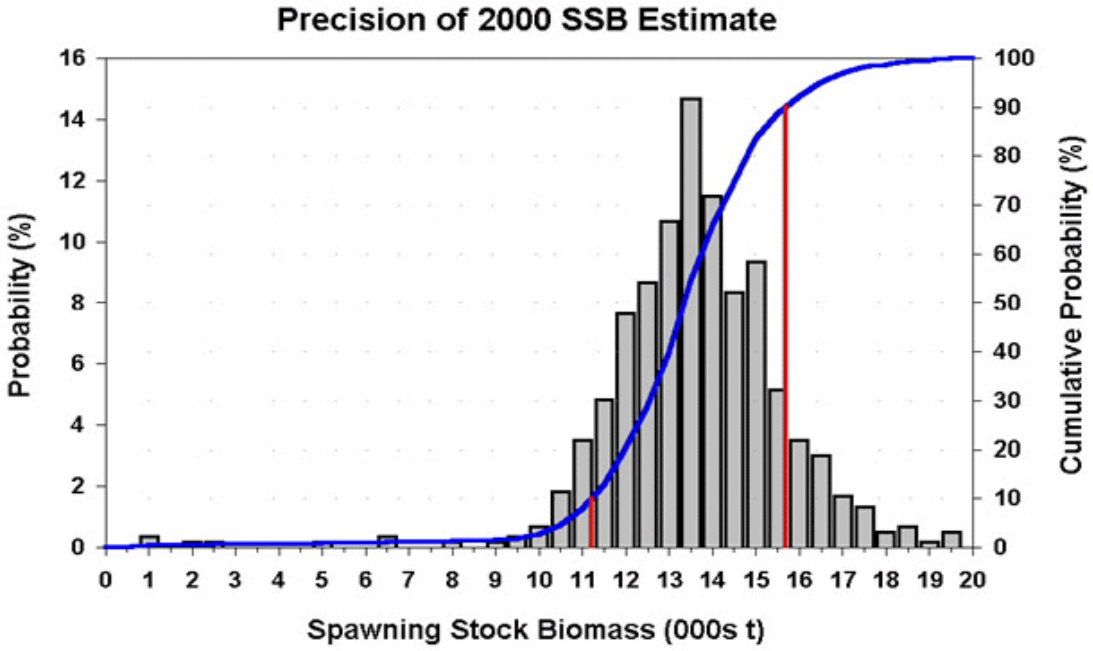


Figure 17. Precision of the estimated spawning stock biomass in 2000 based on 600 bootstrap realizations of the VPA for Gulf of Maine cod.

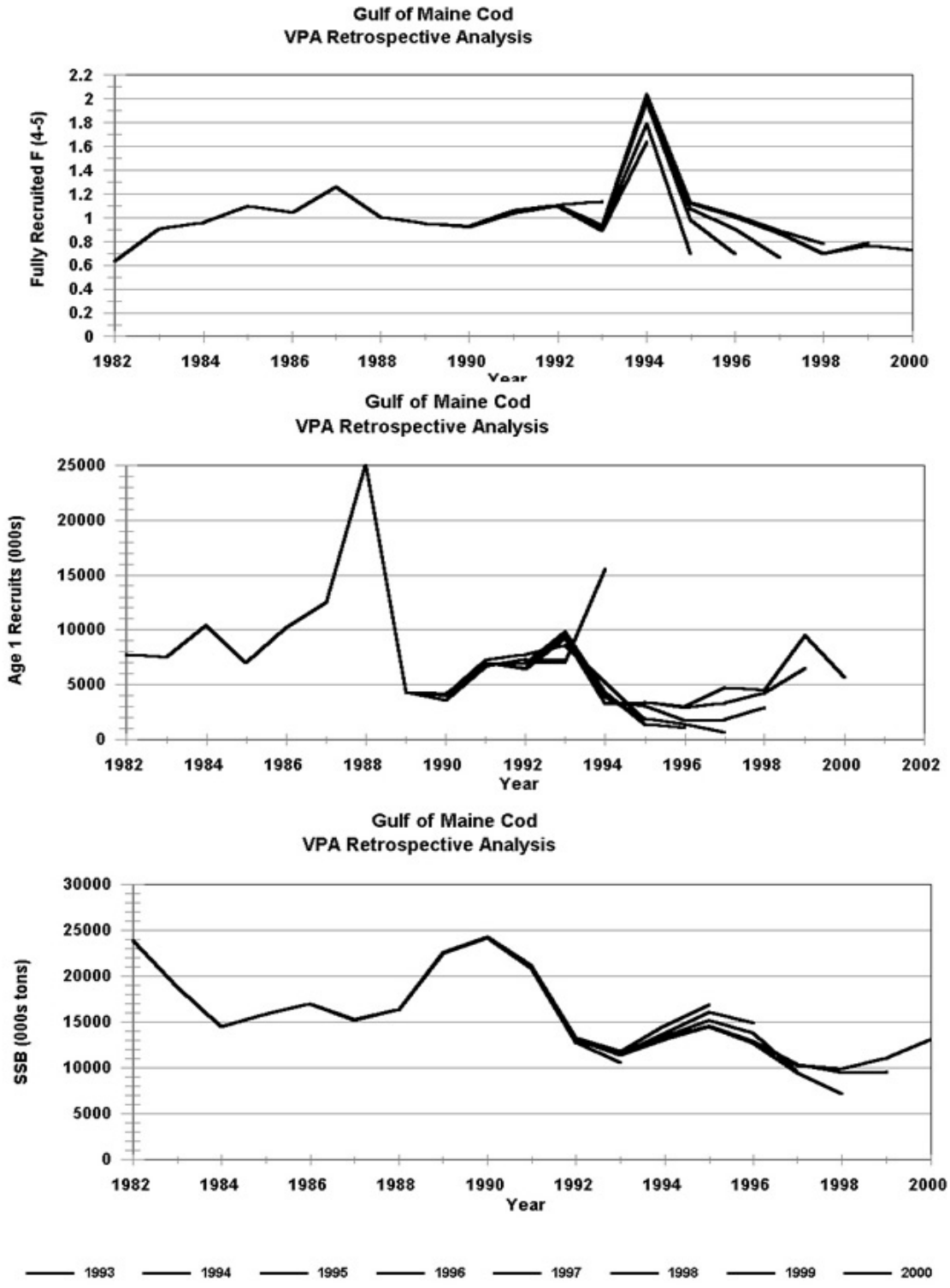


Figure 18. Retrospective analysis of estimates of terminal year F, recruitment and SSB from the VPA for Gulf of Maine cod.

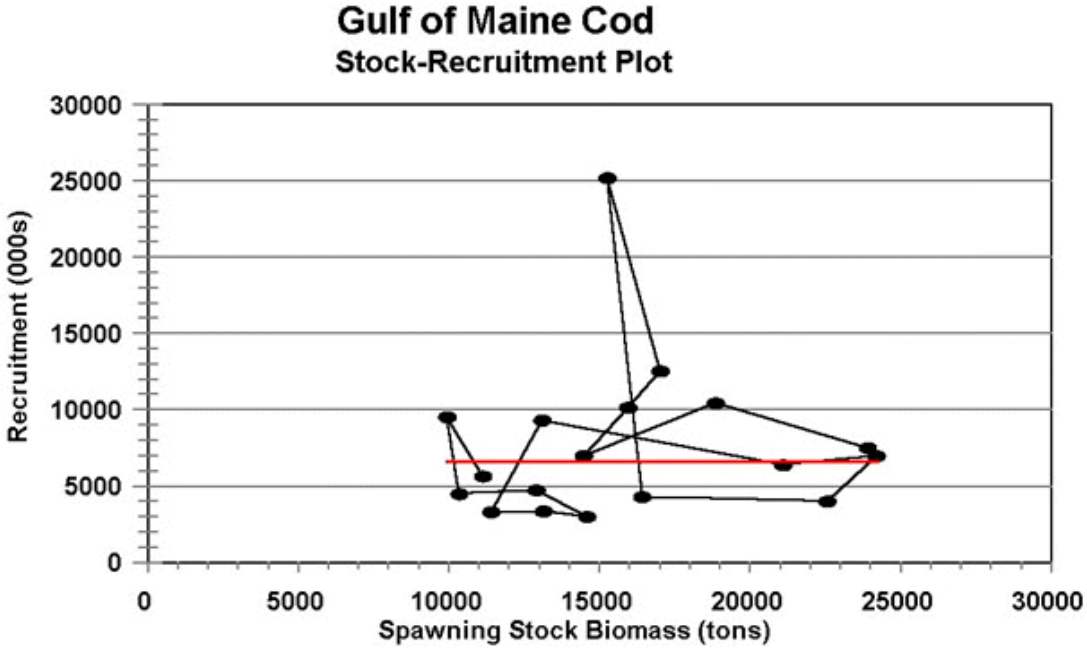


Figure 19a. Spawning stock-recruitment scatterplot for Gulf of Maine cod. The solid horizontal line represents the geometric mean.

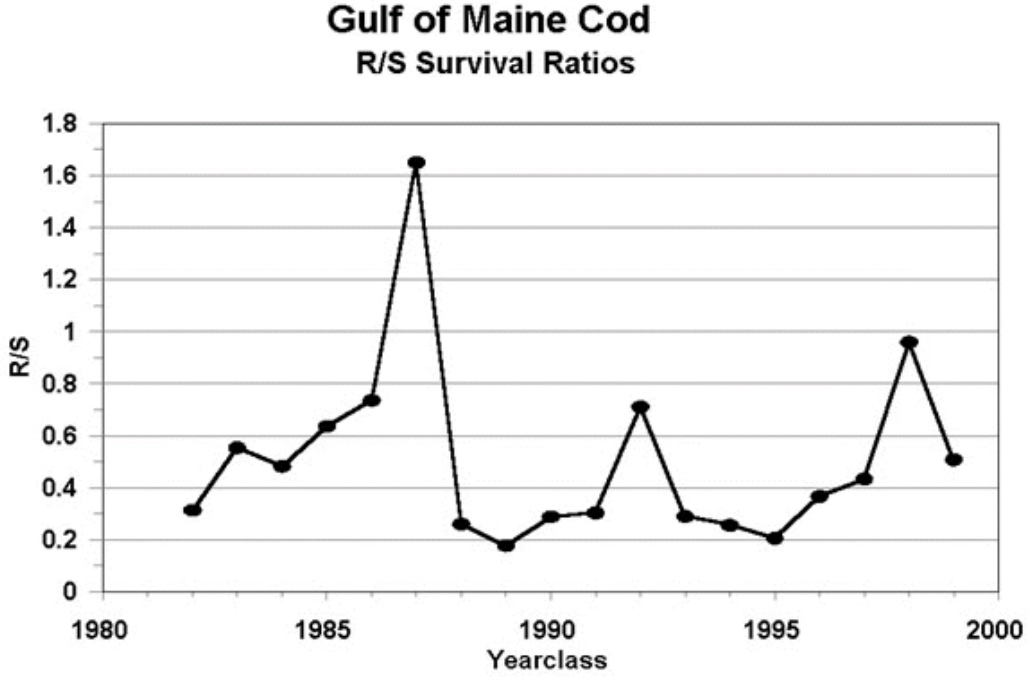
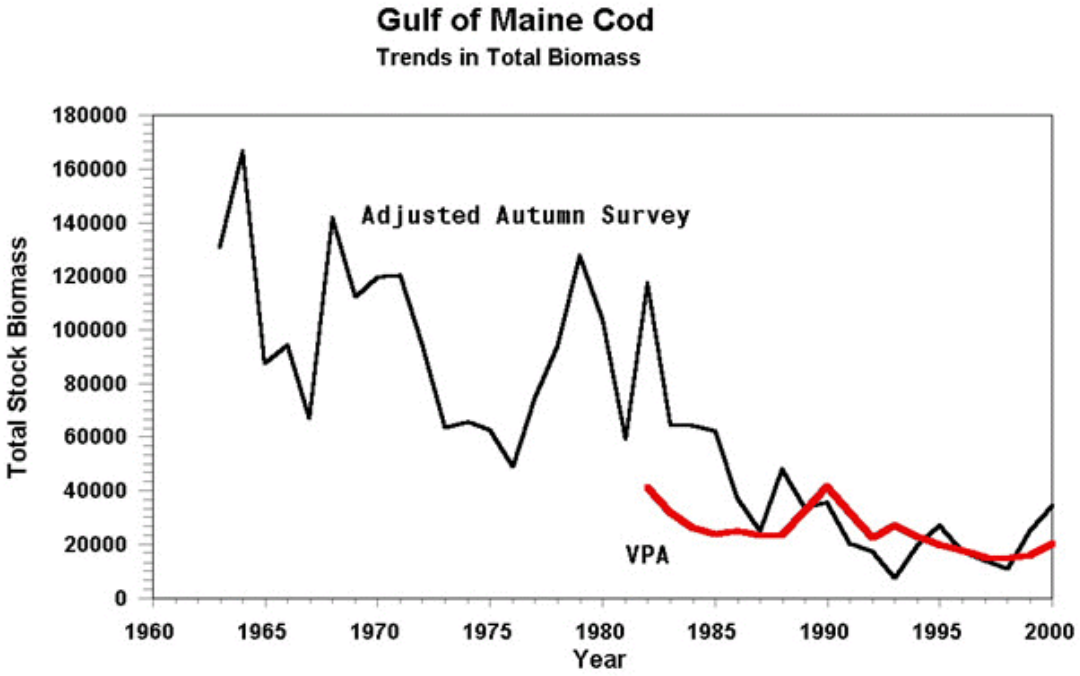


Figure 19b. Trends in survival ratios (R/SSB) for Gulf of Maine cod.



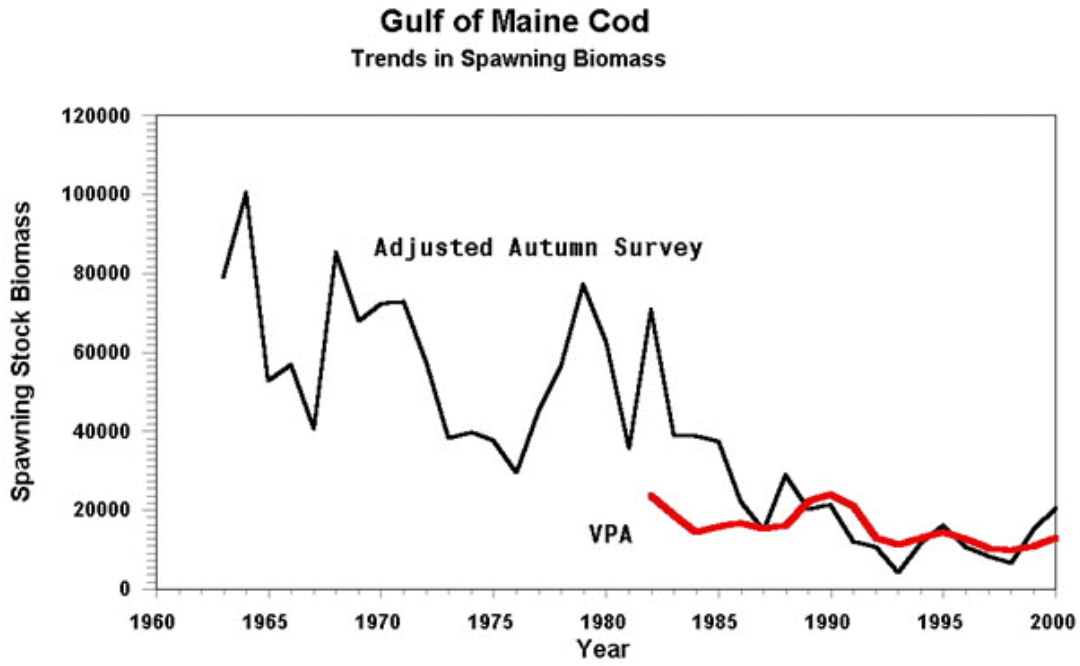


Figure 20. Hind-cast estimates of total stock biomass (upper panel) and spawning stock biomass (lower panel) for Gulf of Maine cod based on VPA-NEFSC autumn survey biomass relaionships.

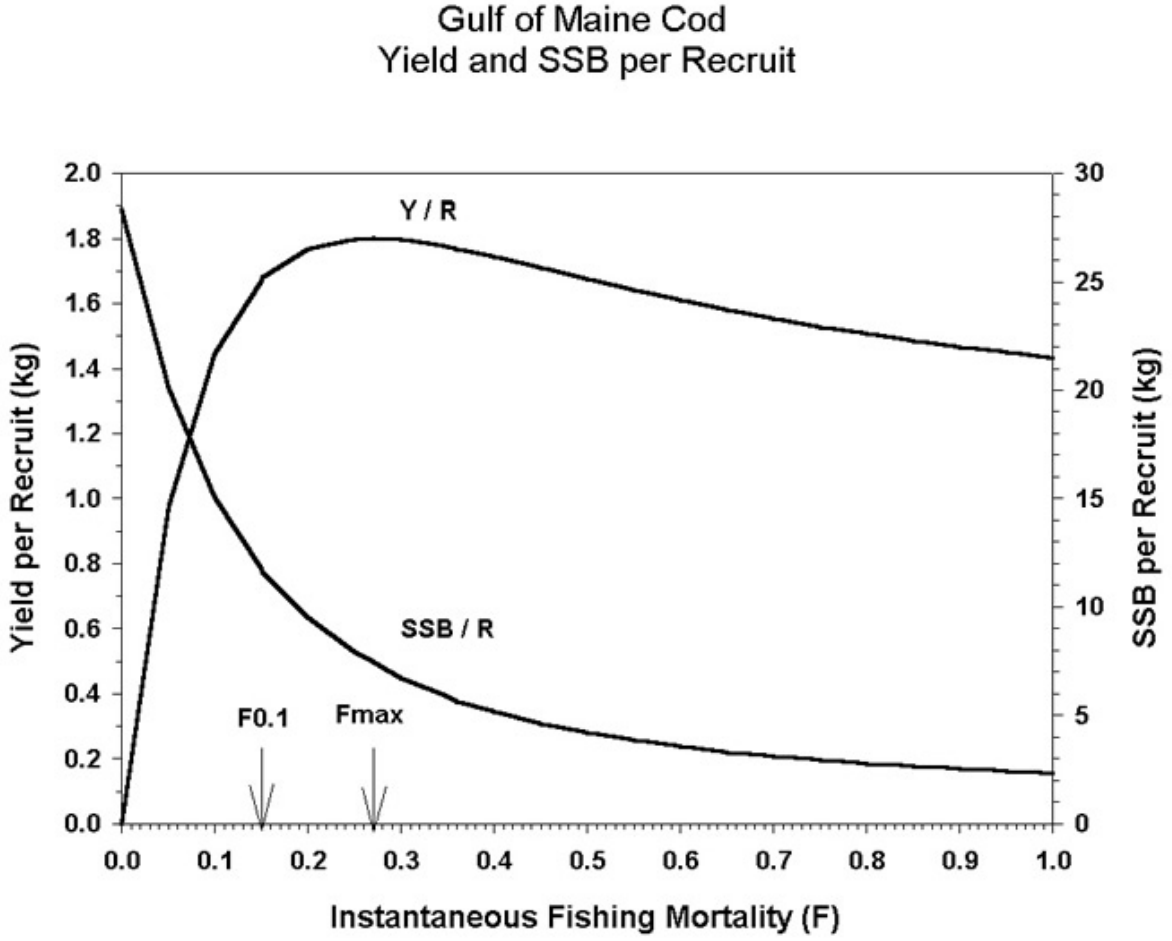


Figure 21. Yield and SSB per recruit results for Gulf of Maine cod.

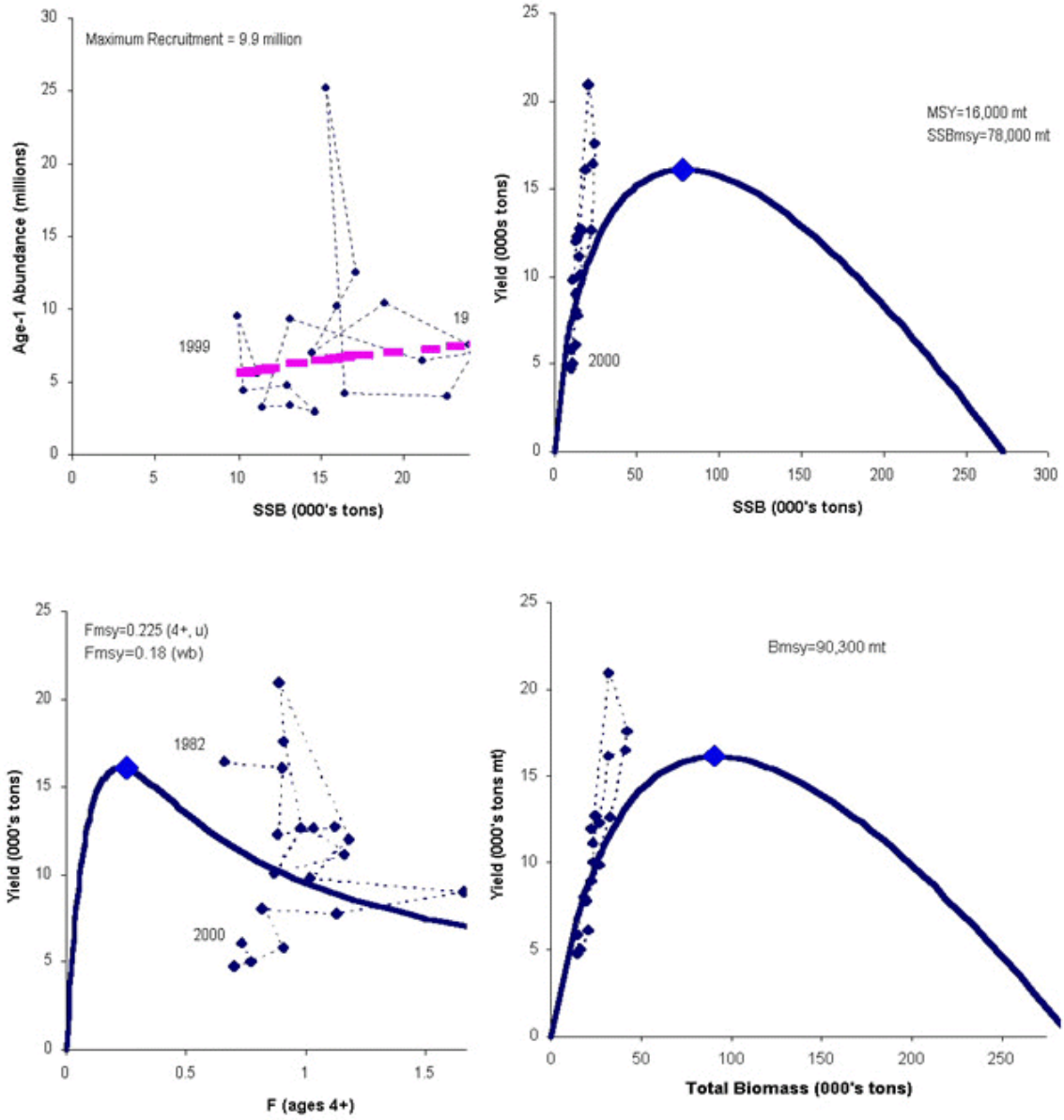


Figure 22. Age structured production model results for Gulf of Maine cod.

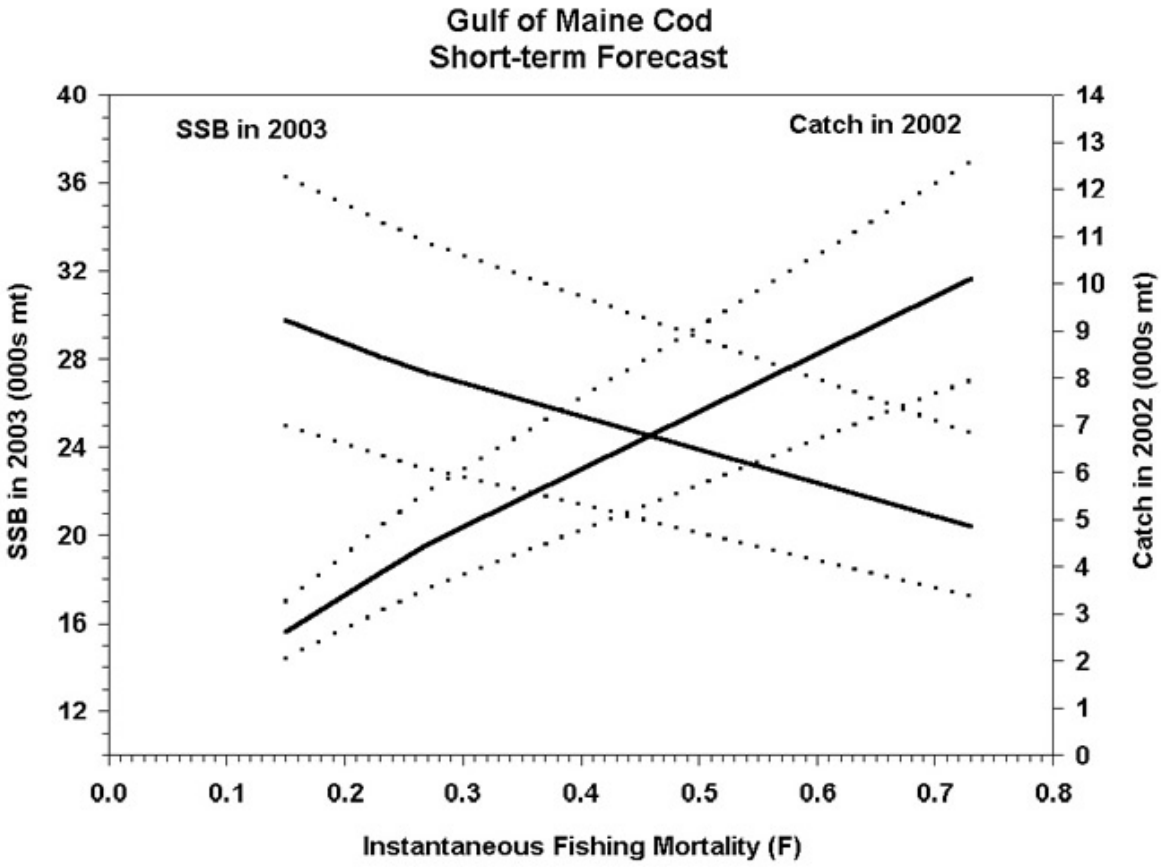


Figure 23. Short-term stochastic catch and stock biomass projection results for Gulf of Maine cod.

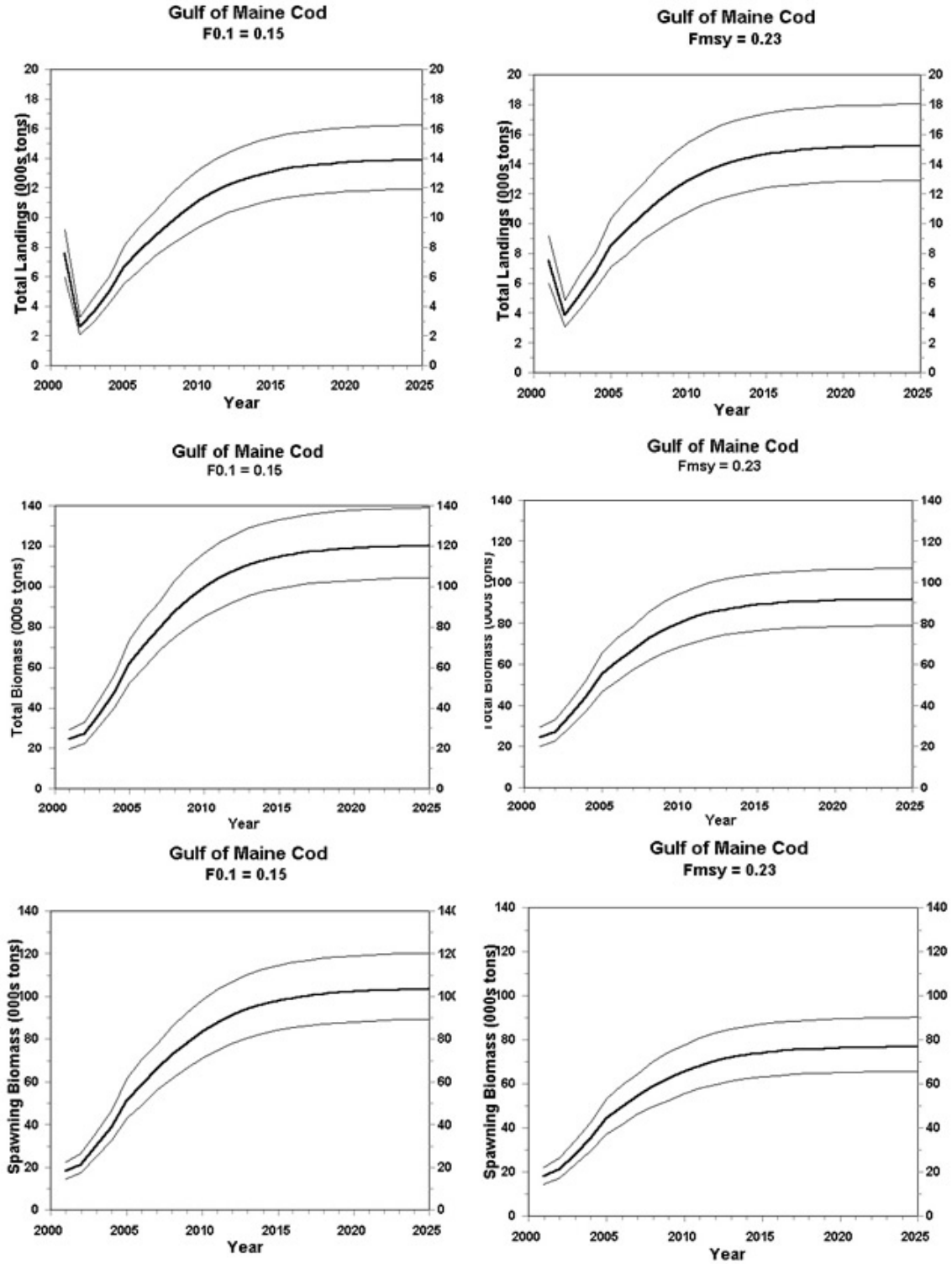


Figure 24. Long-term stochastic catch and stock biomass results for Gulf of Maine cod at F0.1 (0.15) and Fmsy (0.23).

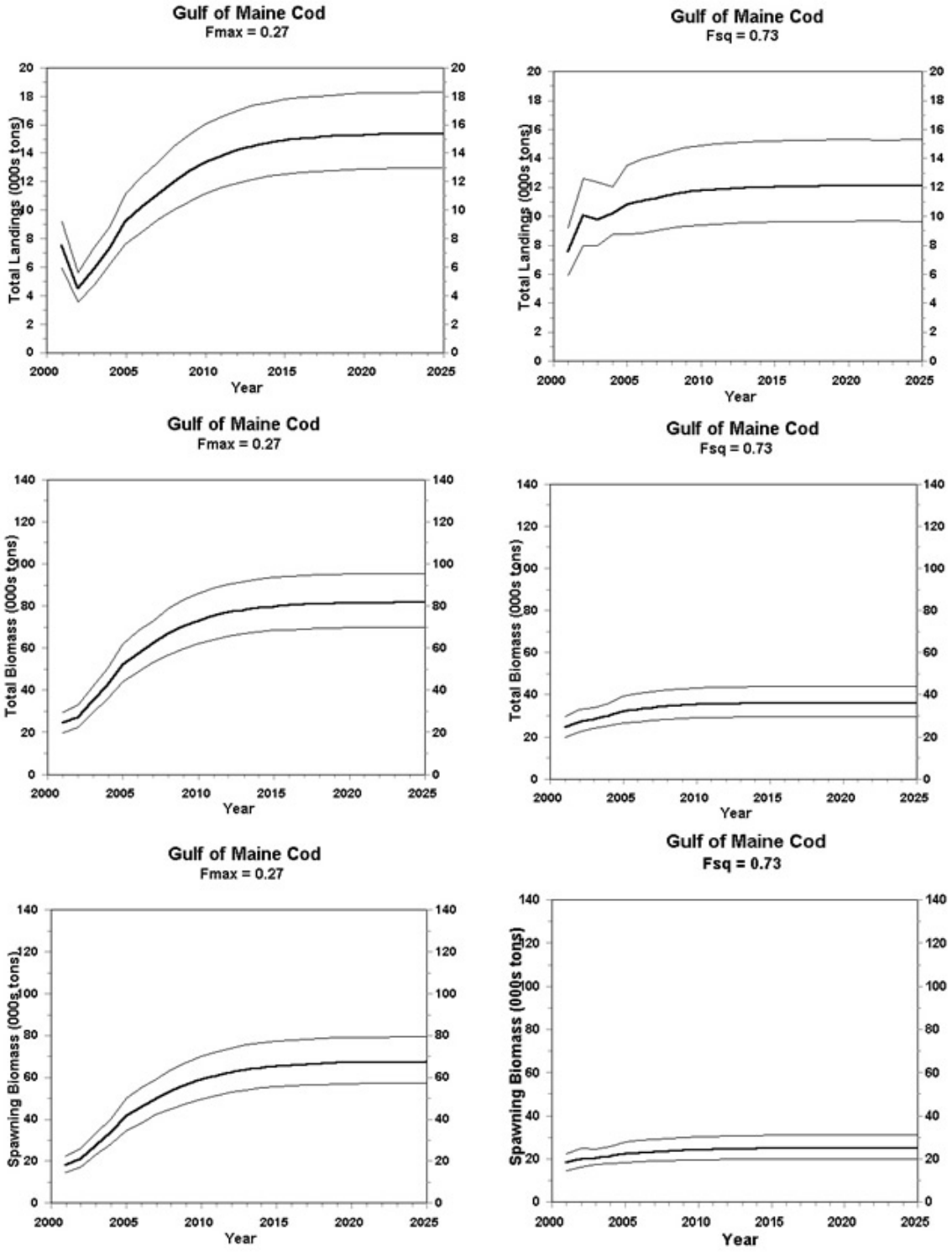


Figure 25. Long-term stochastic catch and stock biomass results for Gulf of Maine cod at Fmax (0.27) and Fsq (0.73).

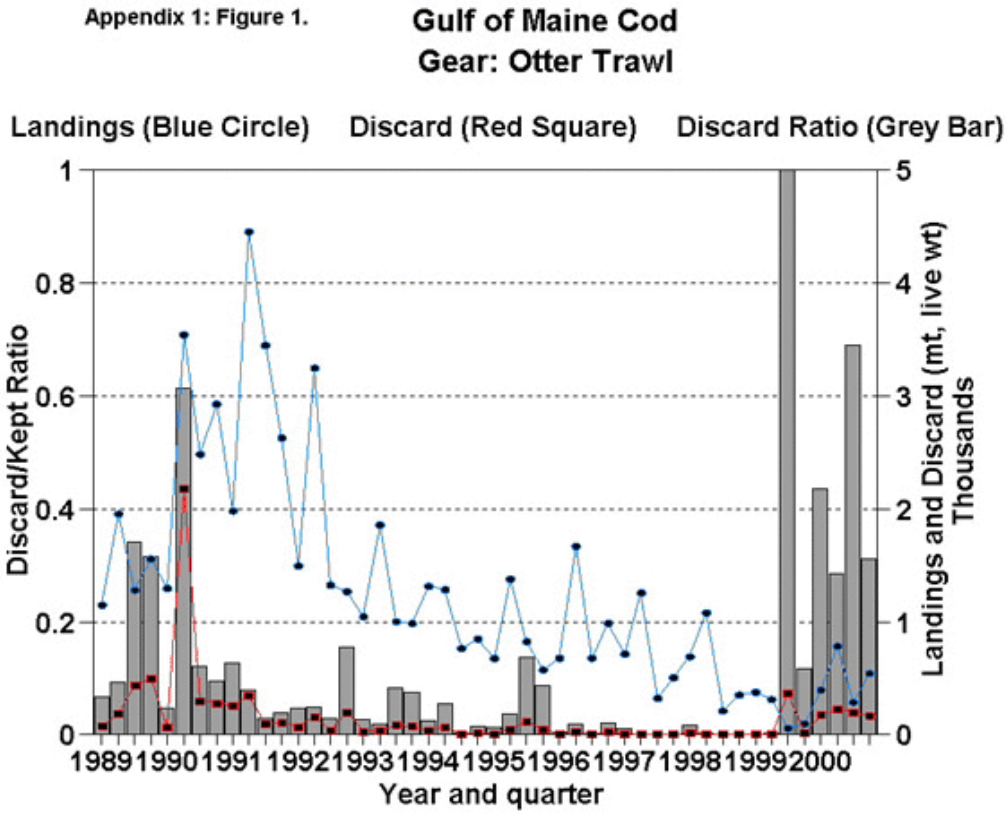
APPENDICES

Appendix 1. Discard Estimates for Gulf of Maine cod derived from NEFSC Sea Sampling data, 1989-2000.

Appendix 1:Table 1. Gulf of Maine cod discard estimates (mt) for otter trawl gear.

Year	Quarter	Num Tows	D/K Ratio	Quarterly Totals Gear=050 Landings	DIscard	Catch	Annual Totals Gear=050 Landings	DIscard	Catch
1989	1	37	0.066	1145	75.6	1220.6			
	2	83	0.093	1956	181.9	2137.9			
	3	82	0.342	1280	437.8	1717.8			
	4	35	0.316	1553	490.7	2043.7	5934.0	1186.0	7120.0
1990	1	3	0.046	1297	59.7	1356.7			
	2	22	0.614	3543	2175.4	5718.4			
	3	39	0.120	2484	298.1	2782.1			
	4	57	0.095	2928	278.2	3206.2	10252.0	2811.3	13063.3
1991	1	33	0.127	1984	252.0	2236.0			
	2	61	0.078	4455	347.5	4802.5			
	3	76	0.028	3448	96.5	3544.5			
	4	295	0.039	2631	102.6	2733.6	12518.0	798.6	13316.6
1992	1	191	0.046	1496	68.8	1564.8			
	2	87	0.049	3248	159.2	3407.2			
	3	83	0.028	1326	37.1	1363.1			
	4	85	0.155	1267	196.4	1463.4	7337.0	461.5	7798.5
1993	1	52	0.027	1046	28.2	1074.2			
	2	33	0.018	1858	33.4	1891.4			
	3	79	0.083	1000	83.0	1083.0			
	4	43	0.075	987	74.0	1061.0	4891.0	218.7	5109.7
1994	1	29	0.024	1312	31.5	1343.5			
	2	5	0.055	1283	70.6	1353.6			
	3	22	0.002	763	1.5	764.5			
	4	27	0.014	848	11.9	859.9	4206.0	115.5	4321.5
1995	1	131	0.012	675	8.1	683.1			
	2	62	0.036	1376	49.5	1425.5			
	3	60	0.137	824	112.9	936.9			
	4	86	0.087	575	50.0	625.0	3450.0	220.5	3670.5
1996	1	46	0.005	678	3.4	681.4			
	2	70	0.018	1669	30.0	1699.0			
	3	11	0.000	678	0.0	678.0			
	4	59	0.020	987	19.7	1006.7	4012.0	53.2	4065.2
1997	1	85	0.011	716	7.9	723.9			
	2	0	0.000	1257	0.0	1257.0			
	3	16	0.001	322	0.3	322.3			
	4	0	0.000	503	0.0	503.0	2798.0	8.2	2806.2
1998	1	18	0.017	692.6	11.8	704.4			
	2	15	0.002	1078.1	2.2	1080.3			
	3	0	0.000	208.1	0.0	208.1			
	4	0	0.000	349.9	0.0	349.9	2328.7	13.9	2342.6
1999	1	0	0.000	374.2	0.0	374.2			
	2	1	0.002	309.04	0.6	309.7			
	3	12	6.289	57.59	362.2	419.8			
	4	20	0.116	97.32	11.3	108.6	838.2	374.1	1212.2
2000	1	52	0.435	395.2	171.9	567.1			
	2	110	0.285	784.8	223.7	1008.5			
	3	73	0.690	287.6	198.4	486.0			
	4	49	0.310	539.6	167.3	706.9	2007.2	761.3	2768.5

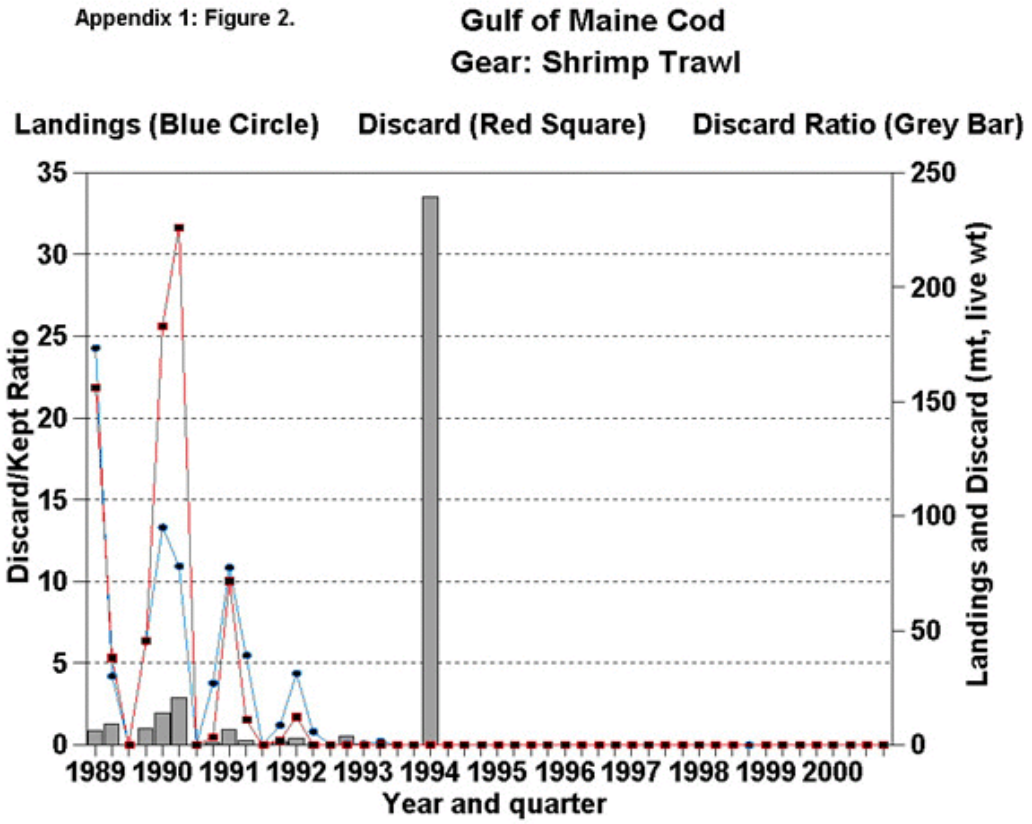
Appendix 1: Figure 1.



Appendix 1:Table 2. Gulf of Maine cod discard estimates (mt) for shrimp trawl gear.

Year	Quarter	Num Tows	D/K Ratio	Quarterly Totals Gear=058 Landings	DIscard	Catch	Annual Totals Gear=058 Landings	DIscard	Catch
1989	1	34	0.901	173.4	156.2	329.6			
	2	37	1.272	30.0	38.2	68.2			
	3	0		0.0	0.0	0.0			
	4	19	1.008	45.3	45.7	91.0	248.7	240.1	488.8
1990	1	48	1.922	95.2	183.0	278.2			
	2	17	2.892	78.2	226.2	304.4			
	3	0		0.0	0.0	0.0			
	4	12	0.124	27.0	3.3	30.3	200.4	412.5	612.9
1991	1	68	0.924	77.6	71.7	149.3			
	2	36	0.284	39.1	11.1	50.2			
	3	0		0.0	0.0	0.0			
	4	13	0.203	8.6	1.7	10.3	125.3	84.6	209.9
1992	1	167	0.396	31.3	12.4	43.7			
	2	3	0.000	5.8	0.0	5.8			
	3	0		0.0	0.0	0.0			
	4	7	0.500	0.6	0.3	0.9	37.7	12.7	50.4
1993	1	139	0.000	0.5	0.0	0.5			
	2	2	0.000	1.7	0.0	1.7			
	3	0		0.0	0.0	0.0			
	4	2	0.000	0.2	0.0	0.2	2.4	0.0	2.4
1994	1	138	33.500	0.0	0.0	0.0			
	2	3	0.000	0.0	0.0	0.0			
	3	0		0.0	0.0	0.0			
	4	4	0.000	0.0	0.0	0.0	0.0	0.0	0.0
1995	1	30	0.000	0.0	0.0	0.0			
	2	1	0.000	0.0	0.0	0.0			
	3	0		0.0	0.0	0.0			
	4	4	0.000	0.0	0.0	0.0	0.0	0.0	0.0
1996	1	20	0.000	0.0	0.0	0.0			
	2	2	0.000	0.0	0.0	0.0			
	3	0		0.0	0.0	0.0			
	4	6	0.000	0.0	0.0	0.0	0.0	0.0	0.0
1997	1	16	0.000	0.0	0.0	0.0			
	2	0	0.000	0.0	0.0	0.0			
	3	0	0.000	0.0	0.0	0.0			
	4		0.000	0.0	0.0	0.0	0.0	0.0	0.0
1998	1	0	0.000	0.0	0.0	0.0			
	2	0	0.000	0.0	0.0	0.0			
	3	0	0.000	0.0	0.0	0.0			
	4		0.000	0.0	0.0	0.0	0.0	0.0	0.0
1999	1	0	0.000	0.0	0.0	0.0			
	2	0	0.000	0.0	0.0	0.0			
	3	0	0.000	0.0	0.0	0.0			
	4	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0
2000	1	0	0.000	0.0	0.0	0.0			
	2	0	0.000	0.0	0.0	0.0			
	3	0	0.000	0.0	0.0	0.0			
	4	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0

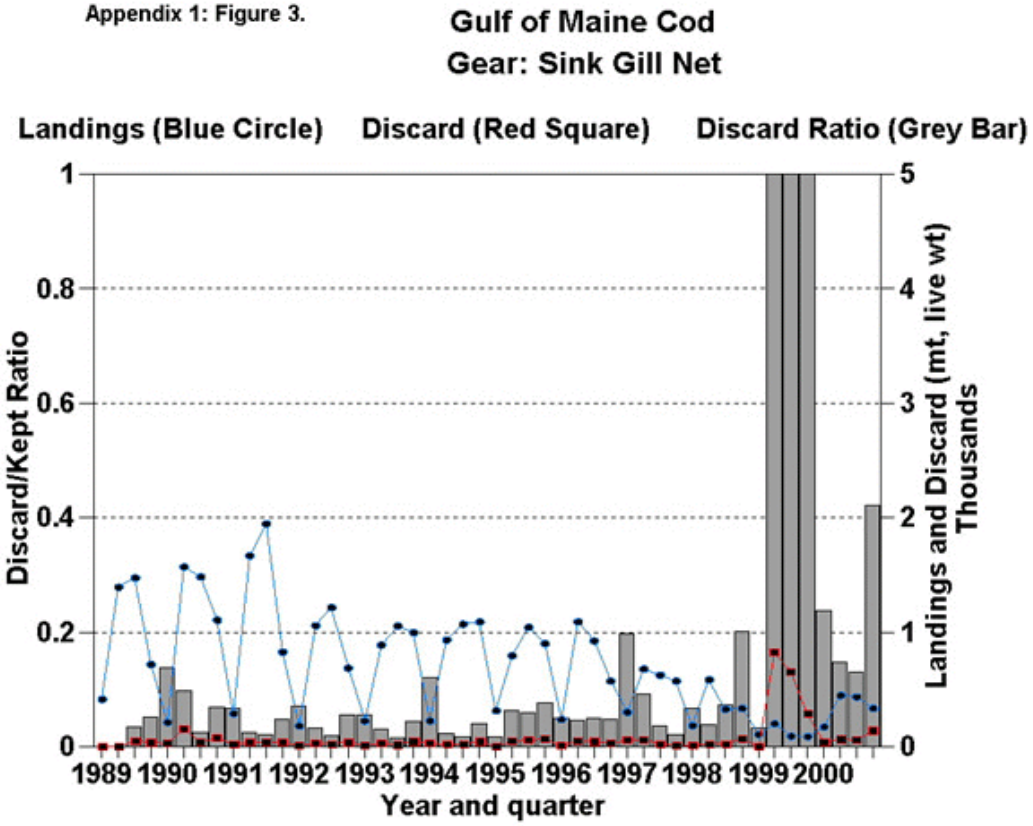
Appendix 1: Figure 2.



Appendix 1:Table 3. Gulf of Maine cod discard estimates (mt) for sink gillnet gear.

Year	Quarter	Num Sets	D/K Ratio	Quarterly Totals Gear=100 Landings	DIscard	Catch	Annual Totals Gear=100 Landings	DIscard	Catch
1989	1	0		415.8	0.0	415.8			
	2	0		1393.1	0.0	1393.1			
	3	104	0.034	1473.3	50.1	1523.4			
	4	133	0.051	717.3	36.6	753.9	3999.5	86.7	4086.2
1990	1	84	0.138	215.0	29.7	244.7			
	2	176	0.097	1572.7	152.6	1725.3			
	3	107	0.026	1481.8	38.5	1520.3			
	4	102	0.069	1105.3	76.3	1181.6	4374.8	297.0	4671.8
1991	1	59	0.067	289.7	19.4	309.1			
	2	508	0.025	1668.4	41.7	1710.1			
	3	1456	0.021	1945.6	40.9	1986.5			
	4	909	0.048	826.8	39.7	866.5	4730.5	141.7	4872.2
1992	1	247	0.071	180.8	12.8	193.6			
	2	1005	0.032	1056.7	33.8	1090.5			
	3	977	0.019	1213.7	23.1	1236.8			
	4	726	0.056	685.1	38.4	723.5	3136.3	108.1	3244.4
1993	1	123	0.056	225.4	12.6	238.0			
	2	780	0.031	889.2	27.6	916.8			
	3	523	0.016	1053.9	16.9	1070.8			
	4	530	0.044	995.7	43.8	1039.5	3164.2	100.9	3265.1
1994	1	93	0.121	227.0	27.5	254.5			
	2	47	0.023	931.0	21.4	952.4			
	3	95	0.018	1069.0	19.2	1088.2			
	4	62	0.041	1089.0	44.6	1133.6	3316.0	112.8	3428.8
1995	1	33	0.017	314.0	5.3	319.3			
	2	55	0.064	794.0	50.8	844.8			
	3	70	0.060	1043.0	62.6	1105.6			
	4	38	0.076	899.0	68.3	967.3	3050.0	187.1	3237.1
1996	1	25	0.050	237.0	11.9	248.9			
	2	63	0.047	1090.0	51.2	1141.2			
	3	50	0.049	926.0	45.4	971.4			
	4	43	0.048	572.0	27.5	599.5	2825.0	135.9	2960.9
1997	1	7	0.196	301.0	59.0	360.0			
	2	48	0.092	677.0	62.3	739.3			
	3	46	0.037	624.0	23.1	647.1			
	4	34	0.020	574.0	11.5	585.5	2176.0	155.8	2331.8
1998	1	17	0.066	185.6	12.2	197.8			
	2	107	0.038	584.9	22.2	607.1			
	3	47	0.072	326.7	23.5	350.2			
	4	82	0.202	334.2	67.5	401.7	1431.4	125.5	1556.9
1999	1	23	0.033	110.5	3.6	114.1			
	2	44	4.101	201.1	824.7	1025.8			
	3	57	7.123	91.8	653.8	745.6			
	4	63	3.156	90.5	285.7	376.3	493.9	1767.9	2261.7
2000	1	45	0.237	172.4	40.9	213.3			
	2	82	0.148	449.6	66.5	516.1			
	3	51	0.131	436.4	57.2	493.6			
	4	63	0.422	335.3	141.5	476.8	1393.7	306.1	1699.8

Appendix 1: Figure 3.



Appendix 2. Age-specific bottom trawl survey abundance indices for Gulf of Maine cod.

Table 1. Stratified mean catch per tow at age (numbers) of Atlantic cod in NEFC offshore spring and autumn bottom trawl surveys in the Gulf of Maine, 1963 - 2000.

Table 2. Standardized [for both door and gear changes] stratified mean number per tow at age and standardized stratified mean weight (kg) per tow of Atlantic cod in NEFSC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine, 1963-2000.

Table 3. Stratified mean catch per tow in numbers and weight (kg) of Atlantic cod in State of Massachusetts inshore spring and autumn bottom trawl surveys in territorial waters adjacent to the Georges Bank area (Mass. Regions 1-3) and in the Gulf of Maine (Mass. Regions 4-5), 1978 - 2000.

Appendix 2:Table 1. Stratified mean catch per tow at age (numbers) of Atlantic cod in NEFC offshore spring and autumn bottom trawl surveys in the Gulf of Maine, 1963 - 2000. [**a**,**b**]

	Age Group											Totals						Str.Mean
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+	Wgt per tow
Spring [**b**]																		
1968	0.082	0.393	0.791	0.902	0.542	0.345	0.133	0.083	0.071	0.038	0.106	3.486	3.404	3.011	2.220	1.318	0.776	11.06
1969	0.000	0.000	0.023	0.197	0.564	0.517	0.406	0.164	0.092	0.057	0.065	2.085	2.085	2.085	2.062	1.865	1.301	8.15
1970	0.000	0.102	0.079	0.035	0.060	0.175	0.299	0.394	0.048	0.038	0.184	1.414	1.414	1.312	1.233	1.198	1.138	6.83
1971	0.000	0.016	0.091	0.070	0.187	0.031	0.053	0.192	0.132	0.099	0.046	0.917	0.917	0.901	0.810	0.740	0.553	4.31
1972	0.000	0.226	0.098	0.333	0.126	0.128	0.023	0.068	0.065	0.147	0.105	1.319	1.319	1.093	0.995	0.662	0.536	4.96
1973	0.000	0.022	2.724	0.581	0.397	0.224	0.125	0.061	0.143	0.161	0.392	4.830	4.830	4.808	2.084	1.503	1.106	11.60
1974	0.000	0.305	0.036	0.871	0.211	0.142	0.073	0.031	0.031	0.013	0.149	1.862	1.862	1.557	1.521	0.650	0.439	4.59
1975	0.004	0.060	0.448	0.068	0.683	0.166	0.071	0.003	0.003	0.012	0.092	1.610	1.606	1.546	1.098	1.030	0.347	3.72
1976	0.000	0.027	0.195	0.672	0.098	0.575	0.055	0.069	0.042	0.000	0.047	1.780	1.780	1.753	1.558	0.886	0.788	4.66
1977	0.000	0.016	0.191	0.334	1.278	0.070	0.507	0.004	0.065	0.000	0.024	2.489	2.489	2.473	2.282	1.948	0.670	5.27
1978	0.000	0.022	0.067	0.183	0.223	0.491	0.048	0.205	0.005	0.068	0.005	1.317	1.317	1.295	1.228	1.045	0.822	4.75
1979	0.028	0.343	1.045	0.136	0.320	0.257	0.439	0.038	0.091	0.008	0.034	2.739	2.711	2.368	1.323	1.187	0.867	5.86
1980	0.057	0.057	0.357	0.278	0.100	0.339	0.194	0.246	0.000	0.105	0.011	1.744	1.687	1.630	1.273	0.995	0.895	5.69
1981	0.000	0.823	0.537	0.800	0.987	0.266	0.233	0.089	0.126	0.086	0.000	3.947	3.947	3.124	2.587	1.787	0.800	9.94
1982	0.012	0.273	0.827	0.419	0.563	0.701	0.095	0.088	0.000	0.034	0.032	3.044	3.032	2.759	1.932	1.513	0.950	7.94
1983	0.008	0.401	0.627	0.534	0.411	0.229	0.116	0.059	0.000	0.058	0.065	2.508	2.500	2.099	1.472	0.938	0.527	6.48
1984	0.000	0.097	0.662	0.735	0.475	0.122	0.034	0.037	0.019	0.000	0.000	2.181	2.181	2.084	1.422	0.687	0.212	3.60
1985	0.000	0.028	0.238	0.622	0.665	0.677	0.095	0.114	0.052	0.000	0.026	2.517	2.517	2.489	2.251	1.629	0.964	7.65
1986	0.000	0.417	0.330	0.647	0.387	0.074	0.046	0.027	0.011	0.000	0.018	1.957	1.957	1.540	1.210	0.563	0.176	3.60
1987	0.000	0.049	0.638	0.486	0.300	0.128	0.011	0.045	0.011	0.000	0.014	1.682	1.682	1.633	0.995	0.509	0.209	3.01
1988	0.029	0.663	1.053	0.633	0.355	0.217	0.087	0.063	0.000	0.027	0.000	3.127	3.098	2.435	1.382	0.749	0.394	3.30
1989	0.000	0.029	0.822	1.000	0.800	0.114	0.097	0.000	0.000	0.000	0.000	2.862	2.862	2.833	2.011	1.011	0.211	3.78
1990	0.000	0.000	0.241	1.680	0.794	0.211	0.041	0.023	0.000	0.000	0.000	2.990	2.990	2.990	2.749	1.069	0.275	4.59
1991	0.000	0.054	0.265	0.449	1.870	0.339	0.030	0.023	0.000	0.000	0.000	3.030	3.030	2.976	2.711	2.262	0.392	4.31
1992	0.000	0.050	0.230	0.240	0.280	1.310	0.220	0.070	0.000	0.010	0.000	2.410	2.410	2.350	2.130	1.890	1.610	8.66
1993	0.000	0.200	0.500	0.800	0.330	0.090	0.480	0.060	0.020	0.000	0.023	2.503	2.503	2.303	1.803	1.003	0.673	5.87
1994	0.000	0.020	0.400	0.490	0.270	0.120	0.060	0.160	0.030	0.030	0.020	1.609	1.609	1.589	1.189	0.699	0.429	3.62
1995	0.000	0.050	0.180	1.120	0.370	0.150	0.030	0.000	0.010	0.000	0.000	1.930	1.930	1.880	1.700	0.580	0.210	2.43
1996	0.000	0.060	0.020	0.590	1.330	0.040	0.060	0.000	0.000	0.000	0.000	2.465	2.465	2.405	2.385	1.795	0.465	5.43
1997	0.000	0.158	0.132	0.399	0.264	0.876	0.242	0.120	0.000	0.000	0.000	2.191	2.191	2.033	1.901	1.502	1.238	5.62
1998	0.000	0.018	0.224	0.330	0.517	0.142	0.421	0.022	0.037	0.000	0.000	1.710	1.710	1.692	1.468	1.138	0.621	4.18
1999	0.000	0.166	0.344	0.713	0.344	0.315	0.134	0.273	0.000	0.000	0.011	2.301	2.301	2.135	1.791	1.078	0.734	5.09
2000	0.026	1.184	0.725	0.438	0.457	0.107	0.101	0.024	0.022	0.000	0.000	3.083	3.057	1.873	1.148	0.710	0.253	3.21

[**a**] Strata 26-30 and 36-40.

[**b**] 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.

Appendix 2:Table 1 (Continued). [**a**,**b**]

	Age Group											Totals						Str.Mean
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+	Wgt per tow
Autumn [b]																		
1963	0.032	0.416	0.865	0.803	0.544	0.371	0.344	0.192	0.117	0.061	0.048	3.793	3.761	3.345	2.480	1.677	1.133	11.08
1964	0.000	0.059	0.078	0.302	0.549	0.547	0.502	0.239	0.152	0.073	0.065	2.566	2.566	2.507	2.429	2.127	1.578	14.07
1965	0.001	0.545	0.564	0.528	0.481	0.318	0.240	0.109	0.051	0.028	0.016	2.881	2.880	2.335	1.771	1.243	0.762	7.41
1966	0.109	0.131	0.410	0.447	0.460	0.358	0.283	0.123	0.050	0.031	0.023	2.425	2.316	2.185	1.775	1.328	0.868	7.97
1967	0.008	0.083	0.138	0.368	0.430	0.246	0.172	0.104	0.045	0.026	0.022	1.642	1.634	1.551	1.413	1.045	0.615	5.70
1968	0.008	0.023	0.115	0.461	0.805	0.624	0.402	0.167	0.100	0.046	0.061	2.812	2.804	2.781	2.666	2.205	1.400	12.00
1969	0.010	0.038	0.079	0.227	0.404	0.354	0.299	0.141	0.093	0.083	0.040	1.768	1.758	1.720	1.641	1.414	1.010	9.49
1970	0.476	0.603	0.170	0.353	0.211	0.313	0.271	0.506	0.084	0.060	0.094	3.141	2.665	2.062	1.892	1.539	1.328	10.14
1971	0.863	0.114	0.153	0.135	0.383	0.295	0.278	0.163	0.204	0.128	0.082	2.798	1.935	1.821	1.668	1.533	1.150	10.20
1972	0.020	3.576	0.780	0.978	0.150	0.060	0.110	0.025	0.102	0.155	0.010	5.966	5.946	2.370	1.590	0.612	0.462	8.00
1973	0.408	0.210	1.393	0.089	0.325	0.136	0.050	0.018	0.033	0.108	0.087	2.857	2.449	2.239	0.846	0.757	0.432	5.39
1974	0.181	0.720	0.121	1.118	0.187	0.230	0.050	0.008	0.008	0.027	0.127	2.777	2.596	1.876	1.755	0.637	0.450	5.54
1975	0.030	0.094	1.966	0.086	1.510	0.163	0.070	0.011	0.002	0.002	0.008	3.942	3.912	3.818	1.852	1.766	0.256	5.32
1976	0.000	0.156	0.134	0.405	0.064	0.492	0.037	0.061	0.000	0.010	0.020	1.379	1.379	1.223	1.089	0.684	0.620	4.16
1977	0.000	0.018	0.291	0.446	0.937	0.123	0.481	0.031	0.079	0.018	0.078	2.502	2.502	2.484	2.193	1.747	0.810	9.42
1978	0.202	1.111	0.301	0.907	0.532	1.160	0.091	0.264	0.007	0.049	0.041	4.665	4.463	3.352	3.051	2.144	1.612	11.88
1979	0.003	0.236	0.381	0.104	0.536	0.251	0.501	0.033	0.138	0.000	0.053	2.236	2.233	1.997	1.616	1.512	0.976	10.83
1980	0.022	1.026	2.111	1.423	0.403	0.188	0.272	0.168	0.024	0.015	0.058	5.710	5.688	4.662	2.551	1.128	0.725	13.09
1981	0.008	0.397	0.245	0.352	0.304	0.057	0.076	0.024	0.069	0.000	0.018	1.550	1.542	1.145	0.900	0.548	0.244	4.97
1982	0.000	0.449	2.014	1.585	0.748	0.159	0.000	0.025	0.000	0.000	0.000	4.980	4.980	4.531	2.517	0.932	0.184	9.92
1983	0.029	1.064	0.626	0.546	0.089	0.169	0.126	0.000	0.000	0.000	0.058	2.707	2.678	1.614	0.988	0.442	0.353	5.44
1984	0.028	0.246	0.270	0.362	0.256	0.141	0.131	0.057	0.000	0.020	0.042	1.553	1.525	1.279	1.009	0.647	0.391	5.44
1985	0.266	0.378	0.910	0.763	0.209	0.218	0.074	0.000	0.034	0.021	0.049	2.922	2.656	2.278	1.368	0.605	0.396	8.49
1986	0.000	0.301	0.490	0.654	0.333	0.086	0.042	0.000	0.000	0.024	0.021	1.951	1.951	1.650	1.160	0.506	0.173	5.10
1987	0.138	0.599	1.324	0.600	0.257	0.061	0.000	0.000	0.000	0.000	0.000	2.979	2.841	2.242	0.918	0.318	0.061	3.41
1988	0.000	1.951	2.245	0.960	0.528	0.110	0.076	0.033	0.000	0.000	0.000	5.903	5.903	3.952	1.707	0.747	0.219	6.61
1989	0.000	0.526	3.026	1.717	0.372	0.220	0.018	0.000	0.000	0.011	0.000	5.890	5.890	5.364	2.338	0.621	0.249	6.84
1990	0.008	0.037	0.464	2.080	0.788	0.352	0.036	0.013	0.000	0.000	0.000	3.778	3.770	3.733	3.269	1.189	0.401	7.33
1991	0.010	0.180	0.180	0.280	0.800	0.100	0.000	0.030	0.000	0.000	0.000	1.580	1.570	1.390	1.210	0.930	0.130	4.15
1992	0.060	0.290	0.450	0.140	0.040	0.330	0.110	0.000	0.010	0.000	0.000	1.430	1.370	1.080	0.630	0.490	0.450	2.45
1993	0.050	0.250	0.720	0.460	0.040	0.000	0.040	0.000	0.000	0.000	0.000	1.560	1.510	1.260	0.540	0.080	0.040	1.50
1994	0.030	0.210	0.880	0.830	0.090	0.050	0.000	0.050	0.000	0.000	0.000	2.140	2.110	1.900	1.020	0.190	0.100	2.74
1995	0.010	0.070	0.280	1.232	0.330	0.080	0.010	0.000	0.000	0.000	0.000	2.010	2.000	1.930	1.650	0.420	0.090	3.67
1996	0.030	0.120	0.380	0.190	0.540	0.060	0.000	0.000	0.000	0.000	0.000	1.320	1.290	1.170	0.790	0.600	0.060	2.35
1997	0.000	0.297	0.086	0.160	0.182	0.149	0.000	0.000	0.000	0.000	0.000	0.872	0.872	0.575	0.490	0.330	0.149	1.87
1998	0.050	0.097	0.320	0.115	0.192	0.039	0.031	0.000	0.000	0.000	0.000	0.843	0.793	0.696	0.376	0.261	0.069	1.50
1999	0.025	0.431	0.363	0.590	0.243	0.132	0.023	0.000	0.000	0.000	0.000	1.807	1.782	1.351	0.998	0.408	0.165	3.50
2000	0.008	0.533	0.984	0.394	0.507	0.134	0.010	0.034	0.000	0.000	0.000	2.604	2.596	2.063	1.079	0.685	0.178	4.65

[**a**] Strata 26-30 and 36-40.

[**b**] Autumn catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey.

Appendix 2:Table 2. Standardized [for both door and gear changes] stratified mean number per tow at age and standardized stratified mean weight (kg) per tow of Atlantic cod in NEFSC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine, 1963-2000. [**a**,**b**]

	Age Group											Totals						Standardized
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+	Mean Wt (kg)/Tow
Spring [c,d,e]																		
1968	0.128	0.613	1.234	1.407	0.846	0.538	0.207	0.129	0.111	0.059	0.165	5.438	5.310	4.697	3.463	2.056	1.211	17.92
1969	0.000	0.000	0.036	0.307	0.880	0.807	0.633	0.256	0.144	0.089	0.101	3.253	3.253	3.253	3.217	2.909	2.030	13.20
1970	0.000	0.159	0.123	0.055	0.094	0.273	0.466	0.615	0.075	0.059	0.287	2.206	2.206	2.047	1.923	1.869	1.775	11.06
1971	0.000	0.025	0.142	0.109	0.292	0.048	0.083	0.300	0.206	0.154	0.072	1.431	1.431	1.406	1.264	1.154	0.863	6.98
1972	0.000	0.353	0.153	0.519	0.197	0.200	0.036	0.106	0.101	0.229	0.164	2.058	2.058	1.705	1.552	1.033	0.836	8.04
1973	0.000	0.034	4.249	0.906	0.619	0.349	0.195	0.095	0.223	0.251	0.612	7.535	7.535	7.500	3.251	2.345	1.725	18.79
1974	0.000	0.476	0.056	1.359	0.329	0.222	0.114	0.048	0.048	0.020	0.232	2.905	2.905	2.429	2.373	1.014	0.685	7.44
1975	0.006	0.094	0.699	0.106	1.065	0.259	0.111	0.005	0.005	0.019	0.144	2.512	2.505	2.412	1.713	1.607	0.541	6.03
1976	0.000	0.042	0.304	1.048	0.153	0.897	0.086	0.108	0.066	0.000	0.073	2.777	2.777	2.735	2.430	1.382	1.229	7.55
1977	0.000	0.025	0.298	0.521	1.994	0.109	0.791	0.006	0.101	0.000	0.037	3.883	3.883	3.858	3.560	3.039	1.045	8.54
1978	0.000	0.034	0.105	0.285	0.348	0.766	0.075	0.320	0.008	0.106	0.008	2.055	2.055	2.020	1.916	1.630	1.282	7.70
1979	0.044	0.535	1.630	0.212	0.499	0.401	0.685	0.059	0.142	0.012	0.053	4.273	4.229	3.694	2.064	1.852	1.353	9.49
1980	0.070	0.070	0.440	0.343	0.123	0.418	0.239	0.303	0.000	0.129	0.014	2.149	2.079	2.009	1.569	1.226	1.103	6.18
1981	0.000	1.014	0.662	0.986	1.216	0.328	0.287	0.110	0.155	0.106	0.000	4.864	4.864	3.850	3.188	2.202	0.986	10.79
1982	0.015	0.336	1.019	0.516	0.694	0.864	0.117	0.108	0.000	0.042	0.039	3.751	3.737	3.400	2.381	1.865	1.171	8.62
1983	0.012	0.626	0.978	0.833	0.641	0.357	0.181	0.092	0.000	0.090	0.101	3.912	3.900	3.274	2.296	1.463	0.822	10.50
1984	0.000	0.151	1.033	1.147	0.741	0.190	0.053	0.058	0.030	0.000	0.000	3.402	3.402	3.251	2.218	1.072	0.331	5.83
1985	0.000	0.028	0.238	0.622	0.665	0.677	0.095	0.114	0.052	0.000	0.026	2.517	2.517	2.489	2.251	1.629	0.964	7.65
1986	0.000	0.417	0.330	0.647	0.387	0.074	0.046	0.027	0.011	0.000	0.018	1.957	1.957	1.540	1.210	0.563	0.176	3.60
1987	0.000	0.049	0.638	0.486	0.300	0.128	0.011	0.045	0.011	0.000	0.014	1.682	1.682	1.633	0.995	0.509	0.209	3.01
1988	0.029	0.663	1.053	0.633	0.355	0.217	0.087	0.063	0.000	0.027	0.000	3.127	3.098	2.435	1.382	0.749	0.394	3.30
1989	0.000	0.023	0.649	0.790	0.632	0.090	0.077	0.000	0.000	0.000	0.000	2.261	2.261	2.238	1.589	0.799	0.167	2.53
1990	0.000	0.000	0.190	1.327	0.627	0.167	0.032	0.018	0.000	0.000	0.000	2.362	2.362	2.362	2.172	0.845	0.217	3.08
1991	0.000	0.043	0.209	0.355	1.477	0.268	0.024	0.018	0.000	0.000	0.000	2.394	2.394	2.351	2.142	1.787	0.310	2.89
1992	0.000	0.050	0.230	0.240	0.280	1.310	0.220	0.070	0.000	0.010	0.000	2.410	2.410	2.360	2.130	1.890	1.610	8.66
1993	0.000	0.200	0.500	0.800	0.330	0.090	0.480	0.060	0.020	0.000	0.023	2.503	2.503	2.303	1.803	1.003	0.673	5.87
1994	0.000	0.016	0.316	0.387	0.213	0.095	0.047	0.126	0.024	0.024	0.018	1.266	1.266	1.251	0.935	0.547	0.334	2.43
1995	0.000	0.050	0.180	1.120	0.370	0.150	0.030	0.000	0.010	0.000	0.000	1.910	1.910	1.860	1.680	0.560	0.190	2.43
1996	0.000	0.060	0.020	0.590	1.330	0.400	0.060	0.000	0.000	0.000	0.000	2.465	2.465	2.405	2.385	1.795	0.465	5.43
1997	0.000	0.158	0.132	0.399	0.264	0.876	0.242	0.120	0.000	0.000	0.000	2.191	2.191	2.033	1.901	1.502	1.238	5.62
1998	0.000	0.018	0.224	0.330	0.517	0.142	0.421	0.022	0.037	0.000	0.000	1.710	1.710	1.692	1.468	1.138	0.621	4.18
1999	0.000	0.166	0.344	0.713	0.344	0.315	0.134	0.273	0.000	0.000	0.011	2.301	2.301	2.135	1.791	1.078	0.734	5.09
2000	0.026	1.184	0.725	0.438	0.457	0.107	0.101	0.024	0.022	0.000	0.000	3.083	3.057	1.873	1.148	0.710	0.253	3.21

[**a**] Strata 26-30 and 36-40.

[**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 differences.

[**d**] During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portugeuse 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 (NESFC 1991).

[**e**] In the Gulf of Maine, spring surveys during 1980-1982, 1989-1991 amd 1994, and autumn surveys during 1977-1978, 1980, 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 ALBTATROSS IV equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFSC 1991).

Appendix 2:Table 2 (Continued). [**a**,**b**]

Year	Age Group 0	1	2	3	4	5	6	7	8	9	10+	Totals 0+	1+	2+	3+	4+	5+	Standardized Mean Wt (kg)/Tow
Autumn [d,e]																		
1963	0.050	0.649	1.349	1.253	0.849	0.579	0.537	0.300	0.183	0.095	0.075	5.917	5.867	5.218	3.869	2.616	1.767	17.95
1964	0.000	0.092	0.122	0.471	0.856	0.853	0.783	0.373	0.237	0.114	0.101	4.003	4.003	3.911	3.789	3.318	2.462	22.79
1965	0.002	0.850	0.880	0.824	0.750	0.496	0.374	0.170	0.080	0.044	0.025	4.494	4.493	3.643	2.763	1.939	1.189	12.00
1966	0.170	0.204	0.640	0.697	0.718	0.558	0.441	0.192	0.078	0.048	0.036	3.783	3.613	3.409	2.769	2.072	1.354	12.91
1967	0.012	0.129	0.215	0.574	0.671	0.384	0.268	0.162	0.070	0.041	0.034	2.562	2.549	2.420	2.204	1.630	0.959	9.23
1968	0.012	0.036	0.179	0.719	1.256	0.973	0.627	0.261	0.156	0.072	0.095	4.387	4.374	4.338	4.159	3.440	2.184	19.44
1969	0.016	0.059	0.123	0.354	0.630	0.552	0.466	0.220	0.145	0.129	0.062	2.758	2.742	2.683	2.560	2.206	1.576	15.37
1970	0.743	0.941	0.265	0.551	0.329	0.488	0.423	0.789	0.131	0.094	0.147	4.900	4.157	3.217	2.952	2.401	2.072	16.43
1971	1.346	0.178	0.239	0.211	0.597	0.460	0.434	0.254	0.318	0.200	0.128	4.365	3.019	2.841	2.602	2.391	1.794	16.52
1972	0.031	5.579	1.217	1.526	0.234	0.094	0.172	0.039	0.159	0.242	0.016	9.307	9.276	3.697	2.480	0.955	0.721	12.96
1973	0.636	0.328	2.173	0.139	0.507	0.212	0.078	0.028	0.051	0.168	0.136	4.457	3.820	3.493	1.320	1.181	0.674	8.73
1974	0.282	1.123	0.189	1.744	0.292	0.359	0.078	0.012	0.012	0.042	0.198	4.332	4.050	2.927	2.738	0.994	0.702	8.97
1975	0.047	0.147	3.067	0.134	2.356	0.254	0.109	0.017	0.003	0.003	0.012	6.150	6.103	5.956	2.889	2.755	0.399	8.62
1976	0.000	0.243	0.209	0.632	0.100	0.768	0.058	0.095	0.000	0.016	0.031	2.151	2.151	1.908	1.699	1.067	0.967	6.74
1977	0.000	0.022	0.359	0.550	1.155	0.152	0.593	0.038	0.097	0.022	0.096	3.083	3.083	3.061	2.703	2.153	0.998	10.22
1978	0.249	1.369	0.371	1.118	0.656	1.430	0.112	0.325	0.009	0.060	0.051	5.749	5.500	4.131	3.760	2.642	1.987	12.89
1979	0.005	0.368	0.594	0.162	0.836	0.392	0.782	0.051	0.215	0.000	0.083	3.488	3.483	3.115	2.521	2.359	1.523	17.54
1980	0.027	1.264	2.602	1.754	0.497	0.232	0.335	0.207	0.030	0.018	0.071	7.037	7.010	5.745	3.144	1.390	0.893	14.21
1981	0.012	0.619	0.382	0.549	0.474	0.089	0.119	0.037	0.108	0.000	0.028	2.418	2.406	1.786	1.404	0.855	0.381	8.05
1982	0.000	0.700	3.142	2.473	1.167	0.248	0.000	0.039	0.000	0.000	0.000	7.769	7.769	7.068	3.927	1.454	0.287	16.07
1983	0.045	1.660	0.977	0.852	0.139	0.264	0.197	0.000	0.000	0.000	0.090	4.223	4.178	2.518	1.541	0.690	0.551	8.81
1984	0.044	0.384	0.421	0.565	0.399	0.220	0.204	0.089	0.000	0.031	0.066	2.423	2.379	1.995	1.574	1.009	0.610	8.81
1985	0.266	0.378	0.910	0.763	0.209	0.218	0.074	0.000	0.034	0.021	0.049	2.922	2.656	2.278	1.368	0.605	0.396	8.49
1986	0.000	0.301	0.490	0.654	0.333	0.086	0.042	0.000	0.000	0.024	0.021	1.951	1.951	1.650	1.160	0.506	0.173	5.10
1987	0.138	0.599	1.324	0.600	0.257	0.061	0.000	0.000	0.000	0.000	0.000	2.979	2.841	2.242	0.918	0.318	0.061	3.41
1988	0.000	1.951	2.245	0.960	0.528	0.110	0.076	0.033	0.000	0.000	0.000	5.903	5.903	3.952	1.707	0.747	0.219	6.61
1989	0.000	0.416	2.391	1.356	0.294	0.174	0.014	0.000	0.000	0.009	0.000	4.653	4.653	4.238	1.847	0.491	0.197	4.58
1990	0.006	0.029	0.367	1.643	0.623	0.278	0.028	0.010	0.000	0.000	0.000	2.985	2.978	2.949	2.583	0.939	0.317	4.91
1991	0.008	0.142	0.142	0.221	0.632	0.079	0.000	0.024	0.000	0.000	0.000	1.248	1.240	1.098	0.956	0.735	0.103	2.78
1992	0.060	0.290	0.450	0.140	0.040	0.330	0.110	0.000	0.010	0.000	0.000	1.430	1.370	1.080	0.630	0.490	0.450	2.45
1993	0.040	0.198	0.569	0.363	0.032	0.000	0.032	0.000	0.000	0.000	0.000	1.232	1.193	0.995	0.427	0.063	0.032	1.00
1994	0.030	0.210	0.880	0.830	0.090	0.050	0.000	0.050	0.000	0.000	0.000	2.140	2.110	1.900	1.020	0.190	0.100	2.74
1995	0.010	0.070	0.280	1.230	0.330	0.080	0.010	0.000	0.000	0.000	0.000	2.010	2.000	1.930	1.650	0.420	0.090	3.67
1996	0.030	0.120	0.380	0.190	0.540	0.060	0.000	0.000	0.000	0.000	0.000	1.320	1.290	1.170	0.790	0.600	0.060	2.35
1997	0.000	0.297	0.086	0.160	0.182	0.149	0.000	0.000	0.000	0.000	0.000	0.872	0.872	0.575	0.490	0.330	0.149	1.87
1998	0.050	0.097	0.320	0.115	0.192	0.039	0.031	0.000	0.000	0.000	0.000	0.843	0.793	0.696	0.376	0.261	0.069	1.50
1999	0.025	0.431	0.363	0.590	0.243	0.132	0.023	0.000	0.000	0.000	0.000	1.807	1.782	1.351	0.998	0.408	0.165	3.50
2000	0.008	0.533	0.984	0.394	0.507	0.134	0.010	0.034	0.000	0.000	0.000	2.804	2.596	2.063	1.079	0.685	0.178	4.65

[**a**] Strata 26-30 and 36-40.

[**b**] Autumn catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey.

[**d**] During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portugeuse 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).

[**e**] In the Gulf of Maine, spring surveys during 1980-1982, 1989-1991 and 1994, and autumn surveys during 1977-1978, 1980, 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 ALBTATROSS IV equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFSC 1991).

Appendix 2:Table 3. Stratified mean catch per tow in numbers and weight (kg) of Atlantic cod in State of Massachusetts inshore spring and autumn bottom trawl surveys in territorial waters adjacent to the Gulf of Maine (Mass. Regions 4-5), 1978 - 2000. **[a]**

	Age Group											Totals				Stratified Mean
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	Weight/tow (kg)
Spring				**Gulf of Maine Area (Mass. Regions 4-5)**												
1978	21.965	12.784	4.162	4.572	0.872	1.028	0.000	0.000	0.023	0.000	0.000	45.406	23.441	10.657	6.495	12.16
1979	56.393	36.630	2.581	1.533	4.659	1.995	0.183	0.000	0.000	0.000	0.069	104.043	47.650	11.020	8.439	20.53
1980	8.156	50.311	12.679	0.971	0.745	0.737	0.080	0.214	0.000	0.025	0.000	73.918	65.762	15.451	2.772	17.71
1981	19.753	24.794	23.884	3.122	1.279	0.041	0.146	0.022	0.022	0.000	0.000	73.063	53.310	28.516	4.632	21.79
1982	1.489	16.235	7.060	3.418	1.147	0.232	0.011	0.057	0.045	0.000	0.000	29.694	28.205	11.970	4.910	13.42
1983	0.453	27.703	18.572	5.331	0.501	1.221	0.142	0.022	0.000	0.000	0.000	53.945	53.492	25.789	7.217	19.77
1984	0.206	2.896	5.408	2.271	0.865	0.138	0.162	0.000	0.000	0.000	0.000	11.946	11.740	8.844	3.436	8.63
1985	0.793	2.711	3.822	2.794	0.692	0.000	0.000	0.000	0.000	0.000	0.000	10.812	10.019	7.308	3.486	6.42
1986	0.957	19.960	3.222	0.887	0.426	0.090	0.019	0.000	0.000	0.000	0.000	25.561	24.604	4.644	1.422	7.77
1987	0.659	8.590	6.997	2.268	0.257	0.147	0.048	0.000	0.000	0.087	0.000	19.053	18.394	9.804	2.807	9.59
1988	1.595	11.841	11.356	2.511	1.370	0.000	0.039	0.000	0.000	0.000	0.000	28.712	27.117	15.276	3.920	9.66
1989	0.157	20.679	25.260	6.580	0.458	0.106	0.124	0.000	0.000	0.000	0.000	53.364	53.207	32.528	7.268	18.26
1990	4.10	6.33	6.89	17.77	2.64	0.18	0.05	0.02	0.000	0.000	0.000	37.980	33.88	27.55	20.66	19.51
1991	0.32	5.88	3.56	2.54	5.03	0.36	0.000	0.000	0.000	0.000	0.000	17.69	17.37	11.49	7.93	11.37
1992	1.36	6.42	6.35	3.58	0.65	1.37	0.12	0.04	0.00	0.00	0.00	19.88	18.53	12.11	5.76	10.10
1993	69.03	3.40	7.76	3.60	1.45	0.05	0.30	0.00	0.00	0.00	0.00	85.59	16.56	13.16	5.40	7.63
1994	3.90	4.45	5.67	2.46	0.52	0.23	0.03	0.06	0.00	0.03	0.00	17.35	13.45	9.00	3.33	4.83
1995	9.84	6.41	1.36	3.89	1.20	0.09	0.00	0.00	0.00	0.00	0.00	22.79	12.95	6.54	5.18	4.49
1996	6.39	1.37	0.65	1.15	2.00	0.38	0.00	0.00	0.00	0.00	0.00	11.96	5.57	4.20	3.55	4.06
1997	10.40	3.66	1.25	1.05	0.22	0.50	0.03	0.00	0.00	0.00	0.00	17.09	6.69	3.03	1.78	2.97
1998	20.72	3.15	1.80	0.99	1.06	0.08	0.46	0.04	0.00	0.00	0.00	28.30	7.58	4.43	2.63	5.76
1999	116.22	14.36	3.57	3.46	1.20	1.08	0.06	0.22	0.04	0.00	0.00	140.08	23.84	9.48	5.91	14.19
2000	1.83	27.99	7.12	2.85	2.60	0.78	0.77	0.06	0.13	0.00	0.00	44.10	42.47	14.48	7.36	22.36
Autumn																
1978	151.533	2.082	0.000	0.120	0.140	0.318	0.000	0.080	0.000	0.000	0.000	154.273	2.740	0.658	0.658	3.02
1979	4.933	3.430	0.042	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.000	8.431	3.498	0.068	0.026	0.99
1980	5.680	8.834	0.052	0.000	0.000	0.050	0.000	0.000	0.000	0.000	0.000	14.616	8.936	0.102	0.050	1.57
1981	2.018	5.652	7.290	0.729	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.689	13.671	8.019	0.729	6.65
1982	4.667	2.346	1.005	0.060	0.050	0.000	0.000	0.000	0.000	0.000	0.000	8.128	3.461	1.115	0.110	1.35
1983	1.308	0.651	0.100	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.072	0.764	0.113	0.013	0.18
1984	12.296	0.344	0.022	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	12.675	0.379	0.035	0.013	0.18
1985	2.832	0.419	0.018	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.279	0.447	0.028	0.010	0.09
1986	2.478	1.150	0.833	0.000	0.067	0.000	0.000	0.000	0.000	0.000	0.000	4.528	2.050	0.900	0.067	0.55
1987	389.584	2.386	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	391.990	2.406	0.020	0.000	0.45
1988	4.571	20.490	0.679	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	25.740	21.169	0.679	0.000	1.57
1989	2.971	2.700	0.350	0.210	0.185	0.000	0.000	0.000	0.000	0.000	0.000	6.416	3.445	0.745	0.395	1.27
1990	9.37	9.13	1.74	0.31	0.06	0.03	0.000	0.000	0.000	0.000	0.000	20.638	11.27	2.14	0.40	1.56
1991	4.65	4.20	0.81	0.03	0.05	0.01	0.00	0.00	0.00	0.00	0.00	9.74	5.09	0.89	0.08	0.80
1992	24.30	2.01	0.11	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	26.48	2.18	0.17	0.06	0.42
1993	49.92	3.32	0.61	0.33	0.00	0.00	0.01	0.00	0.00	0.00	0.00	54.21	4.29	0.97	0.36	1.97
1994	33.49	14.13	6.37	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	54.26	20.77	6.64	0.27	4.47
1995	2.56	0.64	0.54	0.79	0.02	0.00	0.00	0.00	0.00	0.00	0.00	4.55	1.99	1.35	0.81	0.74
1996	7.59	0.15	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	7.78	0.19	0.04	0.03	0.09
1997	2.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.04	0.02	0.00	0.00	0.02
1998	2.61	1.04	0.62	0.08	0.11	0.00	0.00	0.00	0.00	0.00	0.00	4.46	1.85	0.81	0.19	0.56
1999	6.34	0.98	0.28	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	7.65	1.31	0.33	0.05	0.43
2000	0.04	0.54	0.27	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.87	0.33	0.06	0.34

[a] Massachusetts sampling strata 25-36.

Appendix 3. Full listing of final ADAPT VPA calibration for Gulf of Maine cod including:

Estimates of 2001 N for ages 2-6 using:
NEFSC spring and autumn surveys for ages 2-6,
Massachusetts DMF spring surveys for ages 2-4 and autumn surveys for age 2, and
USA commercial LPUE indices through 1993 for ages 3-6.

```
Fisheries Assessment Toolbox GoM Cod 2001 Disc Option 2 with Recr. Run Number 1 6/27/2001 3:59:33PM
FACT Version 1.5.0
GoM Cod 2001 Disc Option 2/Recr  Run  1982 - 2001
Input Parameters and Options Selected
---------------------------------------
Natural mortality is a matrix below
Oldest age (not in the plus group) is  6
For all years prior to the terminal year ( 19 ), backcalculated
stock sizes for the following ages used to estimate
total mortality (Z) for age  6 : 4 5 6
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  7 + is then calculated from the following
ratios of F[age 7 +] to F[age 6 ]
          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
          1998               1
          1999               1
          2000               1
Stock size of the  7 + group is then calculated using
the following method:  CATCH EQUATION
 Partial recruitment estimate for  2001
 1             0.0001
 2             0.053
 3             0.421
 4             1
 5             1
 6             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 None or Uniform
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  2          3.00E+03      0.00E+00      1.00E+06
N  3          3.00E+03      0.00E+00      1.00E+06
N  4          5.00E+02      0.00E+00      1.00E+06
N  5          5.00E+02      0.00E+00      1.00E+06
N  6          5.00E+02      0.00E+00      1.00E+06
q WHSpr2      1.00E-02      0.00E+00      1.00E+00
q WHSpr3      1.00E-02      0.00E+00      1.00E+00
q WHSpr4      1.00E-02      0.00E+00      1.00E+00
q WHSpr5      1.00E-02      0.00E+00      1.00E+00
q WHSpr6      1.00E-02      0.00E+00      1.00E+00
q WHAut2      1.00E-02      0.00E+00      1.00E+00
q WHAut3      1.00E-02      0.00E+00      1.00E+00
q WHAut4      1.00E-02      0.00E+00      1.00E+00
q WHAut5      1.00E-02      0.00E+00      1.00E+00
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q WHAut6      1.00E-02      0.00E+00      1.00E+00
q MASpr2      1.00E-02      0.00E+00      1.00E+00
q MASpr3      1.00E-02      0.00E+00      1.00E+00
q MASpr4      1.00E-02      0.00E+00      1.00E+00
q MAAut2      1.00E-02      0.00E+00      1.00E+00
q CM_CPE3     1.00E-02      0.00E+00      1.00E+00
q CM_CPE4     1.00E-02      0.00E+00      1.00E+00
q CM_CPE5     1.00E-02      0.00E+00      1.00E+00
q CM_CPE6     1.00E-02      0.00E+00      1.00E+00

The following indices of abundance are available
 1            WHSpr2
 2            WHSpr3
 3            WHSpr4
 4            WHSpr5
 5            WHSpr6
 6            WHAut2
 7            WHAut3
 8            WHAut4
 9            WHAut5
 10           WHAut6
 11           MASpr2
 12           MASpr3
 13           MASpr4
 14           MAAut1
 15           MAAut2
 16           MAAut3
 17           CM_CPE2
 18           CM_CPE3
 19           CM_CPE4
 20           CM_CPE5
 21           CM_CPE6

 The Indices that will be used in this run are:
 1            WHSpr2
 2            WHSpr3
 3            WHSpr4
 4            WHSpr5
 5            WHSpr6
 6            WHAut2
 7            WHAut3
 8            WHAut4
 9            WHAut5
 10           WHAut6
 11           MASpr2
 12           MASpr3
 13           MASpr4
 14           MAAut2
 15           CM_CPE3
 16           CM_CPE4
 17           CM_CPE5
 18           CM_CPE6

Obs Indices (before transvba.formation) by index and year; with Index means

          1982      1983      1984      1985      1986      1987      1988
-------------------------------------------------------------------------------
WHSpr2    1.02      0.98      1.03      0.24      0.33      0.64      1.05
WHSpr3    0.52      0.83      1.15      0.62      0.65      0.49      0.63
WHSpr4    0.69      0.64      0.74      0.67      0.39      0.30      0.36
WHSpr5    0.86      0.36      0.19      0.68      0.07      0.13      0.22
WHSpr6    0.12      0.18      0.05      0.10      0.05      0.01      0.09
WHAut2    0.62      0.70      1.66      0.38      0.38      0.30      0.60
WHAut3    0.38      3.14      0.98      0.42      0.91      0.49      1.32
WHAut4    0.55      2.47      0.85      0.57      0.76      0.65      0.60
WHAut5    0.47      1.17      0.14      0.40      0.21      0.33      0.26
WHAut6    0.09      0.25      0.26      0.22      0.22      0.09      0.06
```

MASpr2	7.06	18.57	5.41	3.82	3.22	7.00	11.36
MASpr3	3.42	5.33	2.27	2.79	0.89	2.27	2.51
MASpr4	1.15	0.50	0.87	0.69	0.43	0.26	1.37
MAAut2	5.65	2.35	0.65	0.34	0.42	1.15	2.39
CM_CPE3	0.07	0.11	0.04	0.04	0.07	0.02	0.05
CM_CPE4	0.05	0.04	0.04	0.03	0.02	0.03	0.02
CM_CPE5	0.02	0.02	0.01	0.02	0.01	0.01	0.01
CM_CPE6	0.00	0.01	0.01	0.00	0.00	0.00	0.00

	1989	1990	1991	1992	1993	1994	1995
WHSpr2	0.65	0.19	0.21	0.23	0.50	0.32	0.18
WHSpr3	0.79	1.33	0.36	0.24	0.80	0.39	1.12
WHSpr4	0.63	0.63	1.48	0.28	0.33	0.21	0.37
WHSpr5	0.09	0.17	0.27	1.31	0.09	0.10	0.15
WHSpr6	0.08	0.03	0.02	0.22	0.48	0.05	0.03
WHAut2	1.95	0.42	0.03	0.14	0.29	0.20	0.21
WHAut3	2.25	2.39	0.37	0.14	0.45	0.57	0.88
WHAut4	0.96	1.36	1.64	0.22	0.14	0.36	0.83
WHAut5	0.53	0.29	0.62	0.63	0.04	0.03	0.09
WHAut6	0.11	0.17	0.28	0.08	0.33	0.00	0.05
MASpr2	25.26	6.89	3.56	6.35	7.76	5.67	1.36
MASpr3	6.58	17.77	2.54	3.58	3.60	2.46	3.89
MASpr4	0.46	2.64	5.03	0.65	1.45	0.52	1.20
MAAut2	20.49	2.70	9.13	4.20	2.01	3.32	14.13
CM_CPE3	0.06	0.16	0.04	0.02	0.05	0.00	0.00
CM_CPE4	0.04	0.08	0.14	0.01	0.02	0.00	0.00
CM_CPE5	0.01	0.01	0.02	0.05	0.00	0.00	0.00
CM_CPE6	0.00	0.01	0.00	0.01	0.01	0.00	0.00

	1996	1997	1998	1999	2000	2001	Average
WHSpr2	0.02	0.13	0.22	0.34	0.73	0.00	0.474
WHSpr3	0.59	0.40	0.33	0.71	0.44	0.00	0.651
WHSpr4	1.33	0.26	0.52	0.34	0.46	0.00	0.559
WHSpr5	0.40	0.88	0.14	0.32	0.11	0.00	0.343
WHSpr6	0.06	0.24	0.42	0.13	0.10	0.00	0.129
WHAut2	0.07	0.12	0.30	0.10	0.43	0.53	0.471
WHAut3	0.28	0.38	0.09	0.32	0.36	0.98	0.855
WHAut4	1.23	0.19	0.16	0.12	0.59	0.39	0.732
WHAut5	0.33	0.54	0.18	0.19	0.24	0.51	0.361
WHAut6	0.08	0.06	0.15	0.04	0.13	0.13	0.147
MASpr2	0.65	1.25	1.80	3.57	7.12	0.00	6.720
MASpr3	1.15	1.05	0.99	3.46	2.85	0.00	3.653
MASpr4	2.00	0.22	1.06	1.20	2.60	0.00	1.278
MAAut2	0.64	0.15	0.02	1.04	0.98	0.54	3.615
CM_CPE3	0.00	0.00	0.00	0.00	0.00	0.00	0.062
CM_CPE4	0.00	0.00	0.00	0.00	0.00	0.00	0.044
CM_CPE5	0.00	0.00	0.00	0.00	0.00	0.00	0.016
CM_CPE6	0.00	0.00	0.00	0.00	0.00	0.00	0.005

Catch at age (thousands) - D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

	1982	1983	1984	1985	1986	1987	1988
1	88	14	24	49	26	41	06
2	1995	1337	813	989	208	907	520
3	2350	2896	1572	2111	2750	1418	2140
4	1386	1184	1636	1122	929	1525	1149
5	717	685	469	665	275	330	434
6	75	448	205	133	197	79	51
7	242	169	142	137	190	97	34
1+	6853	6733	4861	5206	4575	4397	4334

	1989	1990	1991	1992	1993	1994	1995
1	05	07	05	00	01	01	00
2	530	294	447	350	152	57	279
3	2284	4195	1349	600	1998	1380	1152
4	1698	2373	4948	526	787	1228	1324
5	485	488	946	2184	140	315	204
6	91	167	151	216	481	74	14
7	61	105	85	86	39	88	34
1+	5154	7629	7931	3962	3598	3143	3007

	1996	1997	1998	1999	2000
1	00	00	00	01	00
2	86	61	110	08	97
3	688	494	485	563	485
4	1943	466	616	566	934
5	368	894	180	267	211
6	46	72	211	78	96
7	10	08	11	104	25
1+	3141	1995	1613	1587	1848

CAA Summary for ages 4 - 7

1982	1983	1984	1985	1986	1987	1988
2420	2486	2452	2057	1591	2031	1668

1989	1990	1991	1992	1993	1994	1995
2335	3133	6130	3012	1447	1705	1576

1996	1997	1998	1999	2000
2367	1440	1018	1015	1266

Weight at age (mid year) in kg - D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

	1982	1983	1984	1985	1986	1987	1988
1	0.568	0.429	0.500	0.367	0.423	0.317	0.167
2	1.078	1.063	1.009	1.018	1.024	1.011	0.987
3	1.589	1.610	1.623	1.621	1.799	1.541	1.759
4	2.683	2.442	2.697	2.782	2.884	3.116	2.381
5	4.731	3.749	3.646	4.405	4.553	4.739	5.078
6	6.587	6.007	5.815	5.451	6.020	6.924	6.294
7	11.314	9.941	10.296	9.686	11.711	10.289	10.676

	1989	1990	1991	1992	1993	1994	1995
1	0.600	0.143	0.171	0.468	1.000	0.468	0.468
2	1.185	1.017	1.134	1.531	1.132	1.368	1.620
3	1.717	1.655	1.516	1.915	1.827	1.861	1.851
4	2.932	2.282	2.466	2.722	2.418	3.086	2.667
5	3.837	4.193	4.024	3.060	4.243	3.324	5.064
6	4.242	7.581	7.238	5.000	6.085	6.068	7.143
7	11.902	13.562	11.106	10.593	10.974	9.864	13.382

	1996	1997	1998	1999	2000
1	0.468	0.468	0.468	0.331	0.468
2	1.651	1.721	1.336	1.250	1.600
3	2.093	2.202	2.109	1.841	2.274
4	2.335	2.966	2.937	2.776	3.310
5	3.590	3.140	4.133	4.100	4.291
6	7.391	4.556	4.128	5.736	5.811
7	10.900	8.875	9.909	7.702	7.307

January 1 Biomass Weights - D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

	1982	1983	1984	1985	1986	1987	1988
1	0.415	0.280	0.350	0.220	0.274	0.180	0.063
2	0.882	0.777	0.658	0.713	0.613	0.654	0.559
3	1.282	1.317	1.313	1.279	1.353	1.256	1.334
4	2.270	1.970	2.084	2.125	2.162	2.368	1.915
5	4.199	3.172	2.984	3.447	3.559	3.697	3.978
6	5.582	5.331	4.669	4.458	5.150	5.615	5.461
7	11.314	9.941	10.296	9.686	11.711	10.289	10.676

	1989	1990	1991	1992	1993	1994	1995
1	0.461	0.051	0.057	0.301	0.855	0.252	0.249
2	0.445	0.781	0.403	0.512	0.728	1.170	0.871
3	1.302	1.400	1.242	1.474	1.672	1.451	1.591
4	2.271	1.979	2.020	2.031	2.152	2.374	2.228
5	3.023	3.506	3.030	2.747	3.398	2.835	3.953
6	4.641	5.393	5.509	4.486	4.315	5.074	4.873
7	11.902	13.562	11.106	10.593	10.974	9.864	13.382

	1996	1997	1998	1999	2000
1	0.244	0.277	0.286	0.151	0.301
2	0.879	0.897	0.791	0.765	0.728
3	1.841	1.907	1.905	1.568	1.686
4	2.079	2.492	2.543	2.420	2.469
5	3.094	2.708	3.501	3.470	3.451
6	6.118	4.044	3.600	4.869	4.881
7	10.900	8.875	9.909	7.702	7.307

SSB Weights - D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

	1982	1983	1984	1985	1986	1987	1988
1	0.415	0.280	0.350	0.220	0.274	0.180	0.063
2	0.882	0.777	0.658	0.713	0.613	0.654	0.559
3	1.282	1.317	1.313	1.279	1.353	1.256	1.334
4	2.270	1.970	2.084	2.125	2.162	2.368	1.915
5	4.199	3.172	2.984	3.447	3.559	3.697	3.978
6	5.582	5.331	4.669	4.458	5.150	5.615	5.461
7	11.314	9.941	10.296	9.686	11.711	10.289	10.676

	1989	1990	1991	1992	1993	1994	1995
1	0.461	0.051	0.057	0.301	0.855	0.252	0.249
2	0.445	0.781	0.403	0.512	0.728	1.170	0.871
3	1.302	1.400	1.242	1.474	1.672	1.451	1.591
4	2.271	1.979	2.020	2.031	2.152	2.374	2.228
5	3.023	3.506	3.030	2.747	3.398	2.835	3.953
6	4.641	5.393	5.509	4.486	4.315	5.074	4.873
7	11.902	13.562	11.106	10.593	10.974	9.864	13.382

	1996	1997	1998	1999	2000
1	0.244	0.277	0.286	0.151	0.301
2	0.879	0.897	0.791	0.765	0.728
3	1.841	1.907	1.905	1.568	1.686
4	2.079	2.492	2.543	2.420	2.469
5	3.094	2.708	3.501	3.470	3.451
6	6.118	4.044	3.600	4.869	4.881
7	10.900	8.875	9.909	7.702	7.307

Computed (Rivard)from midyear weights: Jan 1 Weights - D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

	1982	1983	1984	1985	1986	1987	1988
1	0.415	0.280	0.350	0.220	0.274	0.180	0.063
2	0.882	0.777	0.658	0.713	0.613	0.654	0.559
3	1.282	1.317	1.313	1.279	1.353	1.256	1.334
4	2.270	1.970	2.084	2.125	2.162	2.368	1.915
5	4.199	3.172	2.984	3.447	3.559	3.697	3.978
6	5.582	5.331	4.669	4.458	5.150	5.615	5.461
7	11.314	9.941	10.296	9.686	11.711	10.289	10.676

	1989	1990	1991	1992	1993	1994	1995
1	0.461	0.051	0.057	0.301	0.855	0.252	0.249
2	0.445	0.781	0.403	0.512	0.728	1.170	0.871
3	1.302	1.400	1.242	1.474	1.672	1.451	1.591
4	2.271	1.979	2.020	2.031	2.152	2.374	2.228
5	3.023	3.506	3.030	2.747	3.398	2.835	3.953
6	4.641	5.393	5.509	4.486	4.315	5.074	4.873
7	11.902	13.562	11.106	10.593	10.974	9.864	13.382

	1996	1997	1998	1999	2000	2001
1	0.244	0.277	0.286	0.151	0.301	0.226
2	0.879	0.897	0.791	0.765	0.728	0.728
3	1.841	1.907	1.905	1.568	1.686	3.518
4	2.079	2.492	2.543	2.420	2.469	3.067
5	3.094	2.708	3.501	3.470	3.451	4.438
6	6.118	4.044	3.600	4.869	4.881	5.335
7	10.900	8.875	9.909	7.702	7.307	7.307

Percent Mature (females)- D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

	1982	1983	1984	1985	1986	1987	1988
1	07	07	07	04	04	04	04
2	26	26	26	48	48	48	48
3	61	61	61	95	95	95	95
4	88	88	88	100	100	100	100
5	97	97	97	100	100	100	100
6	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100

	1989	1990	1991	1992	1993	1994	1995
1	04	11	11	11	11	04	04
2	48	28	28	28	28	38	38
3	95	56	56	56	56	89	89
4	100	81	81	81	81	99	99
5	100	93	93	93	93	100	100
6	100	98	98	98	98	100	100
7	100	100	100	100	100	100	100

	1996	1997	1998	1999	2000
1	04	04	04	04	04
2	38	38	38	38	38
3	89	89	89	89	89
4	99	99	99	99	99
5	100	100	100	100	100
6	100	100	100	100	100
7	100	100	100	100	100

Natural Mortality D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

	1982	1983	1984	1985	1986	1987	1988
1	.200	.200	.200	.200	.200	.200	.200
2	.200	.200	.200	.200	.200	.200	.200
3	.200	.200	.200	.200	.200	.200	.200
4	.200	.200	.200	.200	.200	.200	.200
5	.200	.200	.200	.200	.200	.200	.200
6	.200	.200	.200	.200	.200	.200	.200
7	.200	.200	.200	.200	.200	.200	.200

	1989	1990	1991	1992	1993	1994	1995
1	.200	.200	.200	.200	.200	.200	.200
2	.200	.200	.200	.200	.200	.200	.200
3	.200	.200	.200	.200	.200	.200	.200
4	.200	.200	.200	.200	.200	.200	.200
5	.200	.200	.200	.200	.200	.200	.200
6	.200	.200	.200	.200	.200	.200	.200
7	.200	.200	.200	.200	.200	.200	.200

	1996	1997	1998	1999	2000
1	.200	.200	.200	.200	.200
2	.200	.200	.200	.200	.200
3	.200	.200	.200	.200	.200
4	.200	.200	.200	.200	.200
5	.200	.200	.200	.200	.200
6	.200	.200	.200	.200	.200
7	.200	.200	.200	.200	.200

Sex Ratio (Percent Female) - D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

	1982	1983	1984	1985	1986	1987	1988
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

	1989	1990	1991	1992	1993	1994	1995
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

	1996	1997	1998	1999	2000
1	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5
7	0.5	0.5	0.5	0.5	0.5

pF is 0.1667
pM is 0.1667

Residual Sum of Squares from Marquardt Algorithm

Number 1
RSS 3841.08182267621
Lambda 1.00E-02

Number 2
RSS 2949.80886853128
Lambda 1.00E-03

Number 3
RSS 2304.85287637757
Lambda 1.00E-01

Number 4
RSS 1867.60304194049
Lambda 1.00E-02

Number 5
RSS 1681.66672827415
Lambda 1.00E+00

Number 6
RSS 1353.39506527357
Lambda 1.00E-01

Number 7
RSS 1227.33205557647
Lambda 1.00E+01

Number 8
RSS 1011.42576852553
Lambda 1.00E+00

Number 9
RSS 923.043627741624
Lambda 1.00E+02

Number 10
RSS 774.624621215427
Lambda 1.00E+01

Number 11
RSS 206.654780765569
Lambda 1.00E+00

Number 12
RSS 142.175379643045
Lambda 1.00E+02

Number 13
RSS 134.241386475573
Lambda 1.00E+01

Number 14
RSS 134.03251483151
Lambda 1.00E+00

Number 15
RSS 134.032264575886
Lambda 1.00E+02

Number 16
RSS 134.032266304909
Lambda 1.00E+01

Number 17
RSS 134.032264681567
Lambda 1.00E+00

```
Number  18
RSS            134.032264576869
Lambda        1.00E-01

Number  19
RSS            134.032264575887
Lambda        1.00E-02

Number  20
RSS            134.032264575886
Lambda        1.00E-03

RESULTS
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Approximate Statistics Assuming Linearity Near Solution
Sum of Squares:  134.032264575886
Mean Square Residuals: 0.45281

                  PAR. EST. STD. ERR. T-STATISTIC
                                                  C.V.
N  2              4.63E+03  2.27E+03  2.04E+00  0.49
N  3              6.31E+03  1.99E+03  3.18E+00  0.31
N  4              2.02E+03  5.89E+02  3.44E+00  0.29
N  5              8.03E+02  3.30E+02  2.43E+00  0.41
N  6              1.76E+02  8.79E+01  2.01E+00  0.50
q WHSpr2          1.27E-04  2.00E-05  6.37E+00  0.16
q WHSpr3          2.16E-04  3.37E-05  6.40E+00  0.16
q WHSpr4          3.97E-04  6.19E-05  6.42E+00  0.16
q WHSpr5          9.15E-04  1.43E-04  6.40E+00  0.16
q WHSpr6          3.19E-03  4.98E-04  6.41E+00  0.16
q WHAut2          1.15E-04  1.78E-05  6.45E+00  0.16
q WHAut3          1.58E-04  2.42E-05  6.53E+00  0.15
q WHAut4          3.36E-04  5.14E-05  6.55E+00  0.15
q WHAut5          9.88E-04  1.52E-04  6.49E+00  0.15
q WHAut6          3.99E-03  6.41E-04  6.23E+00  0.16
q MASpr2          1.24E-04  1.95E-05  6.37E+00  0.16
q MASpr3          1.80E-04  2.81E-05  6.40E+00  0.16
q MASpr4          3.34E-04  5.21E-05  6.42E+00  0.16
q MAAut2          6.87E-05  1.07E-05  6.45E+00  0.16
q CM_CPE3         2.32E-04  4.54E-05  5.12E+00  0.20
q CM_CPE4         5.53E-04  1.08E-04  5.12E+00  0.20
q CM_CPE5         1.52E-03  2.98E-04  5.12E+00  0.20
q CM_CPE6         5.00E-03  9.76E-04  5.12E+00  0.20

Catchability Estimates in Original Units

              Estimate      Std.Err.      C.V.
              --------      --------      ------
q WHSpr2      6.04E-05      9.48E-06      0.16
q WHSpr3      1.40E-04      2.19E-05      0.16
q WHSpr4      2.22E-04      3.46E-05      0.16
q WHSpr5      3.14E-04      4.91E-05      0.16
q WHSpr6      4.13E-04      6.44E-05      0.16
q WHAut2      5.41E-05      8.39E-06      0.16
q WHAut3      1.35E-04      2.07E-05      0.15
q WHAut4      2.46E-04      3.76E-05      0.15
q WHAut5      3.56E-04      5.49E-05      0.15
q WHAut6      5.88E-04      9.45E-05      0.16
q MASpr2      8.32E-04      1.31E-04      0.16
q MASpr3      6.58E-04      1.03E-04      0.16
q MASpr4      4.27E-04      6.66E-05      0.16
q MAAut2      2.48E-04      3.85E-05      0.16
q CM_CPE3     1.43E-05      2.79E-06      0.20
q CM_CPE4     2.41E-05      4.71E-06      0.20
q CM_CPE5     2.46E-05      4.81E-06      0.20
q CM_CPE6     2.59E-05      5.05E-06      0.20
```

CORRELATION BETWEEN PARAMETERS ESTIMATED

1	0.04	0.03	0.02	0.01	-0.01	0	0	0	0	-0.17	-0.01	-0.01	0	0	-0.01	0	0	-0.17	0	0	0	0
0.04	1	0.04	0.03	0.02	-0.11	-0.01	0	0	0	-0.11	-0.11	-0.01	-0.01	-0.01	-0.11	-0.01	0	-0.11	0	0	0	0
0.03	0.04	1	0.04	0.03	-0.09	-0.08	0	0	0	-0.09	-0.09	-0.1	-0.01	-0.01	-0.09	-0.08	0	-0.09	0	0	0	0
0.02	0.03	0.04	1	-0.01	-0.07	-0.06	-0.08	-0.02	-0.05	-0.07	-0.07	-0.08	-0.15	-0.04	-0.07	-0.06	-0.08	-0.07	0	0	0	0
0.01	0.02	0.03	-0.01	1	-0.04	-0.04	-0.06	-0.12	-0.09	-0.04	-0.04	-0.06	-0.12	-0.25	-0.04	-0.04	-0.06	-0.04	0	0	0	0
-0.01	-0.11	-0.09	-0.07	-0.04	1	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0	0	0	0
0	-0.01	-0.08	-0.06	-0.04	0.01	1	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0	0
0	0	0	-0.08	-0.06	0.01	0.01	1	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0	0	0	0
0	0	0	-0.02	-0.12	0.01	0.01	0.01	1	0.01	0.01	0.01	0.01	0.02	0.03	0.01	0.01	0.01	0.01	0	0	0	0
0	0	0	-0.05	-0.09	0.01	0.01	0.01	0.01	1	0.01	0.01	0.01	0.02	0.03	0.01	0.01	0.01	0.01	0	0	0	0
-0.17	-0.11	-0.09	-0.07	-0.04	0.02	0.01	0.01	0.01	0.01	1	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.05	0	0	0	0
-0.01	-0.11	-0.09	-0.07	-0.04	0.02	0.01	0.01	0.01	0.01	0.02	1	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0	0	0	0
-0.01	-0.01	-0.1	-0.08	-0.06	0.02	0.02	0.01	0.01	0.01	0.02	0.02	1	0.02	0.02	0.02	0.02	0.01	0.02	0	0	0	0
0	-0.01	-0.01	-0.15	-0.12	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	1	0.04	0.02	0.01	0.02	0.02	0	0	0	0
0	-0.01	-0.01	-0.04	-0.25	0.01	0.01	0.02	0.03	0.03	0.01	0.01	0.02	0.04	1	0.01	0.01	0.02	0.01	0	0	0	0
-0.01	-0.11	-0.09	-0.07	-0.04	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	1	0.01	0.01	0.02	0	0	0	0
0	-0.01	-0.08	-0.06	-0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	1	0.01	0.01	0	0	0	0
0	0	0	-0.08	-0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	1	0.01	0	0	0	0
-0.17	-0.11	-0.09	-0.07	-0.04	0.02	0.01	0.01	0.01	0.01	0.05	0.02	0.02	0.02	0.01	0.02	0.01	0.01	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

CORRELATION BETWEEN PARAMETERS ESTIMATED (SYMBOLIC FORM)

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N 2                             *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
N 3                             .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
N 4                             .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
N 5                             .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
N 6                             .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  -  .  .  .  .  .  .  .  .
WHSpr                              .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
WHSpr                              .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
WHSpr                              .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
WHSpr                              .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
WHSpr                              .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .  .
WHAut                              .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .  .
WHAut                              .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .  .
WHAut                              .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .  .
WHAut                              .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .  .
WHAut                              .  .  .  .  -  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .  .
MASpr                              .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .  .
MASpr                              .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .  .
MASpr                              .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .  .
MAAut                              .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .  .
CM_CPE                             .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .  .
CM_CPE                             .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .  .
CM_CPE                             .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .  .
CM_CPE                             .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  *  .
SYMBOLS:  = LARGE NEGATIVE CORRELATION    whenever -1 <= R <  -L
          - MODERATE NEGATIVE CORRELATION whenever -L <= R <  -M
          . SMALL CORRELATION             whenever -M <= R <= +M
          + MODERATE POSITIVE CORRELATION whenever +M <  R <= +L
          * LARGE POSITIVE CORRELATION    whenever +L <  R <= +1
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Where R is the estimated correlation, M is, 0.25 and L is 0.5

Summary of Residuals
WHSpr
Tuned to: 1-Jan and number
 For ages: 2

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	1.019	0.657	0.765	0.327	1	0.438	0.651	10891
1983	0.978	0.379	0.724	-0.224	1	0.948	1.408	6281
1984	1.033	0.372	0.779	-0.243	1	1.022	1.519	6160
1985	0.238	0.516	-0.689	0.084	1	-0.773	-1.149	8545
1986	0.330	0.343	-0.362	-0.322	1	-0.040	-0.059	5690
1987	0.638	0.501	0.297	0.055	1	0.242	0.360	8296
1988	1.053	0.617	0.798	0.264	1	0.534	0.794	10228
1989	0.649	1.245	0.314	0.965	1	-0.651	-0.968	20625
1990	0.190	0.212	-0.914	-0.803	1	-0.111	-0.165	3518
1991	0.209	0.198	-0.819	-0.872	1	0.053	0.078	3286
1992	0.230	0.345	-0.723	-0.317	1	-0.406	-0.604	5720
1993	0.500	0.317	0.053	-0.403	1	0.456	0.678	5249
1994	0.316	0.461	-0.406	-0.028	1	-0.377	-0.561	7635
1995	0.180	0.164	-0.968	-1.060	1	0.092	0.136	2721
1996	0.020	0.167	-3.166	-1.041	1	-2.124	-3.157	2773
1997	0.132	0.149	-1.279	-1.156	1	-0.123	-0.183	2473
1998	0.224	0.234	-0.750	-0.704	1	-0.046	-0.068	3885
1999	0.344	0.222	-0.321	-0.758	1	0.437	0.649	3683
2000	0.725	0.472	0.425	-0.005	1	0.430	0.639	7817
2001	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.505

WHSpr
Tuned to: 1-Jan and number
 For ages: 3

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.516	0.753	-0.233	0.145	1	-0.377	-0.561	5359
1983	0.833	0.999	0.246	0.428	1	-0.181	-0.270	7112
1984	1.147	0.552	0.566	-0.165	1	0.731	1.086	3933
1985	0.622	0.605	-0.046	-0.074	1	0.028	0.042	4307
1986	0.647	0.857	-0.006	0.274	1	-0.281	-0.417	6101
1987	0.486	0.628	-0.293	-0.037	1	-0.256	-0.380	4471
1988	0.633	0.838	-0.028	0.253	1	-0.281	-0.418	5971
1989	0.790	1.110	0.193	0.533	1	-0.340	-0.505	7903
1990	1.327	2.304	0.712	1.263	1	-0.552	-0.820	16406
1991	0.355	0.367	-0.607	-0.573	1	-0.033	-0.050	2614
1992	0.240	0.321	-0.998	-0.708	1	-0.291	-0.432	2286
1993	0.800	0.613	0.206	-0.060	1	0.266	0.395	4367
1994	0.387	0.584	-0.520	-0.109	1	-0.412	-0.612	4160
1995	1.120	0.871	0.542	0.290	1	0.252	0.374	6200
1996	0.590	0.277	-0.099	-0.853	1	0.755	1.122	1975
1997	0.399	0.308	-0.490	-0.749	1	0.259	0.386	2192
1998	0.330	0.277	-0.680	-0.856	1	0.177	0.263	1969
1999	0.713	0.433	0.091	-0.409	1	0.500	0.743	3081
2000	0.438	0.422	-0.397	-0.433	1	0.036	0.054	3008
2001	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.15

WHSpr
Tuned to: 1-Jan and number
 For ages: 4

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.694	0.672	0.216	0.184	1	0.032	0.047	3026
1983	0.641	0.503	0.137	-0.107	1	0.243	0.361	2262
1984	0.741	0.712	0.282	0.241	1	0.040	0.060	3202
1985	0.665	0.399	0.173	-0.336	1	0.510	0.758	1797
1986	0.387	0.359	-0.368	-0.442	1	0.074	0.111	1616
1987	0.300	0.557	-0.623	-0.004	1	-0.619	-0.920	2507
1988	0.355	0.528	-0.454	-0.057	1	-0.398	-0.591	2377
1989	0.632	0.656	0.122	0.160	1	-0.038	-0.056	2953
1990	0.627	0.979	0.115	0.560	1	-0.445	-0.662	4404
1991	1.477	2.142	0.971	1.343	1	-0.372	-0.552	9637
1992	0.280	0.204	-0.692	-1.007	1	0.315	0.468	920
1993	0.330	0.295	-0.527	-0.639	1	0.111	0.166	1328

1994	0.213	0.393	-0.965	-0.353	1	-0.612	-0.909	1767
1995	0.370	0.479	-0.413	-0.154	1	-0.259	-0.385	2157
1996	1.330	0.896	0.867	0.472	1	0.395	0.586	4033
1997	0.264	0.221	-0.750	-0.928	1	0.177	0.264	995
1998	0.517	0.300	-0.078	-0.624	1	0.546	0.811	1348
1999	0.344	0.261	-0.486	-0.763	1	0.277	0.411	1174
2000	0.457	0.447	-0.202	-0.223	1	0.021	0.032	2013
2001	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.131

WHSpr
Tuned to: 1-Jan and number
For ages: 5

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.864	0.564	0.924	0.496	1	0.427	0.635	1796
1983	0.357	0.384	0.040	0.112	1	-0.072	-0.108	1223
1984	0.190	0.245	-0.591	-0.337	1	-0.253	-0.377	780
1985	0.677	0.358	0.680	0.043	1	0.637	0.946	1142
1986	0.074	0.143	-1.534	-0.874	1	-0.660	-0.981	456
1987	0.128	0.151	-0.986	-0.817	1	-0.169	-0.250	483
1988	0.217	0.211	-0.458	-0.486	1	0.028	0.041	673
1989	0.090	0.284	-1.338	-0.187	1	-1.151	-1.710	907
1990	0.167	0.276	-0.720	-0.216	1	-0.504	-0.749	881
1991	0.268	0.458	-0.247	0.288	1	-0.535	-0.795	1459
1992	1.310	1.071	1.340	1.138	1	0.202	0.300	3413
1993	0.090	0.087	-1.338	-1.373	1	0.035	0.052	277
1994	0.095	0.118	-1.284	-1.069	1	-0.215	-0.320	375
1995	0.150	0.105	-0.827	-1.181	1	0.354	0.526	336
1996	0.400	0.178	0.154	-0.654	1	0.808	1.201	568
1997	0.876	0.484	0.938	0.345	1	0.592	0.880	1544
1998	0.142	0.123	-0.882	-1.024	1	0.142	0.210	393
1999	0.315	0.171	-0.085	-0.694	1	0.609	0.905	546
2000	0.107	0.141	-1.165	-0.890	1	-0.274	-0.408	449
2001	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.263

WHSpr
Tuned to: 1-Jan and number
For ages: 6

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.117	0.070	-0.100	-0.612	1	0.512	0.760	170
1983	0.181	0.339	0.336	0.965	1	-0.629	-0.934	822
1984	0.053	0.158	-0.892	0.198	1	-1.090	-1.620	382
1985	0.095	0.089	-0.309	-0.379	1	0.070	0.104	214
1986	0.046	0.138	-1.034	0.061	1	-1.095	-1.628	333
1987	0.011	0.052	-2.465	-0.920	1	-1.544	-2.295	125
1988	0.087	0.040	-0.397	-1.175	1	0.778	1.156	97
1989	0.077	0.065	-0.519	-0.684	1	0.165	0.245	158
1990	0.032	0.125	-1.397	-0.032	1	-1.365	-2.029	303
1991	0.024	0.116	-1.685	-0.113	1	-1.571	-2.335	280
1992	0.220	0.140	0.531	0.077	1	0.454	0.675	338
1993	0.480	0.338	1.311	0.960	1	0.351	0.522	818
1994	0.047	0.041	-1.013	-1.141	1	0.129	0.192	100
1995	0.030	0.009	-1.461	-2.638	1	1.177	1.749	22
1996	0.060	0.037	-0.768	-1.244	1	0.476	0.708	90
1997	0.242	0.055	0.626	-0.862	1	1.489	2.212	132
1998	0.421	0.188	1.180	0.374	1	0.806	1.198	455
1999	0.134	0.066	0.035	-0.680	1	0.715	1.062	159
2000	0.101	0.085	-0.248	-0.421	1	0.174	0.258	206
2001	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.89

WHAut
Tuned to: 1-Jan and number
 For ages: 2

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.619	0.589	0.273	0.223	1	0.049	0.074	10891
1983	0.700	0.340	0.396	-0.327	1	0.723	1.074	6281
1984	1.660	0.333	1.259	-0.347	1	1.606	2.387	6160
1985	0.384	0.462	-0.205	-0.019	1	-0.185	-0.275	8545
1986	0.378	0.308	-0.220	-0.426	1	0.205	0.305	5690
1987	0.301	0.449	-0.448	-0.049	1	-0.399	-0.593	8296
1988	0.599	0.553	0.240	0.160	1	0.079	0.118	10228
1989	1.951	1.116	1.421	0.862	1	0.559	0.831	20625
1990	0.416	0.190	-0.125	-0.907	1	0.782	1.162	3518
1991	0.029	0.178	-2.788	-0.975	1	-1.813	-2.694	3286
1992	0.142	0.309	-1.200	-0.421	1	-0.779	-1.157	5720
1993	0.290	0.284	-0.486	-0.507	1	0.021	0.031	5249
1994	0.198	0.413	-0.867	-0.132	1	-0.735	-1.092	7635
1995	0.210	0.147	-0.808	-1.164	1	0.355	0.528	2721
1996	0.070	0.150	-1.907	-1.145	1	-0.762	-1.132	2773
1997	0.120	0.134	-1.368	-1.259	1	-0.109	-0.161	2473
1998	0.297	0.210	-0.462	-0.808	1	0.346	0.514	3885
1999	0.097	0.199	-1.581	-0.861	1	-0.720	-1.069	3683
2000	0.431	0.423	-0.089	-0.108	1	0.019	0.029	7817
2001	0.533	0.250	0.123	-0.632	1	0.755	1.122	4630

Partial Variance: 0.568

WHAut
Tuned to: 1-Jan and number
 For ages: 3

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.382	0.725	-0.806	-0.165	1	-0.641	-0.952	5359
1983	3.142	0.962	1.301	0.118	1	1.184	1.759	7112
1984	0.977	0.532	0.133	-0.475	1	0.608	0.904	3933
1985	0.421	0.583	-0.709	-0.384	1	-0.325	-0.483	4307
1986	0.910	0.825	0.062	-0.036	1	0.098	0.145	6101
1987	0.490	0.605	-0.557	-0.347	1	-0.210	-0.312	4471
1988	1.324	0.808	0.437	-0.057	1	0.494	0.735	5971
1989	2.245	1.069	0.965	0.223	1	0.742	1.103	7903
1990	2.391	2.219	1.028	0.954	1	0.075	0.111	16406
1991	0.367	0.354	-0.846	-0.883	1	0.037	0.055	2614
1992	0.142	0.309	-1.795	-1.017	1	-0.778	-1.156	2286
1993	0.450	0.591	-0.642	-0.370	1	-0.272	-0.404	4367
1994	0.569	0.563	-0.407	-0.419	1	0.011	0.017	4160
1995	0.880	0.839	0.029	-0.020	1	0.048	0.072	6200
1996	0.280	0.267	-1.116	-1.163	1	0.047	0.070	1975
1997	0.380	0.296	-0.811	-1.059	1	0.248	0.369	2192
1998	0.086	0.266	-2.297	-1.166	1	-1.131	-1.680	1969
1999	0.320	0.417	-0.983	-0.719	1	-0.264	-0.392	3081
2000	0.363	0.407	-0.857	-0.743	1	-0.114	-0.169	3008
2001	0.984	0.854	0.140	-0.002	1	0.142	0.211	6312

Partial Variance: 0.281

WHAut
Tuned to: 1-Jan and number
 For ages: 4

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.549	0.746	-0.288	0.018	1	-0.306	-0.455	3026
1983	2.473	0.557	1.217	-0.273	1	1.490	2.214	2262
1984	0.852	0.789	0.151	0.075	1	0.077	0.114	3202
1985	0.565	0.443	-0.260	-0.503	1	0.244	0.362	1797
1986	0.763	0.398	0.041	-0.609	1	0.650	0.966	1616
1987	0.654	0.618	-0.113	-0.170	1	0.057	0.085	2507
1988	0.600	0.586	-0.199	-0.223	1	0.024	0.036	2377
1989	0.960	0.728	0.271	-0.007	1	0.277	0.412	2953
1990	1.356	1.085	0.616	0.393	1	0.223	0.331	4404
1991	1.643	2.375	0.808	1.176	1	-0.368	-0.547	9637
1992	0.221	0.227	-1.198	-1.173	1	-0.025	-0.037	920
1993	0.140	0.327	-1.655	-0.805	1	-0.849	-1.262	1328
1994	0.363	0.435	-0.702	-0.520	1	-0.182	-0.270	1767

1995	0.830	0.532	0.125	-0.320	1	0.446	0.662	2157
1996	1.230	0.994	0.518	0.305	1	0.213	0.317	4033
1997	0.190	0.245	-1.349	-1.095	1	-0.255	-0.379	995
1998	0.160	0.332	-1.521	-0.791	1	-0.730	-1.085	1348
1999	0.115	0.289	-1.851	-0.929	1	-0.922	-1.370	1174
2000	0.590	0.496	-0.216	-0.390	1	0.174	0.258	2013
2001	0.394	0.499	-0.620	-0.384	1	-0.236	-0.350	2024

Partial Variance: 0.299

WHAut
Tuned to: 1-Jan and number
For ages: 5

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.474	0.640	0.274	0.574	1	-0.300	-0.446	1796
1983	1.167	0.436	1.175	0.190	1	0.985	1.464	1223
1984	0.139	0.278	-0.953	-0.260	1	-0.693	-1.030	780
1985	0.399	0.407	0.101	0.121	1	-0.019	-0.029	1142
1986	0.209	0.163	-0.545	-0.797	1	0.251	0.373	456
1987	0.333	0.172	-0.079	-0.740	1	0.660	0.981	483
1988	0.257	0.240	-0.339	-0.408	1	0.070	0.104	673
1989	0.528	0.323	0.381	-0.110	1	0.491	0.730	907
1990	0.294	0.314	-0.204	-0.139	1	-0.065	-0.097	881
1991	0.623	0.520	0.547	0.366	1	0.181	0.270	1459
1992	0.632	1.216	0.561	1.216	1	-0.654	-0.972	3413
1993	0.040	0.099	-2.199	-1.296	1	-0.903	-1.342	277
1994	0.032	0.134	-2.422	-0.991	1	-1.430	-2.126	375
1995	0.090	0.120	-1.388	-1.104	1	-0.284	-0.422	336
1996	0.330	0.202	-0.089	-0.577	1	0.489	0.726	568
1997	0.540	0.550	0.404	0.423	1	-0.019	-0.028	1544
1998	0.182	0.140	-0.684	-0.946	1	0.263	0.390	393
1999	0.192	0.195	-0.630	-0.617	1	-0.013	-0.020	546
2000	0.243	0.160	-0.395	-0.813	1	0.419	0.622	449
2001	0.507	0.286	0.341	-0.231	1	0.572	0.850	803

Partial Variance: 0.347

WHAut
Tuned to: 1-Jan and number
For ages: 6

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.089	0.100	-0.505	-0.389	1	-0.116	-0.172	170
1983	0.248	0.484	0.520	1.188	1	-0.668	-0.992	822
1984	0.264	0.225	0.583	0.421	1	0.162	0.240	382
1985	0.220	0.126	0.400	-0.156	1	0.556	0.826	214
1986	0.218	0.196	0.391	0.284	1	0.107	0.159	333
1987	0.086	0.073	-0.539	-0.697	1	0.158	0.235	125
1988	0.061	0.057	-0.882	-0.952	1	0.069	0.103	97
1989	0.110	0.093	-0.293	-0.461	1	0.168	0.249	158
1990	0.174	0.179	0.166	0.191	1	-0.026	-0.038	303
1991	0.278	0.165	0.634	0.110	1	0.524	0.779	280
1992	0.079	0.199	-0.624	0.300	1	-0.924	-1.373	338
1993	0.330	0.481	0.806	1.183	1	-0.377	-0.561	818
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.050	0.013	-1.081	-2.415	1	1.334	1.982	22
1996	0.080	0.053	-0.611	-1.021	1	0.410	0.609	90
1997	0.060	0.078	-0.899	-0.639	1	-0.260	-0.386	132
1998	0.149	0.268	0.011	0.597	1	-0.587	-0.872	455
1999	0.039	0.093	-1.330	-0.456	1	-0.873	-1.298	159
2000	0.132	0.121	-0.110	-0.198	1	0.088	0.130	206
2001	0.134	0.104	-0.095	-0.350	1	0.255	0.379	176

Partial Variance: 0.301

MASpr
Tuned to: 1-Jan and number
 For ages: 2

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	7.060	9.066	0.049	0.299	1	-0.250	-0.372	10891
1983	18.572	5.228	1.017	-0.251	1	1.268	1.884	6281
1984	5.408	5.127	-0.217	-0.271	1	0.053	0.079	6160
1985	3.822	7.113	-0.564	0.057	1	-0.621	-0.923	8545
1986	3.222	4.737	-0.735	-0.350	1	-0.385	-0.573	5690
1987	6.997	6.905	0.040	0.027	1	0.013	0.020	8296
1988	11.356	8.514	0.525	0.237	1	0.288	0.428	10228
1989	25.260	17.168	1.324	0.938	1	0.386	0.574	20625
1990	6.890	2.928	0.025	-0.831	1	0.856	1.272	3518
1991	3.560	2.735	-0.635	-0.899	1	0.264	0.392	3286
1992	6.350	4.761	-0.057	-0.345	1	0.288	0.428	5720
1993	7.760	4.369	0.144	-0.430	1	0.574	0.854	5249
1994	5.670	6.355	-0.170	-0.056	1	-0.114	-0.170	7635
1995	1.360	2.265	-1.598	-1.087	1	-0.510	-0.758	2721
1996	0.650	2.308	-2.336	-1.069	1	-1.267	-1.883	2773
1997	1.250	2.058	-1.682	-1.183	1	-0.499	-0.741	2473
1998	1.800	3.233	-1.317	-0.732	1	-0.586	-0.870	3885
1999	3.570	3.065	-0.632	-0.785	1	0.152	0.226	3683
2000	7.120	6.507	0.058	-0.032	1	0.090	0.134	7817
2001	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.347

MASpr
Tuned to: 1-Jan and number
 For ages: 3

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	3.418	3.524	-0.066	-0.036	1	-0.031	-0.046	5359
1983	5.331	4.677	0.378	0.247	1	0.131	0.195	7112
1984	2.271	2.586	-0.475	-0.345	1	-0.130	-0.193	3933
1985	2.794	2.833	-0.268	-0.254	1	-0.014	-0.020	4307
1986	0.887	4.012	-1.415	0.094	1	-1.509	-2.243	6101
1987	2.268	2.940	-0.477	-0.217	1	-0.259	-0.386	4471
1988	2.511	3.927	-0.375	0.072	1	-0.447	-0.664	5971
1989	6.580	5.197	0.589	0.353	1	0.236	0.351	7903
1990	17.770	10.789	1.582	1.083	1	0.499	0.742	16406
1991	2.540	1.719	-0.363	-0.754	1	0.390	0.580	2614
1992	3.580	1.503	-0.020	-0.888	1	0.868	1.290	2286
1993	3.600	2.871	-0.015	-0.241	1	0.226	0.336	4367
1994	2.460	2.736	-0.395	-0.289	1	-0.106	-0.158	4160
1995	3.890	4.077	0.063	0.110	1	-0.047	-0.070	6200
1996	1.150	1.299	-1.156	-1.034	1	-0.122	-0.181	1975
1997	1.050	1.442	-1.247	-0.930	1	-0.317	-0.471	2192
1998	0.990	1.295	-1.305	-1.037	1	-0.269	-0.399	1969
1999	3.460	2.026	-0.054	-0.589	1	0.535	0.795	3081
2000	2.850	1.978	-0.248	-0.613	1	0.365	0.543	3008
2001	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.252

MASpr
Tuned to: 1-Jan and number
 For ages: 4

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	1.147	1.292	-0.108	0.011	1	-0.119	-0.177	3026
1983	0.501	0.966	-0.937	-0.280	1	-0.656	-0.975	2262
1984	0.865	1.367	-0.390	0.067	1	-0.458	-0.680	3202
1985	0.692	0.767	-0.614	-0.510	1	-0.103	-0.154	1797
1986	0.426	0.690	-1.099	-0.616	1	-0.483	-0.717	1616
1987	0.257	1.070	-1.604	-0.177	1	-1.427	-2.120	2507
1988	1.370	1.015	0.069	-0.231	1	0.300	0.446	2377
1989	0.458	1.261	-1.026	-0.014	1	-1.013	-1.505	2953
1990	2.640	1.880	0.725	0.386	1	0.339	0.504	4404
1991	5.030	4.114	1.370	1.169	1	0.201	0.299	9637
1992	0.650	0.393	-0.676	-1.180	1	0.504	0.749	920
1993	1.450	0.567	0.126	-0.813	1	0.939	1.395	1328
1994	0.520	0.755	-0.899	-0.527	1	-0.372	-0.553	1767

1995	1.200	0.921	-0.063	-0.328	1	0.265	0.393	2157
1996	2.000	1.722	0.448	0.298	1	0.150	0.222	4033
1997	0.220	0.425	-1.760	-1.102	1	-0.658	-0.978	995
1998	1.060	0.575	-0.187	-0.798	1	0.611	0.908	1348
1999	1.200	0.501	-0.063	-0.936	1	0.873	1.298	1174
2000	2.600	0.859	0.710	-0.397	1	1.107	1.645	2013
2001	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.472

MAAut
Tuned to: 1-Jan and number
For ages: 2

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	5.652	2.703	0.447	-0.291	1	0.738	1.096	10891
1983	2.346	1.559	-0.432	-0.841	1	0.409	0.607	6281
1984	0.651	1.529	-1.714	-0.861	1	-0.854	-1.269	6160
1985	0.344	2.121	-2.352	-0.533	1	-1.819	-2.703	8545
1986	0.419	1.412	-2.155	-0.940	1	-1.215	-1.806	5690
1987	1.150	2.059	-1.145	-0.563	1	-0.582	-0.866	8296
1988	2.386	2.538	-0.415	-0.354	1	-0.062	-0.092	10228
1989	20.490	5.119	1.735	0.348	1	1.387	2.061	20625
1990	2.700	0.873	-0.292	-1.421	1	1.129	1.678	3518
1991	9.130	0.815	0.927	-1.489	1	2.416	3.590	3286
1992	4.200	1.420	0.150	-0.935	1	1.085	1.612	5720
1993	2.010	1.303	-0.587	-1.021	1	0.434	0.644	5249
1994	3.320	1.895	-0.085	-0.646	1	0.561	0.833	7635
1995	14.130	0.675	1.363	-1.678	1	3.041	4.519	2721
1996	0.640	0.688	-1.731	-1.659	1	-0.072	-0.108	2773
1997	0.150	0.614	-3.182	-1.773	1	-1.409	-2.094	2473
1998	0.020	0.964	-5.197	-1.322	1	-3.875	-5.759	3885
1999	1.040	0.914	-1.246	-1.375	1	0.129	0.192	3683
2000	0.980	1.940	-1.305	-0.622	1	-0.683	-1.015	7817
2001	0.540	1.149	-1.901	-1.146	1	-0.755	-1.122	4630

Partial Variance: 2.382

CM_CPE
Tuned to: mean and number
For ages: 3

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.074	0.051	0.182	-0.181	1	0.364	0.540	3590
1983	0.110	0.070	0.580	0.130	1	0.451	0.670	4900
1984	0.045	0.039	-0.318	-0.456	1	0.139	0.206	2727
1985	0.042	0.039	-0.376	-0.450	1	0.074	0.110	2746
1986	0.069	0.058	0.111	-0.063	1	0.174	0.259	4041
1987	0.019	0.047	-1.196	-0.261	1	-0.934	-1.389	3314
1988	0.049	0.061	-0.224	-0.004	1	-0.219	-0.326	4286
1989	0.064	0.086	0.035	0.329	1	-0.295	-0.438	5984
1990	0.160	0.182	0.953	1.084	1	-0.131	-0.195	12723
1991	0.040	0.023	-0.420	-0.976	1	0.556	0.827	1622
1992	0.017	0.025	-1.267	-0.892	1	-0.375	-0.557	1764
1993	0.050	0.041	-0.208	-0.404	1	0.196	0.291	2873
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
1999	0.000	0.000	0	0	1	0.000	0.000	00
2000	0.000	0.000	0	0	1	0.000	0.000	00
2001	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.178

CM_CPE
Tuned to: mean and number
 For ages: 4

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.045	0.048	0.032	0.096	1	-0.064	-0.096	1990
1983	0.042	0.034	-0.034	-0.262	1	0.227	0.338	1392
1984	0.044	0.048	0.013	0.100	1	-0.087	-0.129	1998
1985	0.029	0.024	-0.410	-0.614	1	0.204	0.303	978
1986	0.023	0.023	-0.659	-0.656	1	-0.003	-0.004	938
1987	0.026	0.034	-0.518	-0.260	1	-0.258	-0.383	1394
1988	0.024	0.037	-0.590	-0.170	1	-0.420	-0.624	1526
1989	0.040	0.041	-0.095	-0.054	1	-0.041	-0.061	1713
1990	0.078	0.064	0.583	0.388	1	0.195	0.290	2665
1991	0.136	0.145	1.134	1.199	1	-0.065	-0.097	5996
1992	0.014	0.013	-1.151	-1.217	1	0.066	0.098	535
1993	0.023	0.018	-0.630	-0.874	1	0.245	0.364	754
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
1999	0.000	0.000	0	0	1	0.000	0.000	00
2000	0.000	0.000	0	0	1	0.000	0.000	00
2001	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.043

CM_CPE
Tuned to: mean and number
 For ages: 5

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.022	0.031	0.293	0.642	1	-0.348	-0.518	1246
1983	0.021	0.018	0.259	0.097	1	0.162	0.241	723
1984	0.012	0.011	-0.316	-0.404	1	0.088	0.131	438
1985	0.018	0.016	0.103	0.001	1	0.103	0.153	656
1986	0.007	0.006	-0.894	-0.942	1	0.048	0.071	256
1987	0.006	0.006	-1.039	-1.005	1	-0.034	-0.051	240
1988	0.009	0.009	-0.551	-0.613	1	0.062	0.092	355
1989	0.011	0.014	-0.423	-0.174	1	-0.249	-0.370	551
1990	0.012	0.013	-0.282	-0.224	1	-0.058	-0.086	524
1991	0.022	0.019	0.294	0.156	1	0.138	0.206	767
1992	0.051	0.045	1.158	1.019	1	0.139	0.207	1816
1993	0.004	0.004	-1.379	-1.329	1	-0.051	-0.075	174
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
1999	0.000	0.000	0	0	1	0.000	0.000	00
2000	0.000	0.000	0	0	1	0.000	0.000	00
2001	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.026

CM_CPE
Tuned to: mean and number
 For ages: 6

Year	Obs.	Pred.	Ln Scd. Obs.	Ln Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.003	0.003	-0.669	-0.567	1	-0.102	-0.152	113
1983	0.012	0.013	0.867	0.904	1	-0.037	-0.055	494
1984	0.006	0.006	0.065	0.146	1	-0.081	-0.121	231
1985	0.004	0.003	-0.360	-0.533	1	0.173	0.257	117
1986	0.004	0.005	-0.190	-0.056	1	-0.134	-0.200	189
1987	0.002	0.002	-1.073	-1.093	1	0.020	0.030	67
1988	0.001	0.002	-1.259	-1.216	1	-0.043	-0.063	59
1989	0.002	0.002	-0.807	-0.781	1	-0.026	-0.038	92
1990	0.005	0.005	-0.015	-0.099	1	0.084	0.125	181
1991	0.004	0.004	-0.273	-0.168	1	-0.105	-0.155	169
1992	0.005	0.005	0.003	-0.104	1	0.106	0.158	180
1993	0.014	0.012	0.992	0.848	1	0.144	0.214	467
1994	0.000	0.000	0	0	1	0.000	0.000	00

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 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
 1999  0.000   0.000      0            0            1      0.000     0.000        00
 2000  0.000   0.000      0            0            1      0.000     0.000        00
 2001  0.000   0.000      0            0            0      0.000     0.000        00
Partial Variance:  0.011
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Partial variance (and proportion of total) by index

Index	Partial Variance	Proportion
WHSpr 2	0.505	0.068
WHSpr 3	0.15	0.02
WHSpr 4	0.131	0.018
WHSpr 5	0.263	0.035
WHSpr 6	0.89	0.119
WHAut 2	0.568	0.076
WHAut 3	0.281	0.038
WHAut 4	0.299	0.04
WHAut 5	0.347	0.047
WHAut 6	0.301	0.04
MASpr 2	0.347	0.047
MASpr 3	0.252	0.034
MASpr 4	0.472	0.063
MAAut 2	2.382	0.32
CM_CPE 3	0.178	0.024
CM_CPE 4	0.043	0.006
CM_CPE 5	0.026	0.004
CM_CPE 6	0.011	0.001

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

	1982	1983	1984	1985	1986	1987	1988
WHSpr2	0.651	1.408	1.519	-1.149	-0.059	0.360	0.794
WHSpr3	-0.561	-0.270	1.086	0.042	-0.417	-0.380	-0.418
WHSpr4	0.047	0.361	0.060	0.758	0.111	-0.920	-0.591
WHSpr5	0.635	-0.108	-0.377	0.946	-0.981	-0.250	0.041
WHSpr6	0.760	-0.934	-1.620	0.104	-1.628	-2.295	1.156
WHAut2	0.074	1.074	2.387	-0.275	0.305	-0.593	0.118
WHAut3	-0.952	1.759	0.904	-0.483	0.145	-0.312	0.735
WHAut4	-0.455	2.214	0.114	0.362	0.966	0.085	0.036
WHAut5	-0.446	1.464	-1.030	-0.029	0.373	0.981	0.104
WHAut6	-0.172	-0.992	0.240	0.826	0.159	0.235	0.103
MASpr2	-0.372	1.884	0.079	-0.923	-0.573	0.020	0.428
MASpr3	-0.046	0.195	-0.193	-0.020	-2.243	-0.386	-0.664
MASpr4	-0.177	-0.975	-0.680	-0.154	-0.717	-2.120	0.446
MAAut2	1.096	0.607	-1.269	-2.703	-1.806	-0.866	-0.092
CM_CPE3	0.540	0.670	0.206	0.110	0.259	-1.389	-0.326
CM_CPE4	-0.096	0.338	-0.129	0.303	-0.004	-0.383	-0.624
CM_CPE5	-0.518	0.241	0.131	0.153	0.071	-0.051	0.092
CM_CPE6	-0.152	-0.055	-0.121	0.257	-0.200	0.030	-0.063
Col Avg	-0.008	0.493	0.073	-0.104	-0.347	-0.457	0.071

	1989	1990	1991	1992	1993	1994	1995
WHSpr2	-0.968	-0.165	0.078	-0.604	0.678	-0.561	0.136
WHSpr3	-0.505	-0.820	-0.050	-0.432	0.395	-0.612	0.374
WHSpr4	-0.056	-0.662	-0.552	0.468	0.166	-0.909	-0.385
WHSpr5	-1.710	-0.749	-0.795	0.300	0.052	-0.320	0.526
WHSpr6	0.245	-2.029	-2.335	0.675	0.522	0.192	1.749
WHAut2	0.831	1.162	-2.694	-1.157	0.031	-1.092	0.528
WHAut3	1.103	0.111	0.055	-1.156	-0.404	0.017	0.072
WHAut4	0.412	0.331	-0.547	-0.037	-1.262	-0.270	0.662
WHAut5	0.730	-0.097	0.270	-0.972	-1.342	-2.126	-0.422
WHAut6	0.249	-0.038	0.779	-1.373	-0.561	0.000	1.982
MASpr2	0.574	1.272	0.392	0.428	0.854	-0.170	-0.758
MASpr3	0.351	0.742	0.580	1.290	0.336	-0.158	-0.070
MASpr4	-1.505	0.504	0.299	0.749	1.395	-0.553	0.393
MAAut2	2.061	1.678	3.590	1.612	0.644	0.833	4.519
CM_CPE3	-0.438	-0.195	0.827	-0.557	0.291	0.000	0.000
CM_CPE4	-0.061	0.290	-0.097	0.098	0.364	0.000	0.000
CM_CPE5	-0.370	-0.086	0.206	0.207	-0.075	0.000	0.000
CM_CPE6	-0.038	0.125	-0.155	0.158	0.214	0.000	0.000
Col Avg	0.050	0.076	-0.008	-0.017	0.128	-0.441	0.665

	1996	1997	1998	1999	2000	2001
WHSpr2	-3.157	-0.183	-0.068	0.649	0.639	0.000
WHSpr3	1.122	0.386	0.263	0.743	0.054	0.000
WHSpr4	0.586	0.264	0.811	0.411	0.032	0.000
WHSpr5	1.201	0.880	0.210	0.905	-0.408	0.000
WHSpr6	0.708	2.212	1.198	1.062	0.258	0.000
WHAut2	-1.132	-0.161	0.514	-1.069	0.029	1.122
WHAut3	0.070	0.369	-1.680	-0.392	-0.169	0.211
WHAut4	0.317	-0.379	-1.085	-1.370	0.258	-0.350
WHAut5	0.726	-0.028	0.390	-0.020	0.622	0.850
WHAut6	0.609	-0.386	-0.872	-1.298	0.130	0.379
MASpr2	-1.883	-0.741	-0.870	0.226	0.134	0.000
MASpr3	-0.181	-0.471	-0.399	0.795	0.543	0.000
MASpr4	0.222	-0.978	0.908	1.298	1.645	0.000
MAAut2	-0.108	-2.094	-5.759	0.192	-1.015	-1.122
CM_CPE3	0.000	0.000	0.000	0.000	0.000	0.000
CM_CPE4	0.000	0.000	0.000	0.000	0.000	0.000
CM_CPE5	0.000	0.000	0.000	0.000	0.000	0.000
CM_CPE6	0.000	0.000	0.000	0.000	0.000	0.000
Col Avg	-0.064	-0.094	-0.460	0.152	0.197	0.182

Percent of total sum of squares by index and year; with row/column sums

	1982	1983	1984	1985	1986	1987	1988
WHSpr2	0.143	0.670	0.779	0.446	0.001	0.044	0.213
WHSpr3	0.106	0.025	0.399	0.001	0.059	0.049	0.059
WHSpr4	0.001	0.044	0.001	0.194	0.004	0.286	0.118
WHSpr5	0.136	0.004	0.048	0.302	0.325	0.021	0.001
WHSpr6	0.195	0.295	0.887	0.004	0.895	1.779	0.452
WHAut2	0.002	0.390	1.924	0.026	0.032	0.119	0.005
WHAut3	0.306	1.045	0.276	0.079	0.007	0.033	0.182
WHAut4	0.070	1.657	0.004	0.044	0.315	0.002	0.000
WHAut5	0.067	0.724	0.358	0.000	0.047	0.325	0.004
WHAut6	0.010	0.333	0.019	0.231	0.009	0.019	0.004
MASpr2	0.047	1.199	0.002	0.288	0.111	0.000	0.062
MASpr3	0.001	0.013	0.013	0.000	1.699	0.050	0.149
MASpr4	0.011	0.321	0.156	0.008	0.174	1.519	0.067
MAAut2	0.406	0.125	0.544	2.468	1.102	0.253	0.003
CM_CPE3	0.099	0.152	0.014	0.004	0.023	0.651	0.036
CM_CPE4	0.003	0.039	0.006	0.031	0.000	0.050	0.132
CM_CPE5	0.091	0.020	0.006	0.008	0.002	0.001	0.003
CM_CPE6	0.008	0.001	0.005	0.022	0.013	0.000	0.001
++	1.701	7.054	5.442	4.156	4.817	5.202	1.489

	1989	1990	1991	1992	1993	1994	1995
WHSpr2	0.316	0.009	0.002	0.123	0.155	0.106	0.006
WHSpr3	0.086	0.227	0.001	0.063	0.053	0.126	0.047
WHSpr4	0.001	0.148	0.103	0.074	0.009	0.279	0.050
WHSpr5	0.988	0.189	0.214	0.030	0.001	0.035	0.093
WHSpr6	0.020	1.391	1.842	0.154	0.092	0.012	1.033
WHAut2	0.233	0.457	2.452	0.453	0.000	0.403	0.094
WHAut3	0.411	0.004	0.001	0.452	0.055	0.000	0.002
WHAut4	0.057	0.037	0.101	0.000	0.538	0.025	0.148
WHAut5	0.180	0.003	0.025	0.319	0.608	1.527	0.060
WHAut6	0.021	0.000	0.205	0.637	0.106	0.000	1.327
MASpr2	0.111	0.546	0.052	0.062	0.246	0.010	0.194
MASpr3	0.042	0.186	0.114	0.562	0.038	0.008	0.002
MASpr4	0.765	0.086	0.030	0.190	0.657	0.103	0.052
MAAut2	1.435	0.951	4.353	0.878	0.140	0.235	6.899
CM_CPE3	0.065	0.013	0.231	0.105	0.029	0.000	0.000
CM_CPE4	0.001	0.028	0.003	0.003	0.045	0.000	0.000
CM_CPE5	0.046	0.003	0.014	0.014	0.002	0.000	0.000
CM_CPE6	0.000	0.005	0.008	0.008	0.015	0.000	0.000
++	4.780	4.283	9.752	4.127	2.791	2.870	10.009

	1996	1997	1998	1999	2000	2001	++
WHSpr2	3.367	0.011	0.002	0.142	0.138	0.000	6.675
WHSpr3	0.425	0.050	0.023	0.186	0.001	0.000	1.986
WHSpr4	0.116	0.023	0.222	0.057	0.000	0.000	1.732
WHSpr5	0.487	0.262	0.015	0.277	0.056	0.000	3.484
WHSpr6	0.169	1.653	0.484	0.381	0.023	0.000	11.762
WHAut2	0.433	0.009	0.089	0.386	0.000	0.426	7.932
WHAut3	0.002	0.046	0.954	0.052	0.010	0.015	3.931
WHAut4	0.034	0.048	0.398	0.634	0.022	0.041	4.179
WHAut5	0.178	0.000	0.051	0.000	0.131	0.244	4.853
WHAut6	0.125	0.050	0.257	0.569	0.006	0.049	3.976
MASpr2	1.198	0.186	0.256	0.017	0.006	0.000	4.592
MASpr3	0.011	0.075	0.054	0.214	0.100	0.000	3.329
MASpr4	0.017	0.323	0.278	0.569	0.914	0.000	6.240
MAAut2	0.004	1.481	11.206	0.012	0.348	0.426	33.268
CM_CPE3	0.000	0.000	0.000	0.000	0.000	0.000	1.421
CM_CPE4	0.000	0.000	0.000	0.000	0.000	0.000	0.340
CM_CPE5	0.000	0.000	0.000	0.000	0.000	0.000	0.209
CM_CPE6	0.000	0.000	0.000	0.000	0.000	0.000	0.089
++	6.566	4.218	14.290	3.498	1.755	1.200	100.000

STOCK NUMBERS (Jan 1) in thousands - D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

	1982	1983	1984	1985	1986	1987	1988
1	7769	7539	10464	7004	10161	12538	25198
2	10891	6281	6160	8545	5690	8296	10228
3	5359	7112	3933	4307	6101	4471	5971
4	3026	2262	3202	1797	1616	2507	2377
5	1796	1223	780	1142	456	483	673
6	170	822	382	214	333	125	97
7	541	305	260	216	315	150	63
1+	29552	25543	25180	23227	24674	28569	44607

	1989	1990	1991	1992	1993	1994	1995
1	4302	4021	6992	6411	9327	3325	3386
2	20625	3518	3286	5720	5249	7635	2721
3	7903	16406	2614	2286	4367	4160	6200
4	2953	4404	9637	920	1328	1767	2157
5	907	881	1459	3413	277	375	336
6	158	303	280	338	818	100	22
7	104	188	155	132	65	116	53
1+	36951	29721	24421	19219	21430	17478	14876

	1996	1997	1998	1999	2000	2001
1	3020	4745	4498	9549	5656	00
2	2773	2473	3885	3683	7817	4630
3	1975	2192	1969	3081	3008	6312
4	4033	995	1348	1174	2013	2024
5	568	1544	393	546	449	803
6	90	132	455	159	206	176
7	19	14	23	209	53	102
1+	12480	12095	12571	18399	19200	14048

FISHING MORTALITY - D:\ASSESS\GMcod\gmcod2001\gmcod2001_recr_2.2

	1982	1983	1984	1985	1986	1987	1988
1	0.01	0.00	0.00	0.01	0.00	0.00	0.00
2	0.23	0.27	0.16	0.14	0.04	0.13	0.06
3	0.66	0.60	0.58	0.78	0.69	0.43	0.50
4	0.71	0.86	0.83	1.17	1.01	1.12	0.76
5	0.58	0.96	1.09	1.03	1.10	1.41	1.25
6	0.67	0.92	0.90	1.16	1.06	1.20	0.87
7	0.67	0.92	0.90	1.16	1.06	1.20	0.87

	1989	1990	1991	1992	1993	1994	1995
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.03	0.10	0.16	0.07	0.03	0.01	0.12
3	0.38	0.33	0.84	0.34	0.70	0.46	0.23
4	1.01	0.91	0.84	1.00	1.06	1.46	1.13
5	0.89	0.95	1.26	1.23	0.82	2.62	1.11
6	1.01	0.94	0.91	1.22	1.05	1.70	1.17
7	1.01	0.94	0.91	1.22	1.05	1.70	1.17

	1996	1997	1998	1999	2000
1	0.00	0.00	0.00	0.00	0.00
2	0.03	0.03	0.03	0.00	0.01
3	0.49	0.29	0.32	0.23	0.20
4	0.76	0.73	0.70	0.76	0.72
5	1.26	1.02	0.71	0.78	0.73
6	0.83	0.92	0.72	0.78	0.73
7	0.83	0.92	0.72	0.78	0.73

Average F for 1,7 2,7 2,6 4,5

	1982	1983	1984	1985	1986	1987	1988
1,7	0.50	0.65	0.64	0.78	0.71	0.78	0.62
2,7	0.59	0.76	0.74	0.91	0.83	0.92	0.72
2,6	0.57	0.72	0.71	0.86	0.78	0.86	0.69
4,5	0.64	0.91	0.96	1.10	1.05	1.26	1.01

	1989	1990	1991	1992	1993	1994	1995
1,7	0.62	0.59	0.70	0.73	0.67	1.14	0.71
2,7	0.72	0.69	0.82	0.85	0.79	1.32	0.82
2,6	0.67	0.64	0.80	0.77	0.73	1.25	0.75
4,5	0.95	0.93	1.05	1.11	0.94	2.04	1.12

	1996	1997	1998	1999	2000
1,7	0.60	0.56	0.46	0.48	0.44
2,7	0.70	0.65	0.53	0.56	0.52
2,6	0.67	0.60	0.50	0.51	0.48
4,5	1.01	0.88	0.70	0.77	0.73

Average F weighted by N for 1,7 2,7 2,6 4,5

	1982	1983	1984	1985	1986	1987	1988
1,7	0.33	0.40	0.29	0.36	0.30	0.24	0.14
2,7	0.44	0.56	0.50	0.51	0.50	0.42	0.33
2,6	0.44	0.56	0.49	0.50	0.49	0.42	0.33
4,5	0.66	0.90	0.88	1.12	1.03	1.16	0.87

	1989	1990	1991	1992	1993	1994	1995
1,7	0.21	0.37	0.53	0.36	0.27	0.34	0.31
2,7	0.24	0.43	0.75	0.54	0.48	0.42	0.41
2,6	0.23	0.43	0.75	0.53	0.48	0.41	0.40
4,5	0.98	0.91	0.89	1.18	1.02	1.66	1.13

	1996	1997	1998	1999	2000
1,7	0.39	0.26	0.18	0.13	0.14
2,7	0.52	0.43	0.29	0.26	0.20
2,6	0.52	0.43	0.29	0.25	0.19
4,5	0.82	0.91	0.70	0.77	0.72

Average F for weighted by Catch for 1,7 2,7 2,6 4,5

	1982	1983	1984	1985	1986	1987	1988
1,7	0.53	0.65	0.66	0.79	0.78	0.71	0.60
2,7	0.53	0.65	0.67	0.79	0.78	0.71	0.60
2,6	0.53	0.64	0.66	0.78	0.77	0.70	0.60
4,5	0.66	0.90	0.89	1.12	1.03	1.17	0.90

	1989	1990	1991	1992	1993	1994	1995
1,7	0.62	0.56	0.85	0.96	0.81	1.12	0.69
2,7	0.62	0.56	0.85	0.96	0.81	1.12	0.69
2,6	0.62	0.56	0.85	0.96	0.81	1.11	0.69
4,5	0.98	0.91	0.91	1.18	1.03	1.70	1.13

	1996	1997	1998	1999	2000
1,7	0.74	0.74	0.54	0.57	0.55
2,7	0.74	0.74	0.54	0.57	0.55
2,6	0.74	0.74	0.54	0.56	0.54
4,5	0.84	0.92	0.70	0.77	0.72

Biomass Weighted F

1982	1983	1984	1985	1986	1987	1988
0.47	0.60	0.51	0.59	0.54	0.49	0.38

1989	1990	1991	1992	1993	1994	1995
0.30	0.49	0.78	0.53	0.40	0.44	0.41

1996	1997	1998	1999	2000
0.50	0.40	0.32	0.30	0.23

BACKCALCULATED PARTIAL RECRUITMENT

	1982	1983	1984	1985	1986	1987	1988
1	0.02	0.00	0.00	0.01	0.00	0.00	0.00
2	0.32	0.28	0.14	0.12	0.04	0.09	0.05
3	0.94	0.62	0.53	0.67	0.63	0.31	0.40
4	1.00	0.90	0.76	1.00	0.92	0.79	0.61
5	0.82	1.00	1.00	0.88	1.00	1.00	1.00
6	0.95	0.96	0.82	0.99	0.97	0.85	0.70
7	0.95	0.96	0.82	0.99	0.97	0.85	0.70

	1989	1990	1991	1992	1993	1994	1995
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.03	0.10	0.13	0.06	0.03	0.00	0.10
3	0.38	0.35	0.67	0.28	0.66	0.17	0.20
4	1.00	0.96	0.66	0.81	1.00	0.56	0.97
5	0.88	1.00	1.00	1.00	0.77	1.00	0.95
6	1.00	0.99	0.72	1.00	0.99	0.65	1.00
7	1.00	0.99	0.72	1.00	0.99	0.65	1.00

	1996	1997	1998	1999	2000
1	0.00	0.00	0.00	0.00	0.00
2	0.03	0.03	0.04	0.00	0.02
3	0.39	0.28	0.44	0.29	0.27
4	0.60	0.71	0.98	0.97	0.98
5	1.00	1.00	0.98	0.99	1.00
6	0.66	0.90	1.00	1.00	0.99
7	0.66	0.90	1.00	1.00	0.99

MEAN BIOMASS (using catch mean weights at age)

	1982	1983	1984	1985	1986	1987	1988
1	3975	2928	4736	2321	3890	3596	3813
2	9560	5331	5225	7385	5177	7148	8899
3	5705	7889	4426	4451	7270	5108	7540
4	5340	3399	5389	2721	2706	4345	3632
5	5895	2709	1597	2891	1164	1138	1804
6	747	2966	1346	640	1139	464	373
7	4089	1821	1624	1148	2097	829	415
1+	35312	27044	24343	21557	23444	22628	26477

	1989	1990	1991	1992	1993	1994	1995
1	2338	521	1083	2719	8453	1410	1436
2	21846	3095	3125	7675	5302	9429	3772
3	10275	21056	2459	3378	5250	5676	9327
4	5022	6083	14785	1457	1824	2660	3177
5	2114	2197	3085	5558	737	416	946
6	389	1374	1224	902	2841	272	87
7	718	1519	1040	745	408	510	387
1+	42702	35845	26800	22434	24814	20372	19133

	1996	1997	1998	1999	2000
1	1281	2013	1908	2864	2399
2	4080	3806	4632	4167	11260
3	2992	3822	3242	4619	5647
4	6054	1922	2606	2093	4358
5	1074	2800	1068	1429	1252
6	417	362	1230	580	779
7	132	77	152	1023	252
1+	16028	14802	14838	16775	25946

00

Summaries for ages 1,7 2,7 2,6 4,5

	1982	1983	1984	1985	1986	1987	1988
1,7	35312	27044	24343	21557	23444	22628	26477
2,7	31337	24116	19607	19236	19554	19032	22663
2,6	27247	22295	17983	18088	17456	18202	22248
4,5	11235	6108	6986	5612	3870	5483	5437

	1989	1990	1991	1992	1993	1994	1995
1,7	42702	35845	26800	22434	24814	20372	19133
2,7	40364	35325	25717	19715	16361	18962	17696
2,6	39646	33805	24677	18970	15953	18452	17309
4,5	7137	8280	17870	7016	2561	3076	4123

	1996	1997	1998	1999	2000
1,7	16028	14802	14838	16775	25946
2,7	14747	12789	12930	13911	23547
2,6	14615	12712	12778	12888	23296
4,5	7127	4721	3674	3522	5610

Catch BIOMASS (using catch mean weights)

	1982	1983	1984	1985	1986	1987	1988
1	50	06	12	18	11	13	01
2	2162	1430	824	1011	214	921	515
3	3782	4717	2580	3472	5012	2205	3802
4	3768	2937	4480	3187	2728	4847	2775
5	3431	2613	1744	2984	1277	1602	2253
6	500	2737	1212	740	1209	559	326
7	2738	1680	1462	1327	2225	998	363
1+	16431	16120	12314	12738	12675	11144	10034

	1989	1990	1991	1992	1993	1994	1995
1	03	01	01	00	01	01	00
2	629	300	509	537	172	78	454
3	3953	6993	2077	1158	3699	2592	2144
4	5070	5505	12391	1458	1939	3886	3603
5	1892	2082	3891	6828	603	1090	1054
6	393	1288	1111	1103	2982	462	102
7	726	1424	944	911	428	868	455
1+	12666	17592	20925	11995	9825	8977	7811

	1996	1997	1998	1999	2000
1	00	00	00	00	00
2	142	105	147	10	156
3	1454	1095	1030	1042	1108
4	4602	1401	1833	1594	3134
5	1351	2859	754	1111	918
6	345	334	883	454	566
7	109	71	109	801	183
1+	8003	5865	4756	5012	6064

Summaries for ages 1,7 2,7 2,6 4,5

	1982	1983	1984	1985	1986	1987	1988
1,7	16431	16120	12314	12738	12675	11144	10034
2,7	16381	16114	12302	12720	12664	11131	10033
2,6	13643	14434	10840	11393	10439	10133	9670
4,5	7199	5551	6224	6170	4005	6449	5027

	1989	1990	1991	1992	1993	1994	1995
1,7	12666	17592	20925	11995	9825	8977	7811
2,7	12663	17591	20924	11995	9824	8976	7811
2,6	11937	16167	19980	11084	9396	8108	7356
4,5	6961	7587	16283	8286	2542	4976	4656

	1996	1997	1998	1999	2000
1,7	8003	5865	4756	5012	6063
2,7	8003	5865	4756	5011	6063
2,6	7894	5794	4647	4210	5881
4,5	5952	4260	2587	2704	4051

Jan 1 BIOMASS (using Jan 1 mean weights)

	1982	1983	1984	1985	1986	1987	1988
1	3224	2111	3662	1541	2784	2257	1587
2	9606	4880	4053	6093	3488	5426	5717
3	6871	9367	5164	5509	8255	5615	7966
4	6869	4455	6674	3819	3495	5937	4552
5	7542	3880	2328	3935	1624	1785	2676
6	948	4381	1782	956	1715	701	528
7	6122	3030	2678	2097	3690	1543	678
1+	41181	32104	26341	23950	25051	23263	23705

	1989	1990	1991	1992	1993	1994	1995
1	1983	205	399	1930	7974	838	843
2	9178	2747	1324	2929	3821	8933	2370
3	10290	22969	3247	3369	7301	6036	9864
4	6705	8716	19466	1868	2859	4195	4806
5	2741	3089	4420	9375	941	1065	1327
6	734	1636	1541	1517	3529	508	109
7	1238	2544	1720	1396	714	1140	713
1+	32869	41906	32116	22383	27139	22715	20032

	1996	1997	1998	1999	2000
1	737	1314	1286	1442	1702
2	2437	2218	3073	2817	5691
3	3637	4180	3752	4831	5071
4	8385	2479	3427	2840	4970
5	1758	4182	1375	1895	1549
6	552	535	1639	773	1003
7	211	128	232	1607	386
1+	17717	15037	14785	16205	20372

Summaries for ages 1,7 2,7 2,6 4,5

	1982	1983	1984	1985	1986	1987	1988
1,7	41181	32104	26341	23950	25051	23263	23705
2,7	37957	29993	22679	22409	22267	21006	22117
2,6	31835	26963	20001	20312	18577	19463	21440
4,5	14410	8335	9002	7755	5119	7722	7228

	1989	1990	1991	1992	1993	1994	1995
1,7	32869	41906	32116	22383	27139	22715	20032
2,7	30886	41701	31717	20453	19165	21877	19189
2,6	29648	39157	29997	19057	18451	20736	18476
4,5	9446	11804	23886	11242	3800	5260	6133

	1996	1997	1998	1999	2000
1,7	17717	15037	14785	16205	20372
2,7	16980	13722	13498	14763	18669
2,6	16769	13594	13266	13156	18283
4,5	10143	6661	4803	4735	6519

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

	1982	1983	1984	1985	1986	1987	1988
1	218	143	248	60	108	87	61
2	2326	1174	993	2765	1608	2465	2629
3	3630	5002	2764	4445	6762	4801	6729
4	5197	3283	4945	3039	2857	4768	3877
5	6421	3100	1821	3204	1308	1365	2102
6	820	3633	1483	763	1390	554	442
7	5296	2513	2229	1672	2991	1221	567
1+	23908	18848	14484	15947	17024	15262	16406

	1989	1990	1991	1992	1993	1994	1995
1	77	22	42	205	848	32	33
2	4241	732	349	784	1029	3279	854
3	8868	11771	1527	1723	3516	4815	8171
4	5481	5872	13262	1238	1876	3149	3810
5	2284	2372	3221	6871	738	665	1066
6	599	1327	1255	1173	2808	370	87
7	1012	2104	1430	1101	580	831	567
1+	22561	24200	21088	13096	11396	13141	14587

	1996	1997	1998	1999	2000
1	29	51	50	56	66
2	891	812	1123	1035	2087
3	2887	3431	3063	4005	4225
4	7074	2102	2919	2395	4221
5	1379	3411	1182	1610	1325
6	465	444	1407	656	860
7	177	106	199	1364	331
1+	12901	10357	9943	11121	13114

Retrospective Analysis of F, SSB and N

Fishing Mortality

Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1993	0.64	0.91	0.96	1.10	1.05	1.26	1.01	0.95	0.93	1.06	1.11	1.14							
1994	0.64	0.91	0.96	1.10	1.05	1.26	1.01	0.95	0.92	1.04	1.10	0.89	1.64						
1995	0.64	0.91	0.96	1.10	1.05	1.26	1.01	0.95	0.93	1.05	1.10	0.91	1.79	0.70					
1996	0.64	0.91	0.96	1.10	1.05	1.26	1.01	0.95	0.93	1.05	1.11	0.94	1.98	0.98	0.70				
1997	0.64	0.91	0.96	1.10	1.05	1.26	1.01	0.95	0.93	1.05	1.11	0.94	2.02	1.08	0.91	0.67			
1998	0.64	0.91	0.96	1.10	1.05	1.26	1.01	0.95	0.93	1.05	1.11	0.94	2.04	1.13	1.02	0.89	0.78		
1999	0.64	0.91	0.96	1.10	1.05	1.26	1.01	0.95	0.93	1.05	1.11	0.94	2.04	1.12	1.01	0.87	0.70	0.79	
2000	0.64	0.91	0.96	1.10	1.05	1.26	1.01	0.95	0.93	1.05	1.11	0.94	2.04	1.12	1.01	0.88	0.70	0.77	0.73

Spawning Stock Biomass

Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1993	23908	18848	14484	15947	17023	15260	16400	22533	24139	20952	12768	10594							
1994	23908	18848	14484	15948	17024	15265	16414	22595	24275	21225	13334	11534	13060						
1995	23908	18848	14484	15948	17024	15264	16409	22573	24229	21141	13253	11810	14602	16863					
1996	23908	18848	14484	15947	17024	15263	16407	22564	24206	21099	13134	11568	13839	16120	14855				
1997	23908	18848	14484	15947	17024	15263	16406	22562	24202	21091	13105	11462	13393	15258	13770	9667			
1998	23908	18848	14484	15947	17024	15262	16406	22561	24200	21087	13095	11388	13110	14520	12739	9535	7238		
1999	23908	18848	14484	15947	17024	15262	16406	22561	24200	21088	13096	11398	13147	14601	12925	10361	9517	9615	
2000	23908	18848	14484	15947	17024	15262	16406	22561	24200	21088	13096	11396	13141	14587	12901	10357	9943	11121	13114

Population Numbers Age: 1

Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1993	7769	7539	10463	7004	10157	12533	25094	4349	3608	6694	7386	7259	00							
1994	7769	7539	10464	7006	10165	12548	25298	4306	4147	6835	7063	7135	15539	00						
1995	7769	7539	10464	7005	10163	12543	25227	4321	4043	7235	7773	8576	5293	1808	00					
1996	7769	7539	10464	7004	10162	12539	25205	4304	4028	7020	6902	9873	4328	1375	1109	00				
1997	7769	7539	10464	7004	10161	12538	25199	4303	4022	7006	6495	9730	3932	1872	1384	651	00			
1998	7769	7539	10464	7004	10161	12538	25197	4302	4021	6990	6409	9258	3354	3035	1733	1818	2933	00		
1999	7769	7539	10464	7004	10161	12538	25198	4302	4021	6992	6412	9341	3321	3426	2879	3325	4290	6565	00	
2000	7769	7539	10464	7004	10161	12538	25198	4302	4021	6992	6411	9327	3325	3386	3020	4745	4498	9549	5656	00

Population Numbers Age: 2

Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1993	10891	6281	6160	8545	5690	8292	10224	20540	3556	2948	5476	6047	5943							
1994	10892	6281	6160	8545	5691	8299	10236	20707	3521	3389	5591	5782	5840	12721						
1995	10892	6281	6160	8545	5691	8297	10232	20649	3533	3304	5919	6364	7020	4333	1480					
1996	10891	6281	6160	8545	5690	8296	10229	20630	3520	3291	5743	5651	8083	3543	1126	908				
1997	10891	6281	6160	8545	5690	8296	10228	20626	3519	3287	5732	5317	7965	3218	1533	1133	533			
1998	10891	6281	6160	8545	5690	8296	10228	20624	3518	3286	5718	5247	7579	2745	2485	1419	1488	2401		
1999	10891	6281	6160	8545	5690	8296	10228	20625	3518	3286	5720	5250	7647	2718	2805	2357	2722	3512	5374	
2000	10891	6281	6160	8545	5690	8296	10228	20625	3518	3286	5720	5249	7635	2721	2773	2473	3885	3683	7817	4630

Population Numbers Age: 3

Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1993	5359	7112	3933	4307	6101	4470	5969	7900	16337	2646	2009	4167	4813							
1994	5359	7112	3933	4307	6102	4471	5974	7910	16474	2616	2370	4261	4597	4730						
1995	5359	7112	3933	4307	6101	4471	5972	7907	16426	2627	2301	4529	5073	5696	3295					
1996	5359	7112	3933	4307	6101	4471	5972	7904	16411	2616	2290	4385	4489	6566	2648	844				
1997	5359	7112	3933	4307	6101	4471	5971	7904	16408	2615	2286	4376	4216	6470	2382	1177	873			
1998	5359	7112	3933	4307	6101	4471	5971	7903	16406	2614	2286	4365	4159	6153	1995	1957	1107	1119		
1999	5359	7112	3933	4307	6101	4471	5971	7903	16406	2614	2286	4367	4160	6209	1973	2218	1875	2129	2868	
2000	5359	7112	3933	4307	6101	4471	5971	7903	16406	2614	2286	4367	4160	6200	1975	2192	1969	3081	3008	6312

Population Numbers Age: 4

Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1993	3026	2262	3202	1797	1616	2507	2377	2950	4402	9580	946	1102	1604							
1994	3026	2262	3202	1797	1617	2507	2378	2955	4410	9692	922	1397	1681	2515						
1995	3026	2262	3202	1797	1616	2507	2377	2953	4407	9653	930	1341	1900	2904	3621					
1996	3026	2262	3202	1797	1616	2507	2377	2953	4405	9641	921	1332	1782	2427	4333	1546				
1997	3026	2262	3202	1797	1616	2507	2377	2953	4404	9638	920	1329	1775	2203	4255	1328	517			
1998	3026	2262	3202	1797	1616	2507	2377	2953	4404	9637	919	1328	1766	2156	3996	1011	1155	467		
1999	3026	2262	3202	1797	1616	2507	2377	2953	4404	9637	920	1328	1767	2158	4041	993	1369	1096	1234	

2000	3026	2262	3202	1797	1616	2507	2377	2953	4404	9637	920	1328	1767	2157	4033	995	1348	1174	2013	2024
Population Numbers Age:	5																			
Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1993	1796	1223	780	1142	456	483	673	906	879	1457	3366	298	190							
1994	1796	1223	780	1142	456	483	673	907	883	1463	3458	279	432	265						
1995	1796	1223	780	1142	456	483	673	907	882	1461	3426	285	386	445	1180					
1996	1796	1223	780	1142	456	483	673	907	881	1459	3416	278	379	348	789	1790				
1997	1796	1223	780	1142	456	483	673	907	881	1459	3413	277	376	342	606	1725	666			
1998	1796	1223	780	1142	456	483	673	907	881	1459	3413	277	375	335	567	1513	406	388		
1999	1796	1223	780	1142	456	483	673	907	881	1459	3413	277	375	336	569	1551	391	564	385	
2000	1796	1223	780	1142	456	483	673	907	881	1459	3413	277	375	336	568	1544	393	546	449	803
Population Numbers Age:	6																			
Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1993	170	822	382	214	333	125	97	158	303	278	337	780	117							
1994	170	822	382	214	333	125	97	158	304	281	342	855	101	69						
1995	170	822	382	214	333	125	97	158	304	280	340	829	107	31	179					
1996	170	822	382	214	333	125	97	158	303	280	339	821	101	25	101	313				
1997	170	822	382	214	333	125	97	158	303	280	338	819	100	23	95	163	604			
1998	170	822	382	214	333	125	97	158	303	280	338	818	100	22	89	131	430	170		
1999	170	822	382	214	333	125	97	158	303	280	338	818	100	22	90	132	461	157	220	
2000	170	822	382	214	333	125	97	158	303	280	338	818	100	22	90	132	455	159	206	176
Population Numbers Age:	7																			
Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1993	541	305	260	216	315	150	63	104	187	154	131	62	219							
1994	541	305	260	216	315	150	63	104	188	156	133	68	117	35						
1995	541	305	260	216	315	150	63	104	188	155	133	66	124	73	42					
1996	541	305	260	216	315	150	63	104	188	155	132	65	117	60	22	49				
1997	541	305	260	216	315	150	63	104	188	155	132	65	116	54	20	18	76			
1998	541	305	260	216	315	150	63	104	188	155	132	65	116	53	19	14	22	169		
1999	541	305	260	216	315	150	63	104	188	155	132	65	116	53	19	14	24	207	135	
2000	541	305	260	216	315	150	63	104	188	155	132	65	116	53	19	14	23	209	53	102
Age 2 + stock size (N)																				
Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1993	21784	18004	14717	16222	14512	16027	19402	32559	25665	17062	12265	12456	12887							
1994	21784	18004	14717	16223	14514	16036	19421	32741	25779	17597	12816	12642	12768	20335						
1995	21784	18004	14717	16222	14513	16033	19415	32678	25739	17480	13048	13414	14610	13482	9798					
1996	21784	18004	14717	16222	14513	16031	19410	32656	25708	17441	12841	12532	14951	12968	9018	5449				
1997	21784	18004	14717	16222	14512	16031	19410	32651	25702	17432	12822	12183	14549	12310	8891	5544	3268			
1998	21784	18004	14717	16222	14512	16031	19409	32649	25700	17429	12806	12100	14094	11465	9151	6046	4608	4715		
1999	21784	18004	14717	16222	14512	16031	19409	32649	25700	17429	12808	12105	14166	11496	9497	7266	6842	7665	10216	
2000	21784	18004	14717	16222	14512	16031	19409	32649	25700	17429	12808	12104	14153	11489	9459	7351	8073	8850	13545	14048

Appendix 4.

Precision estimates of the 2001 age-specific stock sizes, catchability coefficients, and 2000 instantaneous fishing mortality rates (F) and spawning stock biomass (SSB) for Gulf of Maine cod.

NLLS ESTIMATE is from the final assessment run.

Standard errors, coefficients of variation (C.V.), and bias estimates are derived from 700 bootstrap replications.

F on ages 4+ represents the fully-recruited portion of the stock.

The number of bootstraps: 600

Appendix 4:Table 1. Bootstrap Output Variable: N hat

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
N 2	4630	4975	2179	0.47
N 3	6312	6721	1822	0.29
N 4	2024	2063	568	0.28
N 5	803	851	318	0.40
N 6	176	186	74	0.42

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
N 2	345	89	7.44	4286	0.508345	2578	7261
N 3	408	74	6.47	5904	0.308619	4176	8188
N 4	39	23	1.92	1985	0.285995	1409	2711
N 5	48	13	6.03	754	0.420904	448	1172
N 6	10	03	5.62	167	0.445920	94	278

Appendix 4:Table 2. Bootstrap Output Variable: Q_unscaled

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
q WHSpr2	0.0000604	0.0000603	0.0000082	0.14
q WHSpr3	0.0001404	0.0001414	0.0000195	0.14
q WHSpr4	0.0002222	0.0002225	0.0000306	0.14
q WHSpr5	0.0003137	0.0003149	0.0000424	0.14
q WHSpr6	0.0004130	0.0004177	0.0000578	0.14
q WHAut2	0.0000541	0.0000544	0.0000077	0.14
q WHAut3	0.0001353	0.0001366	0.0000197	0.15
q WHAut4	0.0002464	0.0002473	0.0000331	0.13
q WHAut5	0.0003563	0.0003633	0.0000504	0.14
q WHAut6	0.0005884	0.0005966	0.0000836	0.14
q MASpr2	0.0008324	0.0008413	0.0001213	0.15
q MASpr3	0.0006576	0.0006683	0.0000957	0.15
q MASpr4	0.0004270	0.0004326	0.0000603	0.14
q MAAut2	0.0002482	0.0002509	0.0000349	0.14
q CM_CPE3	0.0000143	0.0000143	0.0000025	0.18
q CM_CPE4	0.0000241	0.0000244	0.0000044	0.18
q CM_CPE5	0.0000246	0.0000251	0.0000044	0.18
q CM_CPE6	0.0000259	0.0000263	0.0000044	0.17

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
q WHSpr2	-0.00000005	0.000000335	-0.079	0.000060402	0.14	0.0000519	0.0000731
q WHSpr3	0.00000099	0.000000796	0.703	0.000139431	0.14	0.0001158	0.0001653
q WHSpr4	0.00000025	0.000001248	0.111	0.000221987	0.14	0.0001853	0.0002602
q WHSpr5	0.00000120	0.000001732	0.383	0.000312546	0.14	0.0002643	0.0003759
q WHSpr6	0.00000470	0.000002361	1.138	0.000408344	0.14	0.0003431	0.0004891
q WHAut2	0.00000027	0.000000314	0.508	0.000053816	0.14	0.0000449	0.0000650
q WHAut3	0.00000135	0.000000806	1.001	0.000133901	0.15	0.0001123	0.0001632
q WHAut4	0.00000092	0.000001351	0.373	0.000245495	0.13	0.0002103	0.0002948
q WHAut5	0.00000707	0.000002056	1.984	0.000349212	0.14	0.0002920	0.0004159
q WHAut6	0.00000820	0.000003411	1.394	0.000580202	0.14	0.0004900	0.0007040
q MASpr2	0.00000890	0.000004953	1.070	0.000823495	0.15	0.0007062	0.0010044
q MASpr3	0.00001066	0.000003907	1.621	0.000646944	0.15	0.0005532	0.0008006
q MASpr4	0.00000562	0.000002461	1.315	0.000421347	0.14	0.0003590	0.0005072
q MAAut2	0.00000269	0.000001425	1.082	0.000245505	0.14	0.0002071	0.0002942
q CM_CPE3	-0.00000001	0.000000103	-0.050	0.000014300	0.18	0.0000117	0.0000182
q CM_CPE4	0.00000026	0.000000178	1.088	0.000023860	0.18	0.0000185	0.0000297
q CM_CPE5	0.00000050	0.000000179	2.008	0.000024154	0.18	0.0000197	0.0000300
q CM_CPE6	0.00000044	0.000000180	1.715	0.000025426	0.17	0.0000203	0.0000315

Appendix 4: Table 3. Bootstrap Output Variable: N t1

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	6616.3	6626.8	214.2	0.0324
Age 2	4630.3	4974.9	2178.6	0.4705
Age 3	6312.1	6720.5	1822.0	0.2886
Age 4	2023.7	2062.5	567.7	0.2805
Age 5	803.0	851.4	317.6	0.3955
Age 6	176.5	186.4	74.3	0.4208
Age 7	102.3	102.6	29.2	0.2857

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
Age 1	10.52	8.74	0.159	6605.75	0.03	6323.1	6872.5
Age 2	344.57	88.94	7.442	4285.76	0.51	2577.7	7260.6
Age 3	408.44	74.38	6.471	5903.65	0.31	4175.9	8188.2
Age 4	38.81	23.18	1.918	1984.91	0.29	1409.2	2710.6
Age 5	48.46	12.96	6.035	754.50	0.42	447.8	1172.3
Age 6	9.92	3.03	5.623	166.54	0.45	94.3	278.5
Age 7	0.31	1.19	0.302	102.00	0.29	70.0	144.0

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

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0000	0.0000	0.0000	0.84
Age 2	0.0138	0.0140	0.0040	0.29
Age 3	0.1963	0.2060	0.0592	0.30
Age 4	0.7191	0.7494	0.2721	0.38
Age 5	0.7333	0.7785	0.2878	0.39
Age 6	0.7262	0.7639	0.2066	0.28
Age 7	0.7262	0.7639	0.2066	0.28

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
Age 1	0.0000000	0.0000000	14.487	0.0000002	0.98	0.0000	0.0000
Age 2	0.0001437	0.0001641	1.041	0.0136654	0.29	0.0106	0.0206
Age 3	0.0097562	0.0024153	4.971	0.1865110	0.32	0.1497	0.2702
Age 4	0.0303115	0.0111074	4.215	0.6887542	0.40	0.5419	1.0393
Age 5	0.0451848	0.0117492	6.162	0.6880971	0.42	0.5217	1.0970
Age 6	0.0377481	0.0084335	5.198	0.6884257	0.30	0.5617	0.9307
Age 7	0.0377481	0.0084335	5.198	0.6884257	0.30	0.5617	0.9307

Appendix 4:Table 5. Bootstrap Output Variable: F full t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
0.7262	0.7639	0.2066	0.28

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
0.03775	0.00843	5.20	0.68843	0.30	0.5617	0.9307

Appendix 4:Table 6. Bootstrap Output Variable: Mean Biomass

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
25946.1513	27159.6758	4140.1812	0.16

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
1213.5245	169.0222	4.68	24732.6269	0.17	20665.6199	30456.5066

Appendix 4:Table 7. Bootstrap Output Variable: SSB spawn t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
13114.3862	13491.5023	1729.6101	0.13

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
377.12	70.61	2.88	12737.27	0.14	10661.8182	14812.9775

Appendix 4:Table 8. Bootstrap Output Variable: Jan 1 biomass

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
20371.5112	21131.1575	2569.7442	0.13

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
759.65	104.91	3.73	19611.87	0.13	16853.60	23009.58

Appendix 5.

Results from biomass production model (ASPIC) conditioned on age 2+ mean biomass and incorporating biomass indices from NEFSC spring and autumn surveys and Massachusetts spring survey.

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

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Tiburon, California 94920 USA

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	38	Number of bootstrap trials:	0
Number of data series:	3	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-03
Relative conv. criterion (restart):	3.000E-08	Upper bound on r:	1.000E+01
Relative conv. criterion (effort):	1.000E-04	Random number seed:	1964285
Maximum F allowed in fitting:	7.000	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		
	38		
2 USA Spring Survey	0.627	1.000	
	33	33	
3 Mass Spring Survey	0.483	0.337	1.000
	23	23	23
	1	2	3

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	2.973E-02	1	N/A	1.000E+00	N/A	
Loss(1) USA Fall Survey	7.196E+00	38	1.999E-01	1.000E+00	9.349E-01	0.599

```
Loss( 2)  USA Spring Survey                        7.966E+00   33     2.570E-01    1.000E+00    7.272E-01        0.370
Loss( 3)  Mass Spring Survey                       2.618E+00   23     1.247E-01    1.000E+00    1.499E+00        0.510

TOTAL OBJECTIVE FUNCTION:                      1.78096796E+01

NOTE: B1-ratio constraint term contributing to loss. Sensitivity analysis advised.

Number of restarts required for convergence:               2
Est. B-ratio coverage index (0 worst, 2 best):        1.6393
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        2.376E+00          2.000E+00            1            1
MSY       Maximum sustainable yield                1.090E+01          1.000E+02            1            1
r         Intrinsic rate of increase               8.360E-01          5.000E-01            1            1
........  Catchability coefficients by fishery:
q( 1)     USA Fall Survey                          2.842E-01          2.842E-01            0            1
q( 2)     USA Spring Survey                        2.482E-01          2.482E-01            0            1
q( 3)     Mass Spring Survey                       5.381E-01          5.381E-01            0            1


MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)
-------------------------------------------------------------------------------------------------------------------
Parameter                                             Estimate           Formula

MSY       Maximum sustainable yield                1.090E+01              Kr/4
K         Maximum stock biomass                    5.215E+01
Bmsy      Stock biomass at MSY                     2.608E+01               K/2
Fmsy      Fishing mortality at MSY                 4.180E-01               r/2

F(0.1)    Management benchmark                     3.762E-01          0.9*Fmsy
Y(0.1)    Equilibrium yield at F(0.1)              1.079E+01          0.99*MSY

B-ratio   Ratio of B(2001) to Bmsy                 9.825E-01
F-ratio   Ratio of F(2000) to Fmsy                 5.454E-01
Y-ratio   Proportion of MSY avail in 2001          9.997E-01         2*Br-Br^2     Ye(2001) = 1.090E+01

........  Fishing effort at MSY in units of each fishery:
fmsy( 1)  USA Fall Survey                          1.471E+00          r/2q( 1)       f(0.1) = 1.324E+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	0.048	6.197E+01	5.746E+01	2.731E+00	2.731E+00	-4.961E+00	1.137E-01	2.376E+00
2	1964	0.062	5.428E+01	5.232E+01	3.251E+00	3.251E+00	-1.548E-01	1.486E-01	2.081E+00
3	1965	0.079	5.087E+01	4.973E+01	3.928E+00	3.928E+00	1.926E+00	1.890E-01	1.951E+00
4	1966	0.091	4.887E+01	4.814E+01	4.392E+00	4.392E+00	3.098E+00	2.183E-01	1.874E+00
5	1967	0.128	4.757E+01	4.656E+01	5.973E+00	5.973E+00	4.172E+00	3.069E-01	1.824E+00
6	1968	0.143	4.577E+01	4.505E+01	6.421E+00	6.421E+00	5.129E+00	3.410E-01	1.755E+00
7	1969	0.196	4.448E+01	4.320E+01	8.484E+00	8.484E+00	6.195E+00	4.699E-01	1.706E+00
8	1970	0.199	4.219E+01	4.153E+01	8.261E+00	8.261E+00	7.071E+00	4.759E-01	1.618E+00
9	1971	0.188	4.100E+01	4.086E+01	7.662E+00	7.662E+00	7.399E+00	4.486E-01	1.572E+00
10	1972	0.169	4.074E+01	4.098E+01	6.917E+00	6.917E+00	7.342E+00	4.038E-01	1.562E+00
11	1973	0.148	4.117E+01	4.165E+01	6.146E+00	6.146E+00	7.014E+00	3.530E-01	1.579E+00
12	1974	0.187	4.203E+01	4.162E+01	7.764E+00	7.764E+00	7.026E+00	4.462E-01	1.612E+00
13	1975	0.223	4.130E+01	4.049E+01	9.015E+00	9.015E+00	7.568E+00	5.326E-01	1.584E+00
14	1976	0.263	3.985E+01	3.880E+01	1.019E+01	1.019E+01	8.301E+00	6.282E-01	1.528E+00
15	1977	0.343	3.796E+01	3.620E+01	1.243E+01	1.243E+01	9.246E+00	8.213E-01	1.456E+00
16	1978	0.371	3.478E+01	3.346E+01	1.243E+01	1.243E+01	1.002E+01	8.885E-01	1.334E+00
17	1979	0.369	3.237E+01	3.167E+01	1.168E+01	1.168E+01	1.040E+01	8.822E-01	1.242E+00
18	1980	0.458	3.109E+01	2.954E+01	1.353E+01	1.353E+01	1.070E+01	1.096E+00	1.192E+00
19	1981	0.458	2.826E+01	2.736E+01	1.253E+01	1.253E+01	1.087E+01	1.096E+00	1.084E+00
20	1982	0.541	2.660E+01	2.513E+01	1.358E+01	1.358E+01	1.088E+01	1.293E+00	1.020E+00
21	1983	0.633	2.389E+01	2.207E+01	1.398E+01	1.398E+01	1.063E+01	1.515E+00	9.162E-01
22	1984	0.532	2.054E+01	2.030E+01	1.081E+01	1.081E+01	1.037E+01	1.273E+00	7.876E-01
23	1985	0.538	2.010E+01	1.988E+01	1.069E+01	1.069E+01	1.028E+01	1.287E+00	7.707E-01
24	1986	0.482	1.969E+01	2.003E+01	9.664E+00	9.664E+00	1.031E+01	1.154E+00	7.551E-01
25	1987	0.343	2.034E+01	2.194E+01	7.527E+00	7.527E+00	1.061E+01	8.209E-01	7.800E-01
26	1988	0.319	2.342E+01	2.495E+01	7.958E+00	7.958E+00	1.087E+01	7.631E-01	8.983E-01
27	1989	0.391	2.634E+01	2.660E+01	1.040E+01	1.040E+01	1.090E+01	9.350E-01	1.010E+00
28	1990	0.619	2.683E+01	2.447E+01	1.515E+01	1.515E+01	1.083E+01	1.482E+00	1.029E+00
29	1991	0.986	2.251E+01	1.803E+01	1.778E+01	1.778E+01	9.777E+00	2.360E+00	8.634E-01
30	1992	0.834	1.451E+01	1.306E+01	1.089E+01	1.089E+01	8.173E+00	1.996E+00	5.564E-01
31	1993	0.731	1.179E+01	1.134E+01	8.287E+00	8.287E+00	7.417E+00	1.749E+00	4.522E-01
32	1994	0.753	1.092E+01	1.046E+01	7.877E+00	7.877E+00	6.989E+00	1.802E+00	4.188E-01
33	1995	0.679	1.003E+01	1.002E+01	6.798E+00	6.798E+00	6.766E+00	1.623E+00	3.848E-01
34	1996	0.742	1.000E+01	9.693E+00	7.194E+00	7.194E+00	6.597E+00	1.776E+00	3.836E-01
35	1997	0.537	9.405E+00	1.010E+01	5.421E+00	5.421E+00	6.806E+00	1.284E+00	3.607E-01
36	1998	0.328	1.079E+01	1.268E+01	4.156E+00	4.156E+00	8.004E+00	7.840E-01	4.138E-01
37	1999	0.238	1.464E+01	1.737E+01	4.136E+00	4.136E+00	9.645E+00	5.695E-01	5.613E-01
38	2000	0.228	2.015E+01	2.294E+01	5.230E+00	5.230E+00	1.070E+01	5.454E-01	7.726E-01
39	2001		2.562E+01						9.825E-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	1.526E-01	1.673E-01	0.0475	2.731E+00	2.731E+00	-0.09196	0.000E+00
2	1964	1.426E-01	2.187E-01	0.0621	3.251E+00	3.251E+00	-0.42757	0.000E+00
3	1965	3.273E-01	2.780E-01	0.0790	3.928E+00	3.928E+00	0.16353	0.000E+00
4	1966	3.405E-01	3.211E-01	0.0912	4.392E+00	4.392E+00	0.05861	0.000E+00
5	1967	6.492E-01	4.515E-01	0.1283	5.973E+00	5.973E+00	0.36329	0.000E+00
6	1968	3.310E-01	5.016E-01	0.1425	6.421E+00	6.421E+00	-0.41575	0.000E+00
7	1969	5.509E-01	6.912E-01	0.1964	8.484E+00	8.484E+00	-0.22680	0.000E+00
8	1970	5.037E-01	7.000E-01	0.1989	8.261E+00	8.261E+00	-0.32907	0.000E+00
9	1971	4.644E-01	6.599E-01	0.1875	7.662E+00	7.662E+00	-0.35148	0.000E+00
10	1972	5.321E-01	5.941E-01	0.1688	6.917E+00	6.917E+00	-0.11019	0.000E+00
11	1973	7.064E-01	5.193E-01	0.1476	6.146E+00	6.146E+00	0.30767	0.000E+00
12	1974	8.627E-01	6.564E-01	0.1865	7.764E+00	7.764E+00	0.27321	0.000E+00
13	1975	1.048E+00	7.835E-01	0.2227	9.015E+00	9.015E+00	0.29107	0.000E+00
14	1976	1.521E+00	9.240E-01	0.2626	1.019E+01	1.019E+01	0.49810	0.000E+00
15	1977	1.218E+00	1.208E+00	0.3433	1.243E+01	1.243E+01	0.00833	0.000E+00
16	1978	9.633E-01	1.307E+00	0.3714	1.243E+01	1.243E+01	-0.30519	0.000E+00
17	1979	6.674E-01	1.298E+00	0.3688	1.168E+01	1.168E+01	-0.66490	0.000E+00
18	1980	9.527E-01	1.612E+00	0.4579	1.353E+01	1.353E+01	-0.52566	0.000E+00
19	1981	1.547E+00	1.612E+00	0.4581	1.253E+01	1.253E+01	-0.04104	0.000E+00
20	1982	8.436E-01	1.902E+00	0.5405	1.358E+01	1.358E+01	-0.81302	0.000E+00
21	1983	1.589E+00	2.229E+00	0.6334	1.398E+01	1.398E+01	-0.33862	0.000E+00
22	1984	1.228E+00	1.873E+00	0.5322	1.081E+01	1.081E+01	-0.42211	0.000E+00
23	1985	1.258E+00	1.893E+00	0.5378	1.069E+01	1.069E+01	-0.40847	0.000E+00
24	1986	1.895E+00	1.698E+00	0.4825	9.664E+00	9.664E+00	0.10976	0.000E+00
25	1987	2.214E+00	1.208E+00	0.3431	7.527E+00	7.527E+00	0.60613	0.000E+00
26	1988	1.206E+00	1.123E+00	0.3190	7.958E+00	7.958E+00	0.07153	0.000E+00
27	1989	2.260E+00	1.375E+00	0.3908	1.040E+01	1.040E+01	0.49669	0.000E+00
28	1990	3.093E+00	2.179E+00	0.6193	1.515E+01	1.515E+01	0.35000	0.000E+00
29	1991	6.350E+00	3.471E+00	0.9863	1.778E+01	1.778E+01	0.60409	0.000E+00
30	1992	4.538E+00	2.935E+00	0.8341	1.089E+01	1.089E+01	0.43560	0.000E+00
31	1993	8.287E+00	2.572E+00	0.7309	8.287E+00	8.287E+00	1.16994	0.000E+00
32	1994	2.917E+00	2.650E+00	0.7531	7.877E+00	7.877E+00	0.09601	0.000E+00
33	1995	1.837E+00	2.388E+00	0.6786	6.798E+00	6.798E+00	-0.26220	0.000E+00
34	1996	2.998E+00	2.612E+00	0.7422	7.194E+00	7.194E+00	0.13769	0.000E+00
35	1997	2.853E+00	1.889E+00	0.5367	5.421E+00	5.421E+00	0.41250	0.000E+00
36	1998	2.771E+00	1.153E+00	0.3277	4.156E+00	4.156E+00	0.87647	0.000E+00
37	1999	1.182E+00	8.377E-01	0.2381	4.136E+00	4.136E+00	0.34401	0.000E+00
38	2000	1.113E+00	8.022E-01	0.2280	5.230E+00	5.230E+00	0.32719	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	-0.0920	==|
1964	-0.4276	=========|
1965	0.1635	|===
1966	0.0586	|=
1967	0.3633	|=======
1968	-0.4157	========|
1969	-0.2268	=====|
1970	-0.3291	=======|
1971	-0.3515	=======|
1972	-0.1102	==|
1973	0.3077	|======
1974	0.2732	|=====
1975	0.2911	|======
1976	0.4981	|==========
1977	0.0083	|
1978	-0.3052	======|
1979	-0.6649	=============|
1980	-0.5257	===========|
1981	-0.0410	=|
1982	-0.8130	================|
1983	-0.3386	=======|
1984	-0.4221	========|
1985	-0.4085	========|
1986	0.1098	|==
1987	0.6061	|============
1988	0.0715	|=
1989	0.4967	|==========
1990	0.3500	|=======
1991	0.6041	|============
1992	0.4356	|=========
1993	1.1699	|========================
1994	0.0960	|==
1995	-0.2622	=====|
1996	0.1377	|===
1997	0.4125	|========
1998	0.8765	|==================
1999	0.3440	|=======
2000	0.3272	|=======

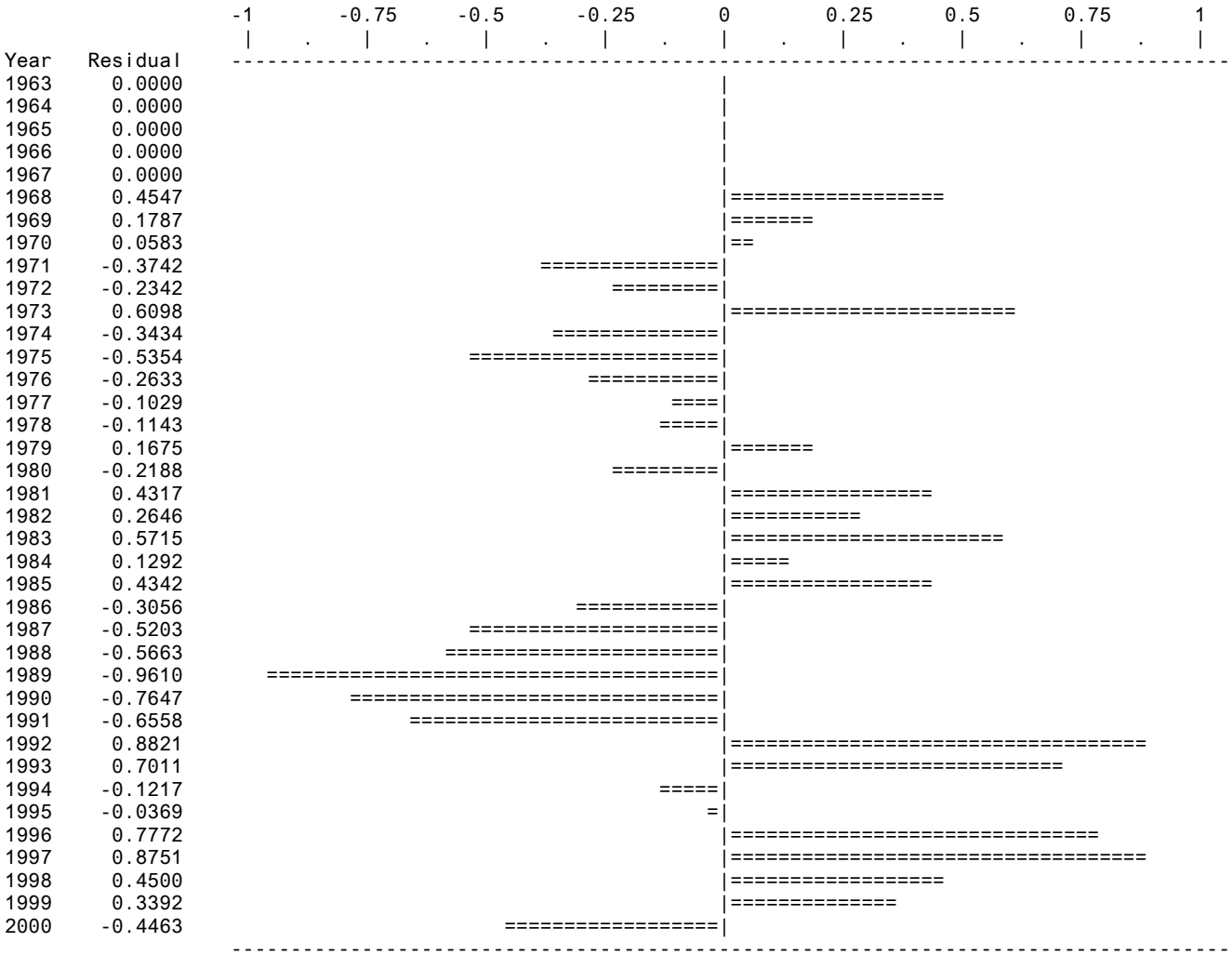
RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) USA Spring Survey

Data type I0: 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	*	1.538E+01	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	1.347E+01	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	1.263E+01	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	1.213E+01	0.00000	0.0
5	1967	0.000E+00	0.000E+00	0.0	*	1.181E+01	0.00000	0.0
6	1968	1.000E+00	1.000E+00	0.0	1.790E+01	1.136E+01	0.45467	6.540E+00
7	1969	1.000E+00	1.000E+00	0.0	1.320E+01	1.104E+01	0.17871	2.160E+00
8	1970	1.000E+00	1.000E+00	0.0	1.110E+01	1.047E+01	0.05826	6.282E-01
9	1971	1.000E+00	1.000E+00	0.0	7.000E+00	1.018E+01	-0.37416	-3.176E+00
10	1972	1.000E+00	1.000E+00	0.0	8.000E+00	1.011E+01	-0.23418	-2.111E+00
11	1973	1.000E+00	1.000E+00	0.0	1.880E+01	1.022E+01	0.60985	8.583E+00
12	1974	1.000E+00	1.000E+00	0.0	7.400E+00	1.043E+01	-0.34340	-3.032E+00
13	1975	1.000E+00	1.000E+00	0.0	6.000E+00	1.025E+01	-0.53540	-4.249E+00
14	1976	1.000E+00	1.000E+00	0.0	7.600E+00	9.890E+00	-0.26334	-2.290E+00
15	1977	1.000E+00	1.000E+00	0.0	8.500E+00	9.421E+00	-0.10291	-9.213E-01
16	1978	1.000E+00	1.000E+00	0.0	7.700E+00	8.632E+00	-0.11427	-9.321E-01
17	1979	1.000E+00	1.000E+00	0.0	9.500E+00	8.035E+00	0.16750	1.465E+00
18	1980	1.000E+00	1.000E+00	0.0	6.200E+00	7.716E+00	-0.21878	-1.516E+00
19	1981	1.000E+00	1.000E+00	0.0	1.080E+01	7.014E+00	0.43168	3.786E+00
20	1982	1.000E+00	1.000E+00	0.0	8.600E+00	6.601E+00	0.26458	1.999E+00
21	1983	1.000E+00	1.000E+00	0.0	1.050E+01	5.929E+00	0.57149	4.571E+00
22	1984	1.000E+00	1.000E+00	0.0	5.800E+00	5.097E+00	0.12919	7.029E-01
23	1985	1.000E+00	1.000E+00	0.0	7.700E+00	4.988E+00	0.43421	2.712E+00
24	1986	1.000E+00	1.000E+00	0.0	3.600E+00	4.887E+00	-0.30556	-1.287E+00
25	1987	1.000E+00	1.000E+00	0.0	3.000E+00	5.048E+00	-0.52034	-2.048E+00
26	1988	1.000E+00	1.000E+00	0.0	3.300E+00	5.814E+00	-0.56628	-2.514E+00
27	1989	1.000E+00	1.000E+00	0.0	2.500E+00	6.536E+00	-0.96103	-4.036E+00
28	1990	1.000E+00	1.000E+00	0.0	3.100E+00	6.660E+00	-0.76467	-3.560E+00
29	1991	1.000E+00	1.000E+00	0.0	2.900E+00	5.588E+00	-0.65584	-2.688E+00
30	1992	1.000E+00	1.000E+00	0.0	8.700E+00	3.601E+00	0.88206	5.099E+00
31	1993	1.000E+00	1.000E+00	0.0	5.900E+00	2.927E+00	0.70112	2.973E+00
32	1994	1.000E+00	1.000E+00	0.0	2.400E+00	2.711E+00	-0.12171	-3.106E-01
33	1995	1.000E+00	1.000E+00	0.0	2.400E+00	2.490E+00	-0.03694	-9.031E-02
34	1996	1.000E+00	1.000E+00	0.0	5.400E+00	2.482E+00	0.77717	2.918E+00
35	1997	1.000E+00	1.000E+00	0.0	5.600E+00	2.334E+00	0.87512	3.266E+00
36	1998	1.000E+00	1.000E+00	0.0	4.200E+00	2.678E+00	0.45005	1.522E+00
37	1999	1.000E+00	1.000E+00	0.0	5.100E+00	3.633E+00	0.33919	1.467E+00
38	2000	1.000E+00	1.000E+00	0.0	3.200E+00	5.000E+00	-0.44635	-1.800E+00

* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2



RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) Mass Spring Survey

Data type I0: Start-of-year biomass index Series weight: 1.000

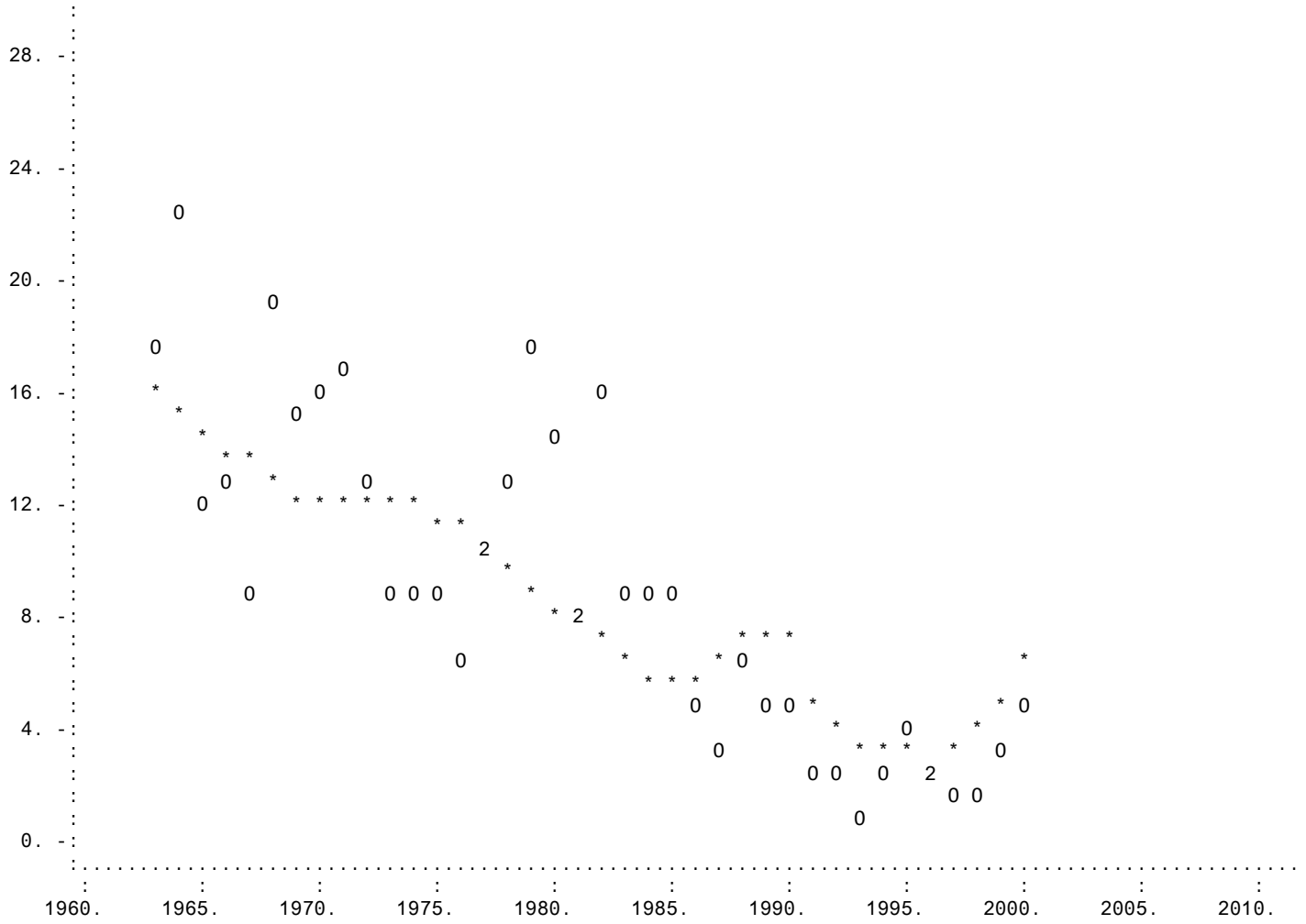
Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1963	0.000E+00	0.000E+00	0.0	*	3.335E+01	0.00000	0.0
2	1964	0.000E+00	0.000E+00	0.0	*	2.921E+01	0.00000	0.0
3	1965	0.000E+00	0.000E+00	0.0	*	2.737E+01	0.00000	0.0
4	1966	0.000E+00	0.000E+00	0.0	*	2.630E+01	0.00000	0.0
5	1967	0.000E+00	0.000E+00	0.0	*	2.560E+01	0.00000	0.0
6	1968	0.000E+00	0.000E+00	0.0	*	2.463E+01	0.00000	0.0
7	1969	0.000E+00	0.000E+00	0.0	*	2.394E+01	0.00000	0.0
8	1970	0.000E+00	0.000E+00	0.0	*	2.270E+01	0.00000	0.0
9	1971	0.000E+00	0.000E+00	0.0	*	2.206E+01	0.00000	0.0
10	1972	0.000E+00	0.000E+00	0.0	*	2.192E+01	0.00000	0.0
11	1973	0.000E+00	0.000E+00	0.0	*	2.215E+01	0.00000	0.0
12	1974	0.000E+00	0.000E+00	0.0	*	2.262E+01	0.00000	0.0
13	1975	0.000E+00	0.000E+00	0.0	*	2.222E+01	0.00000	0.0
14	1976	0.000E+00	0.000E+00	0.0	*	2.144E+01	0.00000	0.0
15	1977	0.000E+00	0.000E+00	0.0	*	2.043E+01	0.00000	0.0
16	1978	1.000E+00	1.000E+00	0.0	1.216E+01	1.872E+01	-0.43122	-6.556E+00
17	1979	1.000E+00	1.000E+00	0.0	2.053E+01	1.742E+01	0.16420	3.109E+00
18	1980	1.000E+00	1.000E+00	0.0	1.771E+01	1.673E+01	0.05691	9.798E-01
19	1981	1.000E+00	1.000E+00	0.0	2.179E+01	1.521E+01	0.35970	6.583E+00
20	1982	1.000E+00	1.000E+00	0.0	1.342E+01	1.431E+01	-0.06432	-8.916E-01
21	1983	1.000E+00	1.000E+00	0.0	1.977E+01	1.286E+01	0.43039	6.914E+00
22	1984	1.000E+00	1.000E+00	0.0	8.630E+00	1.105E+01	-0.24731	-2.421E+00
23	1985	1.000E+00	1.000E+00	0.0	6.420E+00	1.081E+01	-0.52148	-4.395E+00
24	1986	1.000E+00	1.000E+00	0.0	7.770E+00	1.059E+01	-0.31011	-2.825E+00
25	1987	1.000E+00	1.000E+00	0.0	9.590E+00	1.094E+01	-0.13212	-1.355E+00
26	1988	1.000E+00	1.000E+00	0.0	9.660E+00	1.260E+01	-0.26609	-2.945E+00
27	1989	1.000E+00	1.000E+00	0.0	1.826E+01	1.417E+01	0.25350	4.089E+00
28	1990	1.000E+00	1.000E+00	0.0	1.951E+01	1.444E+01	0.30096	5.071E+00
29	1991	1.000E+00	1.000E+00	0.0	1.137E+01	1.211E+01	-0.06346	-7.449E-01
30	1992	1.000E+00	1.000E+00	0.0	1.010E+01	7.808E+00	0.25739	2.292E+00
31	1993	1.000E+00	1.000E+00	0.0	7.630E+00	6.345E+00	0.18437	1.285E+00
32	1994	1.000E+00	1.000E+00	0.0	4.830E+00	5.877E+00	-0.19622	-1.047E+00
33	1995	1.000E+00	1.000E+00	0.0	4.490E+00	5.399E+00	-0.18444	-9.094E-01
34	1996	1.000E+00	1.000E+00	0.0	4.060E+00	5.382E+00	-0.28193	-1.322E+00
35	1997	1.000E+00	1.000E+00	0.0	2.970E+00	5.061E+00	-0.53298	-2.091E+00
36	1998	1.000E+00	1.000E+00	0.0	5.760E+00	5.806E+00	-0.00799	-4.620E-02
37	1999	1.000E+00	1.000E+00	0.0	1.419E+01	7.877E+00	0.58860	6.313E+00
38	2000	1.000E+00	1.000E+00	0.0	2.236E+01	1.084E+01	0.72388	1.152E+01

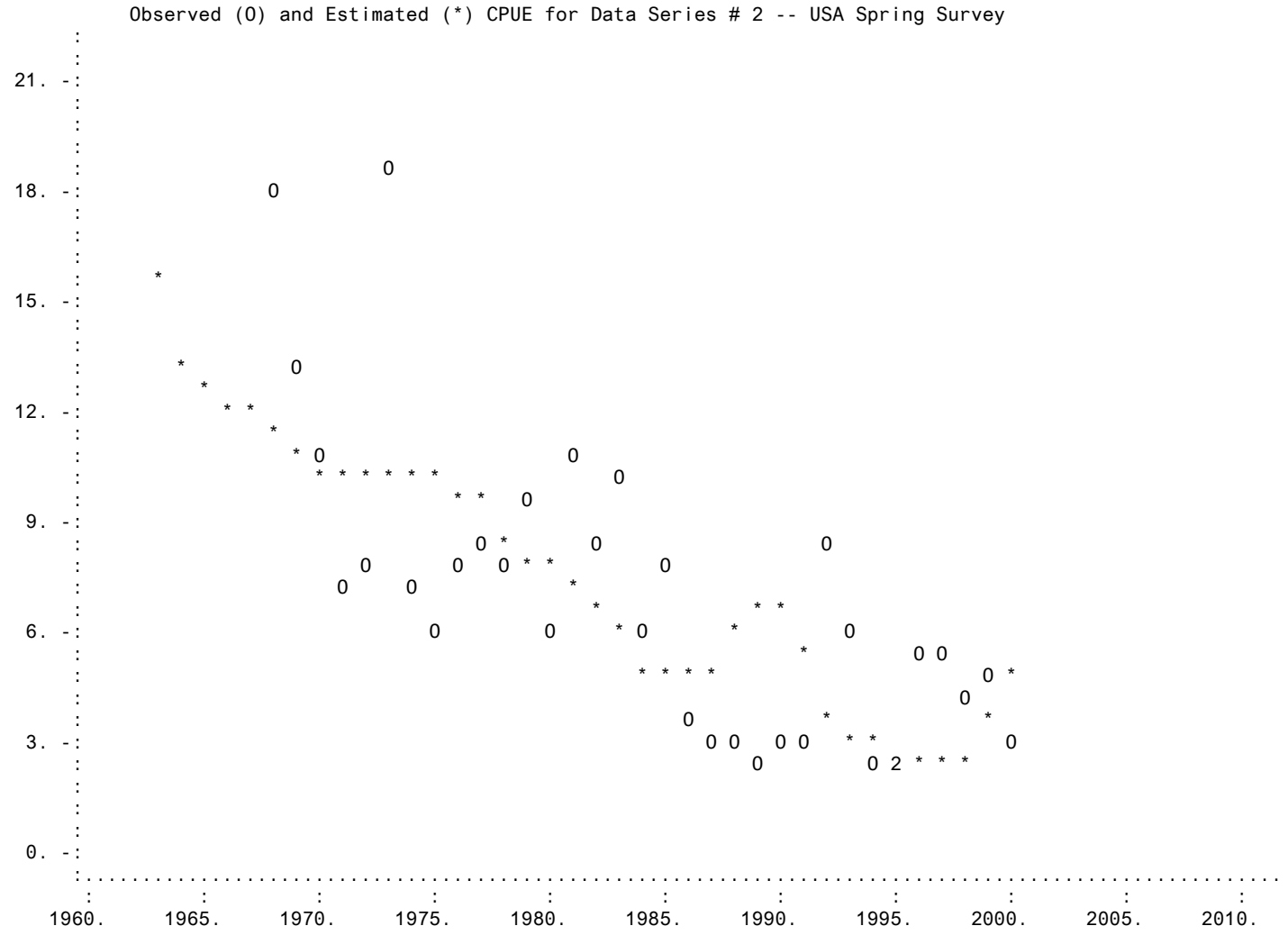
* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3

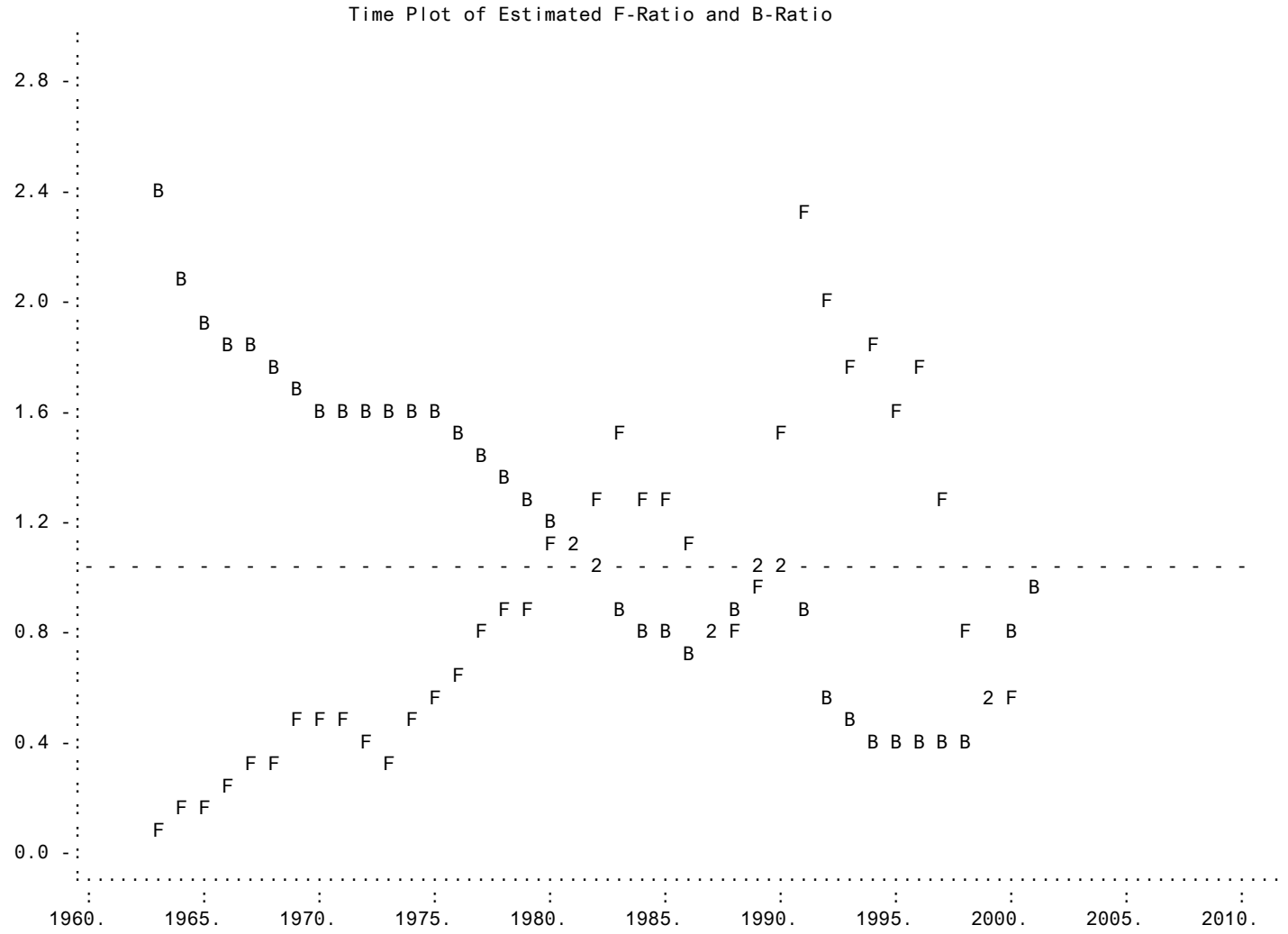
Year	Residual	-1 -0.75 -0.5 -0.25 0 0.25 0.5 0.75 1
1963	0.0000	|
1964	0.0000	|
1965	0.0000	|
1966	0.0000	|
1967	0.0000	|
1968	0.0000	|
1969	0.0000	|
1970	0.0000	|
1971	0.0000	|
1972	0.0000	|
1973	0.0000	|
1974	0.0000	|
1975	0.0000	|
1976	0.0000	|
1977	0.0000	|
1978	-0.4312	==========|
1979	0.1642	|=======
1980	0.0569	|==
1981	0.3597	|==========
1982	-0.0643	===|
1983	0.4304	|==========
1984	-0.2473	==========|
1985	-0.5215	==========|
1986	-0.3101	==========|
1987	-0.1321	=====|
1988	-0.2661	==========|
1989	0.2535	|==========
1990	0.3010	|==========
1991	-0.0635	===|
1992	0.2574	|==========
1993	0.1844	|=======
1994	-0.1962	========|
1995	-0.1844	=======|
1996	-0.2819	==========|
1997	-0.5330	==========|
1998	-0.0080	|
1999	0.5886	|==========
2000	0.7239	|==========

Observed (O) and Estimated (*) CPUE for Data Series # 1 -- USA Fall Survey




Observed (O) and Estimated (*) CPUE for Data Series # 2 -- USA Spring Survey
21.
18.
15.
12.
9.
6.
3.
0.
1960.
1965.
1970.
1975.
1980.
1985.
1990.
1995.
2000.
2005.
2010.

Observed (O) and Estimated (*) CPUE for Data Series # 3 -- Mass Spring Survey


Time Plot of Estimated F-Ratio and B-Ratio
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
1960.
1965.
1970.
1975.
1980.
1985.
1990.
1995.
2000.
2005.
2010.

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Northeast Fisheries Science Center
National Marine Fisheries Service, NOAA
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