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Assessment of the Gulf of Maine Atlantic Cod Stock for 1998

by

Ralph K. Mayo, Loretta O'Brien, and Susan E. Wigley

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

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ABSTRACT

The status of the Gulf of Maine cod (*Gadus morhua*) stock is reviewed, and estimates of 1997 fishing mortality and spawning stock biomass and the 1998 survivors are presented. Precision of the 1997 fishing mortality and spawning stock biomass estimates for Gulf of Maine cod is also provided. Short-term projections of 1999 landings and resulting 2000 spawning stock biomass at various levels of 1999 fishing mortality are also given. The 1998 assessment was based on several sources of information including: USA landings-at-age estimates, Northeast Fisheries Science Center (NEFSC) and Massachusetts Division of Marine Fisheries (DMF) spring and autumn research vessel survey data, NEFSC sea sample data, and standardized USA commercial fishing effort data. This assessment updates the analyses presented in the 1997 assessment of the Gulf of Maine cod stock (Mayo 1998). An updated maturation ogive was incorporated to characterize recent trends in spawning stock biomass.

Total landings of Gulf of Maine cod equalled 5,421 metric tons (mt) in 1997, a 25% decrease from 1996. 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. The 1995, 1996 and 1997 indices suggest that the Gulf of Maine cod stock remains at a record-low biomass level. Except for the 1992 year class, recent recruitment has been well below that observed prior to the 1980s; recruitment prospects for the 1994, 1995 and 1996 year classes are extremely poor.

Spawning stock biomass declined from over 26,000 mt in 1989 to a low of 10,100 mt in 1993, followed by an increase to 14,300 mt in 1995 and a subsequent decline to an estimated record-low of 8,600 mt in 1997. Fishing mortality remained at or near 1.0 since 1983, resulting in an annual exploitation rate of about 58% over the past 15 years. Fishing mortality appears to have declined to about 0.75 in 1997, and if exploitation continues at this rate, commercial landings are projected to decline to about 3,000 mt in 1999, and spawning stock biomass is projected to decline to 4,100 mt in 2000.

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 (Table 1). Although Gulf of Maine landings declined between 1984 and 1987, 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 5,421 in 1997.

This report presents an updated and revised analytical assessment of the Gulf of Maine cod stock (NAFO Division 5Y) for the period 1982-1997 based on analyses of commercial and research vessel survey data through 1997. 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 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), and the data entry and auditing procedures are described by Power *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 revisions were presented at the 12th, 15th, 19th, and 24th Northeast Regional Stock Assessment Workshops in June 1991, December 1992, December 1994, and June 1997 (NEFSC 1991, 1993, 1995, 1997; Mayo *et al.* 1993; Mayo 1995, 1998).

THE FISHERY

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 1997 were 5,421 mt, 25% less than in 1996, and 70% less than the 1991 peak (Table 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 (52% by weight in 1997), the quantity taken by gillnets increased from a low of 23% in 1991 to 38-44% during 1993-1997; the 1997 gill net percentage was similar to the 1987-1989 period (Table 2).

Commercial Fishery Discards

Discard rates were calculated by quarter and gear from NEFSC sea sampling data collected between 1989 and 1997 (Table 3). 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. Calculations and sample sizes are given in Appendix 1:Tables 1-3 and Figures 1-3.

Discard-to-kept ratios and absolute quantities were highest in 1989 and 1990 for the otter trawl and shrimp trawl gear. Ratios in the otter trawl fishery declined from 0.30-0.60 in 1989 and 1990 and remained low through 1997, fluctuating between 0.002 and 0.155. In the shrimp trawl fishery, ratios remained high throughout 1989-1991, but declined substantially in 1992 and remained negligible in 1993. Sea sampling data for 1994-1997 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 1994-1997 period.

Discards of Gulf of Maine cod ranged from 190 mt in 1997 to 3,598 mt in 1990 (Table 3). 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).

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. Revised estimates of the total Gulf of Maine cod recreational catch as well as the portion of the catch excluding those caught and released are provided in Table 4. Information on the catch prior to 1981, which has not been revised, is included in Table 4 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.

Commercial Fishery Sampling Intensity

A summary of USA length frequency and age sampling of Gulf of Maine cod landings during 1982-1997 is presented in Table 5. 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.

Virtually all 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. Of the 78 samples collected in 1997, 29 were scrod samples (37%), 36 were market (46%), and 13 were large (17%). Compared with the 1997 market category landings distribution by weight (scrod: 20%; market: 60%; large: 17%) (Table 6), sampling in 1997 reasonably approximated the market category distribution of the landings.

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 7a).

Age composition of landings from 1994 through 1997 was estimated in a manner similar to that employed for the 1982-1993 estimates except that samples and landings were, on occasion, pooled to the semi-annual level because of the uneven distribution of length and age samples by quarter (Table 5). 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.

Gulf of Maine cod landings are generally dominated by age 3 and 4 fish in numbers and ages 3, 4, and 5 by 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 (Table 7a). 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 7a). Although this pattern may be partly a result of the poor sampling of 'large' category cod, 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.

Commercial Landings Mean Weights at Age

Mean weights at age in the catch for ages 1-11+ during 1982-1997 are given in Table 7b 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 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 increase in mean weights at age 2 in 1995 and 1996 may be related to the 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 8a and 8b. Mean weights at age for calculating stock biomass at the beginning of the year are provided in Table 9. These values were derived from the catch mean weight at age data (Table 7b) using the procedures described by Rivard (1980).

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 4. 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 removals from the stock which could be attributed to this gear type. Overall, sampling for cod taken by recreational gear is poor, averaging less than 1 sample per 1,000 mt removed (Table 4). Sampling of the recreational fishery has improved in recent years. However, given the highly variable sampling over the past 15 years, these data were not formally included in the VPA conducted in 1997 (NEFSC 1997; Mayo 1998). Therefore, no further treatment of the 1997 recreational data was performed in this assessment

STOCK ABUNDANCE and BIOMASS INDICES

Commercial Catch Rates

Trends in commercial 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, these data were not formally included in the VPA conducted in 1997 (NEFSC 1997; Mayo 1998). 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 are illustrated in Figures 2 and 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 in 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 10. Unadjusted catch-per-tow-at-age (number) indices from NEFSC spring and autumn surveys are listed in Appendix 2:Table 1 and standardized catch-per-tow-at-age (number) indices are listed in Appendix 2:Table 2. Catch-per-tow-at-age (number) 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 10, Figure 4). Number-per-tow indices declined during the mid- and late 1960s, but since 1972-73 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 1995 and spring 1996 abundance indices may be attributed to the 1992 year class which was the largest within the recent series of poor year classes (Figure 5).

Spring NEFSC number-per-tow indices have remained relatively low since 1985, below the 1981-1984 average (Table 10); 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.

Autumn number- and weight-per-tow indices declined sharply in 1991 to unprecedented low levels; weight per tow continued to decline to record low levels through 1993 and has remained extremely low through 1996 (Figure 4). The higher abundance in 1988 and 1989, resulting from recruitment of the strong 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), has resulted in the decline and subsequent continuation of low weight-per-tow indices since 1991. Although the recent increase in the autumn abundance and biomass indices in 1994 and 1995 reflected recruitment of the 1992 year class, these indices had already begun to decline by 1996.

Overall, the 1987 year class appears to have been one of the strongest ever produced; catch-per-tow indices of 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 from 1989-1996, only the 1992 year class appears to be of moderate strength; the remaining year classes of Gulf of Maine cod appear to be below average, and the 1994, 1995, and 1996 year classes are likely to be record lows.

MORTALITY

Total Mortality Estimates

Pooled estimates of instantaneous total mortality (Z) were calculated for six time periods encompassed by the NEFSC spring and autumn offshore surveys: 1964-1967, 1968-1976, 1977-1982, 1983-1987, 1988-1990, and 1991-1994 (Table 11). Total mortality was calculated from survey catch per tow at age data (Appendix 2:Table 2) for fully recruited age groups (age 3+) 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 1982-1984 values were derived from:

Spring: ln (Σ age 4+ for 1982-84/ Σ age 5+ for 1983-85)

Autumn: ln (Σ age 3+ for 1981-83/ Σ age 4+ for 1982-84)

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 1982-1994, with an indication of a slight decline after 1994.

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 1997. As in previous assessments, age-disaggregated analyses were performed. Several exploratory ADAPT formulations were performed using NEFSC spring and autumn (ages 2-6) and MADMF spring (ages 2-4) and autumn (ages 1, 2, and 3) survey series. Due to uncertainty in the interpretation of effort units in the 1994-1997 VTR data, USA commercial LPUE abundance indices for ages 3-6 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 assessment (Mayo 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 1982-1997 commercial landings at age as provided in Table 7a 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 previous 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), all trial formulations employed a reduced age range (ages 2-6 and 7+).

As in the past, MADMF survey data were included in the VPA calibration primarily to improve the estimates of recruiting year-class strength. In exploratory analyses, the MADMF autumn age 1 and 3 indices (ages 0 and 2 before lagging) often accounted for up to 40% of the total sum of squares; these indices were again, as in previous assessments, excluded from the final calibration because of their high variability. The series of trial formulations is summarized in Table 12. All of the trial calibrations employed equal weighting among indices in all years. The formulation identical to that employed in the previous assessment (Mayo 1998) is presented first. This formulation and the second one listed in Table 12 employed commercial landings-at-age data as in the previous

assessment. Two additional trial calibration runs were performed as sensitivity analyses. The first of these eliminated all of the LPUE indices and the second excluded the MADMF autumn age 2 index. These formulations employed the same age range in the direct estimation of terminal populations.

In all trials, the F pattern in 1997 was somewhat inconsistent, with relatively high Fs estimated for age 3 relative to age 4. However, CVs among all trials were generally similar, ranging from 30-38% on age 3 to 46-57% on age 6. None of the variations on the initial formulation produced noticeably different results in terms of terminal Fs, population numbers, or CVs. Residuals of the observed and predicted indices derived from the final VPA formulation (Figure 6) do not indicate any consistent trends over the period of the VPA, except for the MADMF age 2 autumn index. Exclusion of this index, however, results in the highest CV on the age 2 stock size estimate, although the magnitude of the estimate is similar. Incorporation of the age 1 and 3 indices from the MADMF survey add additional noise to the calibration analysis, resulting in higher CVs on the estimates of older ages, higher total sums of squares and mean square residual compared to the other trial formulations.

The ADAPT formulation employed in the final VPA calibration was the same as that used in the previous assessment (Mayo 1998). This analysis provided direct stock size estimates for ages 2 through 6 in 1998 and corresponding estimates of F on ages 1 through 5 in 1997. 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 an updated maturity schedule which reflected earlier maturation beginning in 1994.

Virtual Population Analysis Results

Full results from the final VPA calibration are presented in Appendix 3, and estimates of F, stock size, and spawning stock biomass are given in Tables 13a and 13b. All parameter estimates were significant. Coefficients of variation on the stock size estimates ranged from 0.32 (age 3) to 0.52 (age 6), while CVs on the estimates of slopes were between 0.16 and 0.19. Slopes of the abundance index-stock size relationships (Appendix 3) increased with age generally up to age 4 for the NEFSC spring and autumn surveys and the USA commercial LPUE indices. The MADMF spring indices exhibited a decreasing trend in q between ages 2 and 4, possibly reflecting the inshore nature of the survey relative to the distribution of the adult stock.

Average (ages 4-5, unweighted) fishing mortality in 1997 was estimated to be 0.75 (Table 13a, Figure 7), a 21% decrease from 1996. The spawning stock biomass of age 2 and older cod declined from 22,500 mt in 1982 to 14,100 mt in 1987. Following the recruitment and maturation of the strong 1987 year class, SSB increased sharply in 1989 to a maximum of 26,100 mt but declined to 10,100 mt in 1993, a 4-year reduction of 61% (Table 13b, Figure 8). SSB increased to 14,300 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 8,600 mt in 1997. SSB estimates for the 1994-1996 period are higher than those reported in the 1997 assessment primarily as a result of the revision to the maturation schedule employed in the present assessment. Total stock size (ages 2+) has also declined sharply in recent years from 28 million fish in 1989 to 2.6 million in 1998, a decrease of 91% (Table 13a).

Since 1982, recruitment at age 2 has ranged from less than 1.5 million fish (1994, 1995, and 1996 year classes) to 17.7 million fish (1987 year class). Over the 1982-1996 period, geometric mean recruitment for the 1980-1994 year classes was 4.4 million fish. The 1987 year class is the highest in the 1982-1996 series and about twice the size of the above average 1980 and 1986 year classes. Except for the moderate 1992 year class, recent recruitment has been poor as the 1988-1989 and the 1993-1996 year classes (all < 3 million at age 2) are estimated to be among the poorest in the series (Table 13a, Figure 8). In particular, the 1994, 1995, and 1996 year classes average less than 1 million fish. The 1993 through 1996 year classes are each about one-half the size of their immediate predecessor, the 1996 year class being about 1/16th the size of the 1992 year class (Table 13a).

Precision of F and SSB

A bootstrap procedure (Efron 1982) was used to evaluate the precision of the final estimates, by generating 1,000 estimates of the 1997 fishing mortality rate and spawning stock biomass. The distributions of the bootstrap estimates and the corresponding cumulative probability curves are shown in Figures 9 and 10. The cumulative probability expresses the likelihood that the fishing mortality rate was greater than a given level (Figure 9) or the likelihood that spawning stock biomass was less than a given level (Figure 10) when measurement error is considered. An evaluation of the precision of the 1998 stock size, 1997 fishing mortality, 1997 spawning stock biomass, and q estimates is presented in Appendix 4.

Coefficients of variation for the 1997 stock size (numbers) estimates ranged from 0.31 (age 3) to 0.61 (age 2), and CVs for qs among all indices ranged from 0.15 to 0.17 (Appendix 4:Table 1). The fully-recruited fishing mortality in 1997 for ages 4+ was reasonably well estimated (CV = 0.24). The mean bootstrap estimate of F (0.7750) was slightly higher than the point estimate (0.7507) from the VPA (Appendix 4:Table 5), and individual bootstrap estimates of F ranged from 0.46 to 2.04. The 80% probability interval ranged from 0.57 to 1.00 (Figure 9). $F_{20\%}$ and F_{max} are much lower than the lowest bootstrap estimate, and F_{97} is certainly above the overfishing definition mortality rate and the maximum F allowable to achieve stock rebuilding.

Although the abundance estimates for individual ages in 1998 had wide variances (CV = 0.31 to 0.61), the estimate of 1997 spawning stock biomass was robust (CV = 0.15). The bootstrap mean (9,200 mt) was 3.7% higher than the VPA point estimate (8,900 mt) (Appendix 4:Table 6) and individual bootstrap estimates of SSB ranged from 5,700 mt to 15,400 mt. The 80% probability interval ranged from 7,700 mt to 10,900 mt (Figure 10). Despite this variability, current spawning stock biomass is estimated to be the lowest observed in the series. 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 1998). The VPA results are, therefore, considered sufficient to accurately characterize the overall status of the Gulf of Maine cod stock.

Retrospective Analysis

No new retrospective analyses of the Gulf of Maine cod VPA were carried out in the present assessment because only one year of new data was added and the final ADAPT formulation was the same as in the 1997 assessment (Mayo 1998); results from the previous retrospective analysis were reported in Mayo (1998). Convergence of estimates is generally evident within 3 years, and often within 2 years, prior to any given terminal year. Retrospective patterns with respect to terminal F are evident for Gulf of Maine cod in the most recent years. Mean (ages 4-5, unweighted) F in the terminal year was generally under-estimated by the ADAPT calibration in the most recent years and slightly over-estimated in earlier years. Terminal Fs appear to have been well estimated through 1993. Despite these patterns, the retrospective analysis provides additional evidence to substantiate the current high levels of F. Retrospective patterns for SSB and age 2 recruits are similar, both indicating relatively consistent estimates of terminal year values from 1991-1996. Although subject to some variability, terminal year recruitment and SSB appear to have been estimated with a high degree of reliability in recent years.

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 11) was constructed over the period covering the 1982-1996 year classes. In addition, a survival ratio, expressed as recruits per unit of SSB (R/SSB), was also calculated for each year class (Figure 12). 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 1994, 1995, and 1996 year classes appear as the lowest in the series, and each came from SSBs of 10,000-14,000 mt. The 1997 SSB (8,600 mt) and the likely 1998 SSB (6,600 mt) are also noted in Figure 11. The probability of realizing low recruitment appears to increase at SSB levels below 14,000 mt.

Survival ratios of pre-recruits up to age 2 are highest for the 1987 and 1992 year classes, both of which emerged from about average year classes. Survival ratios were consistently higher during the early-to-mid 1980s prior to the emergence of the large 1987 year class. Survival has been declining since the 1992 year class and is at a record-low level for the 1995 and 1996 year classes.

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 yield per recruit were computed as a 16-year arithmetic average of catch mean weights at age (Table 7b) over the 1982-1997 period. Mean weights at age for application to SSB per recruit were computed as a 16-year arithmetic average of stock mean weights at age (Table 9) over the 1992-1997 period. The maturation ogive was the same as used in computing SSB during the 1994-1997 period in the VPA.

To obtain the exploitation pattern for these analyses, a three-year geometric mean F at age was first computed over the period 1994-1996 from the final converged VPA results. These years were chosen specifically to encompass the period since enactment of the increase in the minimum allowable mesh (152 mm). The 1997 results were excluded because the exploitation pattern at age 3 appeared inconsistent with the previous years. 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 as follows:

Age 1 0.000, Age 2 0.027, Age 3 0.231, Age 4 0.786, Ages 5+ 1.000

This pattern is the same as that used in the 1997 assessment (Mayo 1998) but differs from those used in the previous two Gulf of Maine cod assessments (Mayo *et al.* 1993; Mayo 1995), and reflects recent management actions designed to increase mesh selectivity. 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 14 and illustrated in Figure 13. The yield per recruit analyses indicate that $F_{0.1} = 0.16$ and $F_{max} = 0.29$, and SSB per recruit calculations indicate that $F_{20\%} = 0.39$. The yield per recruit reference points are identical to, and the SSB per recruit reference point ($F_{20\%}$) is slightly higher than, those reported in the previous assessment (Mayo 1998).

MSY-Based Reference Points

Estimates of B_{msy} and F_{msy} for Gulf of Maine cod were derived from production model analyses (Prager 1995) integrating landings and relative biomass indices over the period 1963-1996 (Anon. 1998). Results suggest that B_{msy} for Gulf of Maine cod is in the range of 33,000 mt and that the corresponding F_{msy} is 0.31, slightly above the current rebuilding F. The modeling results indicate that total stock biomass was above B_{msy} from the 1960s to the early 1980s (Anon. 1998), but as F exceeded F_{msy} in the early 1980s, stock biomass declined to low levels in the 1990s. Stock biomass in 1997 was estimated to be only 35% of B_{msy} (Anon. 1998). According to a proposed harvest control rule for this stock based on SFA requirements, at the current biomass, fishing mortality should be less than 1/2 F_{msy}, i.e., less than 0.15.

CATCH and STOCK BIOMASS PROJECTIONS

Short-Term Projection Results

Short-term projections of spawning stock biomass, recruitment at age 2 and commercial landings were performed using the VPA-calibrated 1997 fully recruited mean F (ages 4-5, u) and 1998 stock size estimates from the 1,000 bootstrap replications as starting conditions. The stochastic simulations were repeated 100 times to obtain a series of probability profiles for each projected variable. The exploitation pattern and maturation rates were as described above for the yield and SSB per recruit analyses; catch and stock mean weights at age were computed as a five-year arithmetic average over the 1993-1997 period.

Recruitment was generated based on the model 9 formulation of Brodziak and Rago (MS 1994). In this model, age 2 recruitment is estimated two years ahead by re-sampling the distribution of a specified range of empirical recruitment. For the near term, age 2 recruitment in 1998 was fixed at the level estimated in the VPA calibration, and recruitment in 1999 and 2000 was derived by re-sampling the distribution of values observed for the 1993-1995 year classes. This period was chosen based on the expectation that recruitment in the near-term is not likely to improve over the recent past given the current low level of SSB. Short-term projections are provided over a range of 1999-2000 F levels which includes: F=0.0, $F_{0.1}$, F_{max}, $F_{20\%}$, and F_{SQ} (=F_{97}). Input and output from the projections are given in Table 15. The assumption of status quo F in 1998 equal to 0.75 resulted in a 1998 catch of about 3,800 mt and a corresponding SSB of 6,600 mt. Given the potential for further shifts in fishing effort toward coastal Gulf of Maine grounds, the assumption of status quo F in 1998 appears reasonable, unless restrictive management actions are initiated early in the 1998-1999 fishing year.

Continued fishing at F = 0.75 in 1999 will result in projected 1999 landings of about 3,000 mt and will result in a continued decline in SSB to 4,400 mt in 2000 from the record low 1998 level of 6,600 mt (Table 15, Figure 14). Even if fishing mortality is reduced to F_{max} (0.29) in 1999 and 2000, SSB will not increase above the record-low 1998 level (Table 15, Figure 14).

CONCLUSIONS

The Gulf of Maine cod stock is presently at a low biomass level and remains over exploited. Fishing mortality in 1997 (0.75) has decreased from the 1996 level (0.95), but there is a 90% probability that the 1997 F is at least twice the maximum allowable level to achieve stock rebuilding. Spawning stock biomass (SSB) has declined from over 26,000 mt in 1989 to a record low of 6,600 mt in 1998, and is expected to decline further in 1999 to a new record-low 5,700 mt or less. Accounting for the estimation uncertainty associated with the 1997 SSB (8,600 mt) and 1997 F (0.75) estimates, there is an 80% probability that the 1997 SSB lies between 7,700 mt and 10,900 mt, and that the 1997 F lies between 0.57 and 1.00. This further implies a 90% probability that the 1997 F is greater than 0.57, or 1.5 times greater than the overfishing definition ($F_{20\%}$ = 0.41).

At the present level of exploitation and probable levels of recruitment in the near term, the decline in spawning stock biomass is expected to continue. At the current level of exploitation (F = 0.75), landings are expected to decline to about 3,000 mt in 1998, and spawning stock biomass is projected to decline to about 4,400 mt in 2000. Current SSB is no longer dominated by the 1987 year class, but by a series of very low to average year classes produced from 1988 through 1995. The moderate 1992 year class was the only above average year class since 1987. Recruitment from the three most recent year classes produced in 1994, 1995, and 1996 is extremely poor, far below any previously observed levels.

An immediate and substantial reduction in fishing mortality, in the order of 50%, is required to halt the continuing decline in SSB. Rebuilding of SSB will require even further reductions over the long term. If fishing mortality is not reduced from the present level, SSB will decline to less than 6,000 mt in the near future.

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Table 1. Commercial landings (metric tons, live) of Atlantic cod the Gulf of Maine (NAFO Division 5Y), 1960 - 1997.[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

* Provisional

[1] USA 1960-1993 landings from NMFS, NEFSC Detailed Weighout Files and Canvass data.
[2] USA 1994-1996 landings estimated by prorating NMFS, NEFSC Detailed Weighout data by Vessel Trip Reports.

Table 2. Distribution of USA commercial landings (metric tons, live) of Atlantic cod from the Gulf of Maine (Area 5Y), by gear type, 1965 - 1997. 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

[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 3. Discard and total catch estimates (metric tons, live) for Gulf of Maine cod by otter trawl, shrimp trawl, and sink gillnet gear, 1989-1997.

Year	Total Landings	Discard Estimates: Included Landings	Discard Estimates: 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	174	0.0351	190	5611

Table 4. Estimated number (000's) and weight (metric tons, live) of Atlantic cod caught by marine recreational fishermen from the Gulf of Maine stock, 1979 - 1997.[1]

Year	Total Cod Caught: No. of Cod (000's)	Total Cod Caught: Wt. of Cod (mt)	Total Cod Retained (excluding those caught and released): No. of Cod (000's)	Total Cod Retained (excluding those caught and released): 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	1424	2578	516	934	1.844	750	10.6
1995	1206	1799	517	771	1.716	1028	10.2
1996	812	2112	351	913	2.099	1068	11.3
1997	434	671	161	250	2.692		4.4

[1] 1981-1997 from Revised Marine Recreational Fishery Statistics Survey database expanded catch estimates.

Table 5. USA sampling of commercial Atlantic cod landings from the Gulf of Maine cod stock (NAFO Division 5Y), 1982 - 1997.

Year	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			
	No.	# Fish Measured	No.	# Fish Aged	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Scd	Mkt	Lge	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

Source: 1978-1985 from Serchuk and Wigley (Woods Hole Lab. Ref 86-12); 1986-1997 from NEFSC files.

Table 6. Percentage (by weight) of USA commercial Atlantic cod landings from the Gulf of Maine (NAFO Division 5Y), by market category, 1964 - 1997.

	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

[a] Includes landings of 'mixed' cod.

Table 7a. Catch at age (thousands of fish; metric tons) of total commercial landings of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 1997.

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
Total Commercial Catch in Numbers (000's) at Age												
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
Total Commercial Catch in Weight (Tons) at Age												
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

Table 7b. Mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 1997.

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Average
Total Commercial Catch 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
Total Commercial Catch 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

Table 8a. Catch at age (thousands of fish; metric tons) of total commercial landings of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 1997. (Input data for Virtual Population Analysis).

	Age							
Year	1	2	3	4	5	6	7+	Total
				Total Commercial Catch in Numbers (000's) at Age				
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
				Total Commercial Catch in Weight (Tons) at Age				
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

Table 8b. Mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 1997. (Input data for Virtual Population Analysis)

	Age							
Year	1	2	3	4	5	6	7+	Average
Total Commercial Catch 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
Total Commercial Catch 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

Table 9. Mean weight at age at the beginning of the year for Gulf of Maine cod derived from commercial landings mean weight at age using prodedures described by Rivard (1980).

	Age										
Year	1	2	3	4	5	6	7	8	9	10	11+
1982	0.791	0.965	1.364	2.364	4.267	5.670	8.246	9.853	14.071	11.713	18.456
1983	0.793	1.024	1.385	2.029	3.231	5.333	6.256	9.701	10.010	11.867	17.813
1984	0.761	1.021	1.394	2.125	3.017	4.720	6.957	7.465	11.646	11.864	15.028
1985	0.748	1.065	1.423	2.178	3.486	4.507	6.826	9.544	10.468	13.135	14.523
1986	0.745	1.083	1.521	2.259	3.622	5.205	6.509	8.902	11.824	12.141	16.554
1987	0.758	1.087	1.482	2.456	3.758	5.614	7.339	8.767	11.744	13.553	14.596
1988	0.765	1.068	1.572	2.021	4.118	5.718	8.233	9.939	12.245	14.723	20.356
1989	0.825	1.059	1.501	2.373	3.062	5.017	7.919	10.889	12.835	16.499	21.521
1990	0.803	0.982	1.453	2.008	3.573	5.435	7.232	10.438	13.388	14.795	20.295
1991	0.690	1.008	1.296	2.062	3.065	5.583	8.586	11.501	13.520	19.112	21.885
1992	0.751	1.175	1.474	2.063	2.773	4.548	8.362	10.962	12.873	16.080	20.000
1993	0.709	1.079	1.702	2.198	3.438	4.347	7.071	11.518	14.786	14.956	20.000
1994	0.664	1.142	1.585	2.440	2.942	5.168	7.168	11.237	12.929	19.436	19.369
1995	0.657	1.219	1.669	2.322	4.025	5.343	8.113	10.366	14.405	16.099	20.000
1996	0.649	1.232	1.878	2.136	3.182	6.159	9.303	11.316	13.190	18.129	20.000
1997	0.649	1.249	1.941	2.534	2.754	4.118	7.938	11.845	13.281	14.716	21.356
Avg											
1993-97	0.666	1.184	1.755	2.326	3.268	5.027	7.919	11.256	13.718	16.667	20.145
1982-97	0.735	1.091	1.540	2.223	3.395	5.155	7.629	10.265	12.701	14.926	18.860

Table 10. 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 - 1997 [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

[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 11. Estimates of instantaneous total mortality (Z) and fishing mortality (F)[1] for Gulf of Maine Atlantic cod, 1964 - 1996, 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
1988-1990	1.24	1.04	0.72	0.61	0.94	0.74
1991-1994	1.06	0.86	1.13	0.93	1.09	0.89[5]
1991-1996	0.69	0.49	1.07	0.75	0.86	0.66

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 12. Summary statistics of the final, base, and alternative, ADAPT VPA calibration For Gulf of Maine cod; terminal year 1997.

Final Run - Same Formulation as 1997 Assessment (Mayo 1998)
RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 107.044885373016
Mean Square Residuals: 0.42144

1998 Age		PAR. EST.	STD. ERR.	T-STATISTIC	C.V.	1997 Age		
N	2	4.28E+02	2.04E+02	2.10E+00	0.48	F	2	0.07
N	3	6.68E+02	2.13E+02	3.14E+00	0.32	F	3	0.63
N	4	4.56E+02	1.81E+02	2.52E+00	0.40	F	4	0.51
N	5	5.86E+02	2.20E+02	2.67E+00	0.38	F	5	0.99
N	6	4.47E+02	2.33E+02	1.92E+00	0.52	F	6	0.75

Base Run - All Indices
RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 210.074922109211
Mean Square Residuals: 0.70971

1998 Age		PAR. EST.	STD. ERR.	T-STATISTIC	C.V.	1997 Age		
N	2	9.30E+02	4.70E+02	1.98E+00	0.51	F	2	0.06
N	3	7.45E+02	2.80E+02	2.66E+00	0.38	F	3	0.54
N	4	5.55E+02	2.46E+02	2.26E+00	0.44	F	4	0.36
N	5	9.09E+02	3.62E+02	2.51E+00	0.40	F	5	0.73
N	6	6.98E+02	3.99E+02	1.75E+00	0.57	F	6	0.55

1997 Formulation W/O CPUE indices
RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 104.430923491212
Mean Square Residuals: 0.49729

1998 Age		PAR. EST.	STD. ERR.	T-STATISTIC	C.V.	1997 Age		
N	2	4.28E+02	2.21E+02	1.93E+00	0.52	F	2	0.07
N	3	6.68E+02	2.31E+02	2.89E+00	0.35	F	3	0.63
N	4	4.56E+02	1.97E+02	2.32E+00	0.43	F	4	0.51
N	5	5.85E+02	2.39E+02	2.45E+00	0.41	F	5	0.99
N	6	4.46E+02	2.53E+02	1.76E+00	0.57	F	6	0.75

1997 Formulation W/O Mass Autumn Age 2 Index
RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 75.1191873904909
Mean Square Residuals: 0.31563

1998 Age		PAR. EST.	STD. ERR.	T-STATISTIC	C.V.	1997 Age		
N	2	4.24E+03	2.47E+03	1.72E+00	0.58	F	2	0.05
N	3	8.69E+02	2.64E+02	3.29E+00	0.30	F	3	0.63
N	4	4.52E+02	1.63E+02	2.77E+00	0.36	F	4	0.64
N	5	4.35E+02	1.59E+02	2.73E+00	0.37	F	5	1.02
N	6	4.23E+02	1.97E+02	2.15E+00	0.46	F	6	0.83

Table 13a. Estimates of Stock Size (000s of fish) and Instantaneous Fishing Mortality Rate (F) for Gulf of Maine cod obtained from Virtual Population Analysis (VPA).

STOCK NUMBERS (Jan 1) in thousands - C:\ASSESS\Whatzip\gmcod\Gmcod98.11

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	6162	5534	7746	4914	7410	9954	21648	3376	3392
2	9108	5018	4530	6339	4023	6067	8148	17724	2764
3	4328	6208	3325	3306	4821	3218	4772	6526	14206
4	2666	2066	2950	1600	1399	1989	2096	2601	3911
5	1661	1149	734	1058	413	410	625	854	814
6	166	787	363	206	296	112	85	145	293
7+	547	284	250	214	156	132	58	98	182
1+	24639	21046	19900	17636	18519	21882	37432	31324	25561

Age	1991	1992	1993	1994	1995	1996	1997	1998
1	5884	5340	8252	3436	1641	1067	523	0
2	2777	4817	4372	6756	2813	1344	874	428
3	2077	1962	3661	3511	5505	2106	1041	668
4	8532	856	1127	1652	1955	3711	1196	456
5	1334	3220	263	343	325	557	1466	586
6	277	323	811	98	20	91	142	447
7+	151	131	63	114	55	20	17	61
1+	21032	16649	18547	15910	12315	8896	5258	2646

FISHING MORTALITY - C:\ASSESS\Whatzip\gmcod\gmcodf11.out

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.18	0.21	0.12	0.07	0.02	0.04	0.02	0.02	0.09
3	0.54	0.54	0.53	0.66	0.69	0.23	0.41	0.31	0.31
4	0.64	0.83	0.83	1.15	1.03	0.96	0.70	0.96	0.88
5	0.55	0.95	1.07	1.07	1.10	1.37	1.26	0.87	0.88
6	0.61	0.90	0.89	1.16	1.08	1.05	0.82	0.97	0.90
7+	0.61	0.90	0.89	1.16	1.08	1.05	0.82	0.97	0.90
Avg 4-5 u	0.59	0.89	0.95	1.11	1.07	1.17	0.98	0.92	0.88
Avg 4-5 w	0.61	0.88	0.87	1.12	1.05	1.03	0.83	0.94	0.88

Age	1991	1992	1993	1994	1995	1996	1997
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.15	0.07	0.02	0.00	0.09	0.05	0.07
3	0.69	0.35	0.60	0.39	0.19	0.37	0.63
4	0.77	0.98	0.99	1.42	1.05	0.73	0.51
5	1.22	1.18	0.78	2.64	1.08	1.16	0.99
6	0.84	1.18	0.98	1.66	1.09	0.79	0.75
7+	0.84	1.18	0.98	1.66	1.09	0.79	0.75
Avg 4-5 u	1.00	1.08	0.89	2.03	1.07	0.95	0.75
Avg 4-5 w	0.83	1.14	0.95	1.63	1.06	0.79	0.77

Table 13b. Estimates of Spawning Stock Biomass (000s mt) and sexual maturation for Gulf of Maine cod obtained from Virtual Population Analysis (VPA).

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

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	330	297	399	142	214	292	641	108	290
2	2144	1247	1141	3096	2015	3041	4025	8683	725
3	3184	4633	2503	3872	6011	4218	6440	8545	10617
4	4820	3105	4650	2781	2575	4029	3647	5085	5317
5	6071	2971	1738	2983	1205	1184	2017	2187	2260
6	823	3496	1429	739	1245	511	409	597	1298
7+	5415	2311	2125	1659	1297	1096	552	987	2079
1+	22786	18061	13984	15272	14561	14371	17732	26192	22586
2+	22456	17764	13585	15130	14347	14079	17091	26084	22296

Age	1991	1992	1993	1994	1995	1996	1997
1	432	427	622	88	42	27	13
2	740	1514	1273	2833	1242	603	397
3	1300	1477	3056	4492	7657	3203	1568
4	12114	1174	1645	3043	3646	6721	2663
5	3002	6599	713	627	1058	1413	3311
6	1275	1143	2839	373	86	474	500
7+	1451	1108	571	839	579	196	176
1+	20314	13441	10719	12296	14309	12637	8628
2+	19882	13014	10097	12208	14267	12610	8615

PERCENT MATURE (Females)

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	7	7	7	4	4	4	4	4	11
2	26	26	26	48	48	48	48	48	28
3	61	61	61	95	95	95	95	95	56
4	88	88	88	100	100	100	100	100	81
5	97	97	97	100	100	100	100	100	93
6	100	100	100	100	100	100	100	100	98
7+	100	100	100	100	100	100	100	100	100

Age	1991	1992	1993	1994	1995	1996	1997
1	11	11	11	4	4	4	4
2	28	28	28	38	38	38	38
3	56	56	56	89	89	89	89
4	81	81	81	99	99	99	99
5	93	93	93	100	100	100	100
6	98	98	98	100	100	100	100
7+	100	100	100	100	100	100	100

Table 14. 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.1.2 [Method of Thompson and Bell (1934)] 1-Jan-1992

Run Date: 1- 7-1998; Time: 16:46:52.65

GULF OF MAINE COD (5Y) - 1998 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: 10
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
==> C:\ASSESS\GMCOD98\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	.900	.735
2	.0272	1.0000	.3800	1.339	1.091
3	.2305	1.0000	.8900	1.826	1.540
4	.7863	1.0000	.9900	2.734	2.233
5	1.0000	1.0000	1.0000	4.151	3.395
6	1.0000	1.0000	1.0000	6.327	5.155
7	1.0000	1.0000	1.0000	9.031	7.629
8	1.0000	1.0000	1.0000	11.606	10.265
9	1.0000	1.0000	1.0000	13.850	12.701
10+	1.0000	1.0000	1.0000	17.771	17.771

Summary of Yield per Recruit Analysis for:
GULF OF MAINE COD (5Y) - 1998 UPDATED AVE WTS, FPAT AND MAT VECTORS

Slope of the Yield/Recruit Curve at F=0.00: --> 27.4315
F level at slope=1/10 of the above slope (F0.1): -----> .161
Yield/Recruit corresponding to F0.1: -----> 1.7305
F level to produce Maximum Yield/Recruit (Fmax): -----> .287
Yield/Recruit corresponding to Fmax: -----> 1.8591
F level at 20 % of Max Spawning Potential (F20): -----> .407
SSB/Recruit corresponding to F20: --------> 5.7104

Listing of Yield per Recruit Results for:
GULF OF MAINE COD (5Y) - 1998 UPDATED AVE WTS, FPAT AND MAT VECTORS

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.00	.00000	.00000	5.5167	30.9067	3.8396	28.5534	100.00
	.10	.18746	1.45660	4.5839	17.8976	2.9038	15.7285	55.08
F0.1	.16	.25194	1.73046	4.2641	13.9928	2.5822	11.9049	41.69
	.20	.28253	1.80868	4.1127	12.2897	2.4298	10.2435	35.87
Fmax	.29	.33410	1.85915	3.8583	9.6856	2.1729	7.7137	27.01
	.30	.34057	1.85817	3.8265	9.3858	2.1408	7.4234	26.00
	.40	.38006	1.81826	3.6328	7.7003	1.9444	5.7961	20.30
F20%	.41	.38233	1.81429	3.6217	7.6113	1.9332	5.7104	20.00
	.50	.40890	1.75579	3.4920	6.6383	1.8012	4.7755	16.72
	.60	.43106	1.69272	3.3845	5.9253	1.6914	4.0924	14.33
	.70	.44874	1.63582	3.2992	5.4215	1.6039	3.6107	12.65
	.80	.46327	1.58651	3.2295	5.0500	1.5321	3.2558	11.40
	.90	.47548	1.54435	3.1713	4.7662	1.4718	2.9847	10.45
	1.00	.48595	1.50840	3.1216	4.5429	1.4202	2.7713	9.71
	1.10	.49505	1.47765	3.0785	4.3627	1.3753	2.5988	9.10
	1.20	.50308	1.45122	3.0407	4.2140	1.3358	2.4563	8.60
	1.30	.51024	1.42833	3.0072	4.0892	1.3006	2.3365	8.18
	1.40	.51668	1.40838	2.9771	3.9826	1.2690	2.2340	7.82
	1.50	.52253	1.39086	2.9499	3.8904	1.2403	2.1451	7.51
	1.60	.52787	1.37536	2.9252	3.8096	1.2141	2.0671	7.24
	1.70	.53278	1.36157	2.9025	3.7382	1.1900	1.9980	7.00
	1.80	.53732	1.34921	2.8815	3.6744	1.1678	1.9361	6.78
	1.90	.54155	1.33807	2.8621	3.6169	1.1471	1.8803	6.59
	2.00	.54549	1.32797	2.8440	3.5648	1.1278	1.8296	6.41

Table 15. Stochastic stock biomass and catch projections, starting conditions and input data for Gulf of Maine cod, 1998-2000.

Input for Projections:

Number of Years: 3; Initial Year: 1998; Final Year: 2000
Number of Ages : 6; Age at Recruitment: 2; 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;
Original age-specific PRs, Mats, and Mean Wts from file:
==> c:\ASSESS\GMCOD98\PRCODGMA.DAT

Age-specific Input data for Projection # 1

Age	Stock Size in 1998	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
2	428.	.0272	1.0000	.3800	1.563	1.184
3	668.	.2305	1.0000	.8900	2.024	1.755
4	456.	.7863	1.0000	.9900	2.764	2.326
5	586.	1.0000	1.0000	1.0000	3.957	3.268
6	447.	1.0000	1.0000	1.0000	6.524	5.027
7+	61.	1.0000	1.0000	1.0000	11.635	11.635

Projections for 1998-2000; F(98)=0.75, Basis: Status quo 1997 point estimate.
Recruitment (age 2) of the 1997 and 1998 year classes derived by resampling the distribution of empirical recruitment of the 1993-1995 year classes (median=1.34 million).

SSB was estimated to be 8,615 t in 1997.

1998			1999			2000
F	Landings	SSB	F	Landings	SSB	SSB
0.75	3820	6640	F_0 =0.00	0	5980	8150
0.75	3820	6640	$F_{0.1}$ =0.16	820	5840	7090
0.75	3820	6640	F_{max} =0.29	1400	5730	6350
0.75	3820	6640	$F_{20\%}$ =0.41	1890	5630	5760
0.75	3820	6640	F_{SQ} =0.75	3010	5360	4430

GULF OF MAINE COD
TOTAL COMMERCIAL LANDINGS
1893 - 1997

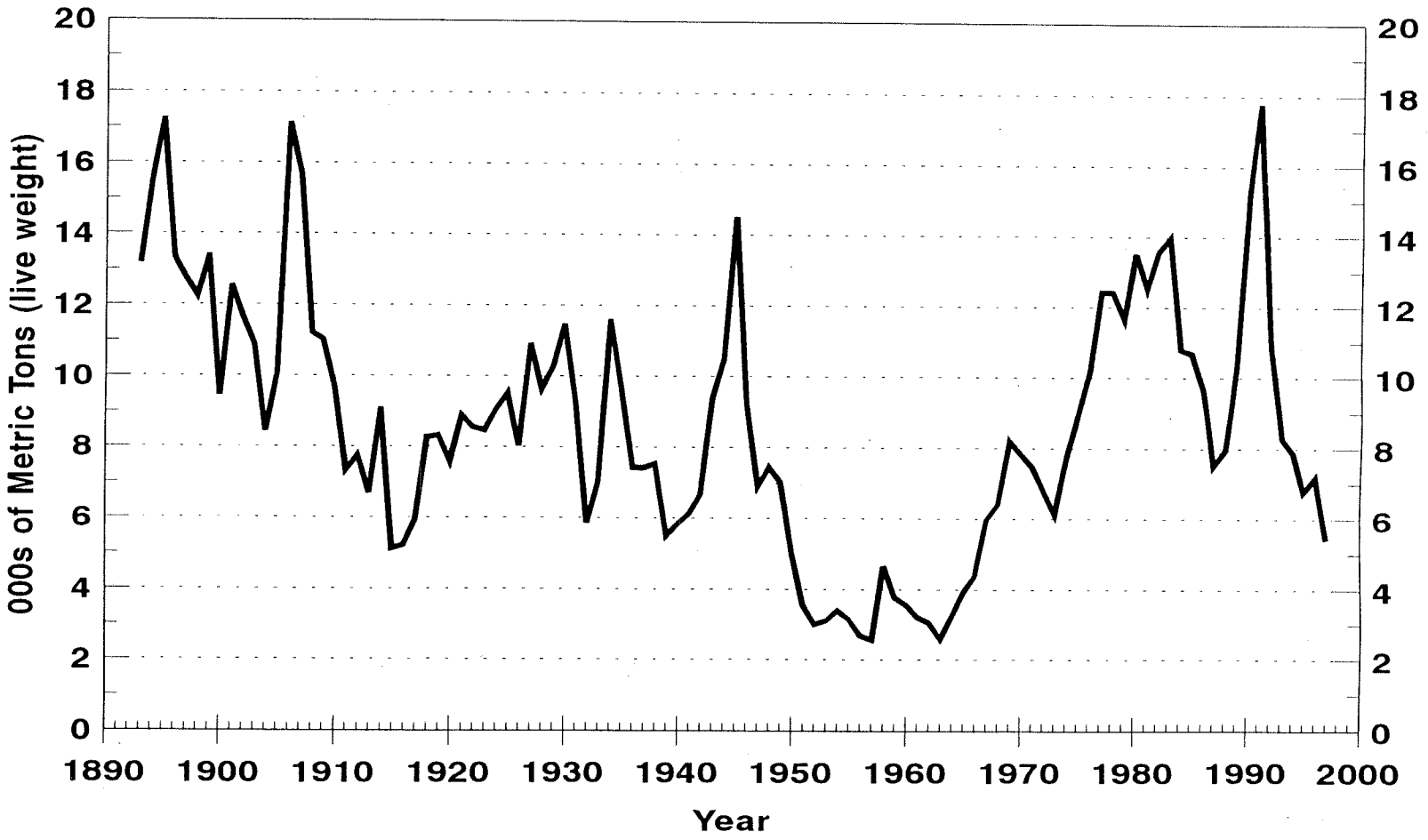


Figure 1. Total commercial landings of Gulf of Maine cod (NAFO Div. 5Y), 1893-1997.

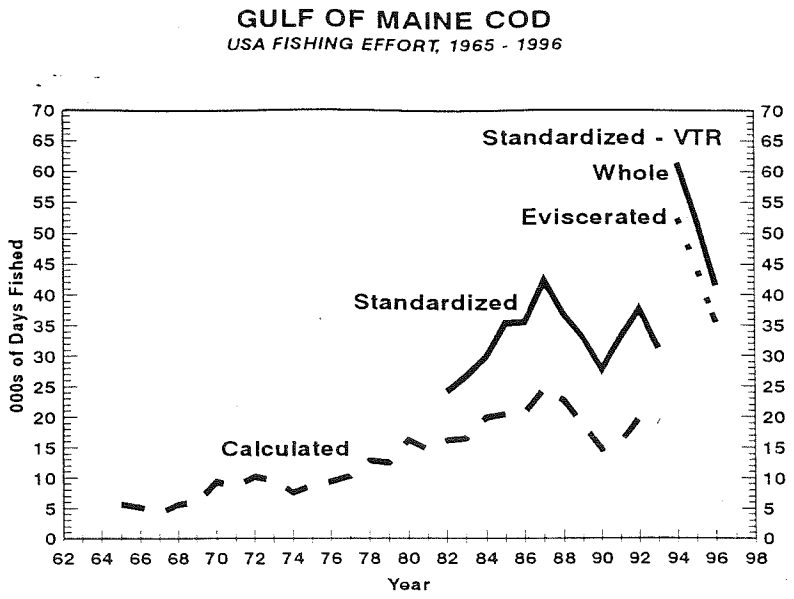


Figure 2. Trends in standardized and 'calculated USA fishing effort (days fished) on Gulf of Maine cod, 1982-1993 and 1994-1996. Calculated effort derived from all otter trawl trips landing cod. Standardized effort series (interviewed) based on GLM incorporating year, tonnage class, area, quarter and depth. Results from 1994-1996 from VTR data assuming portion kept represents either whole or eviscerated weight.

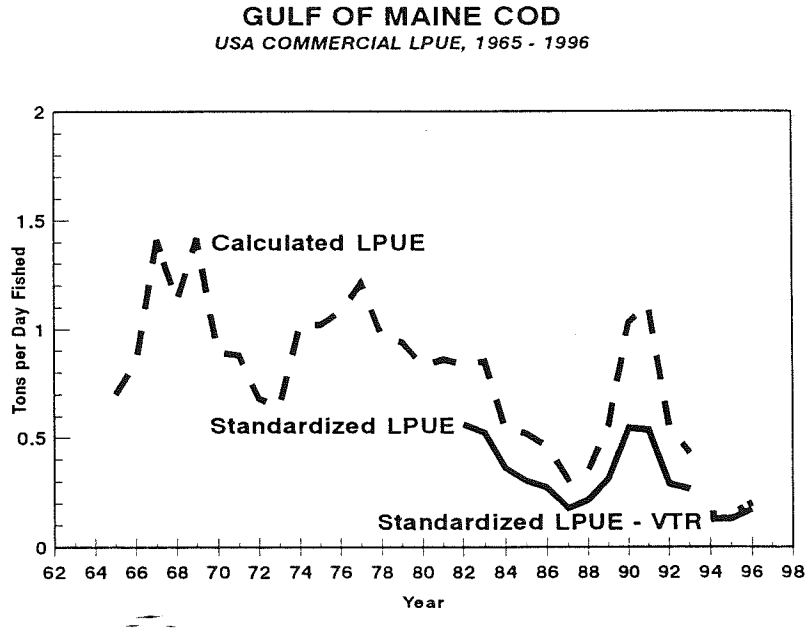


Figure 3. Trends in USA LPUE (landings per day fished) of Gulf of Maine cod. The 1965-1993 indices (dashed line) based on all otter trawl trips landing cod. Standardized LPUE from 1982-1993 (interview data) and 1994-1996 (VTR data) based on GLM incorporating year, tonnage class, area, quarter and depth.

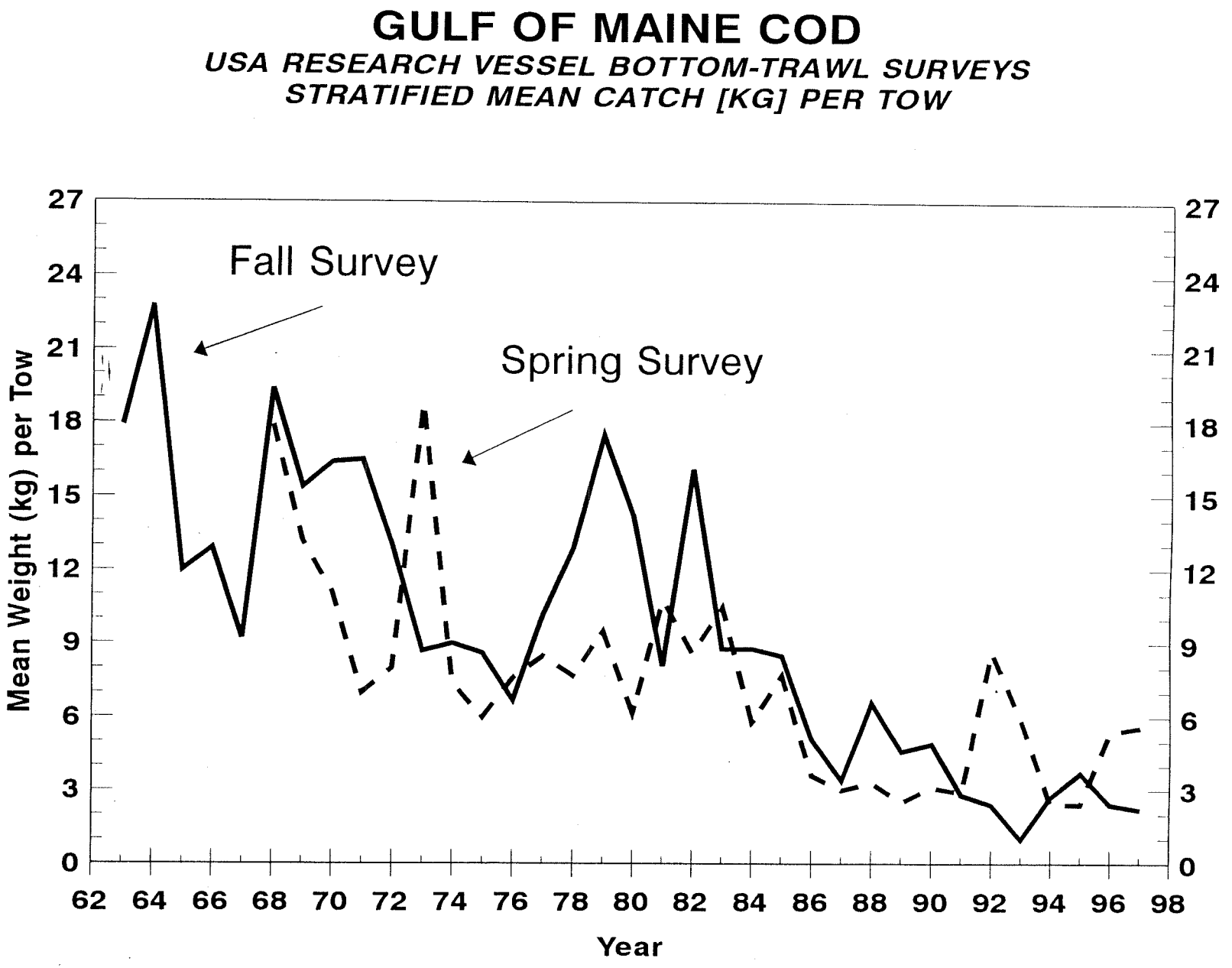


Figure 4. Standardized stratified mean catch (kg) per tow of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys in the Gulf of Maine, 1963-1997.

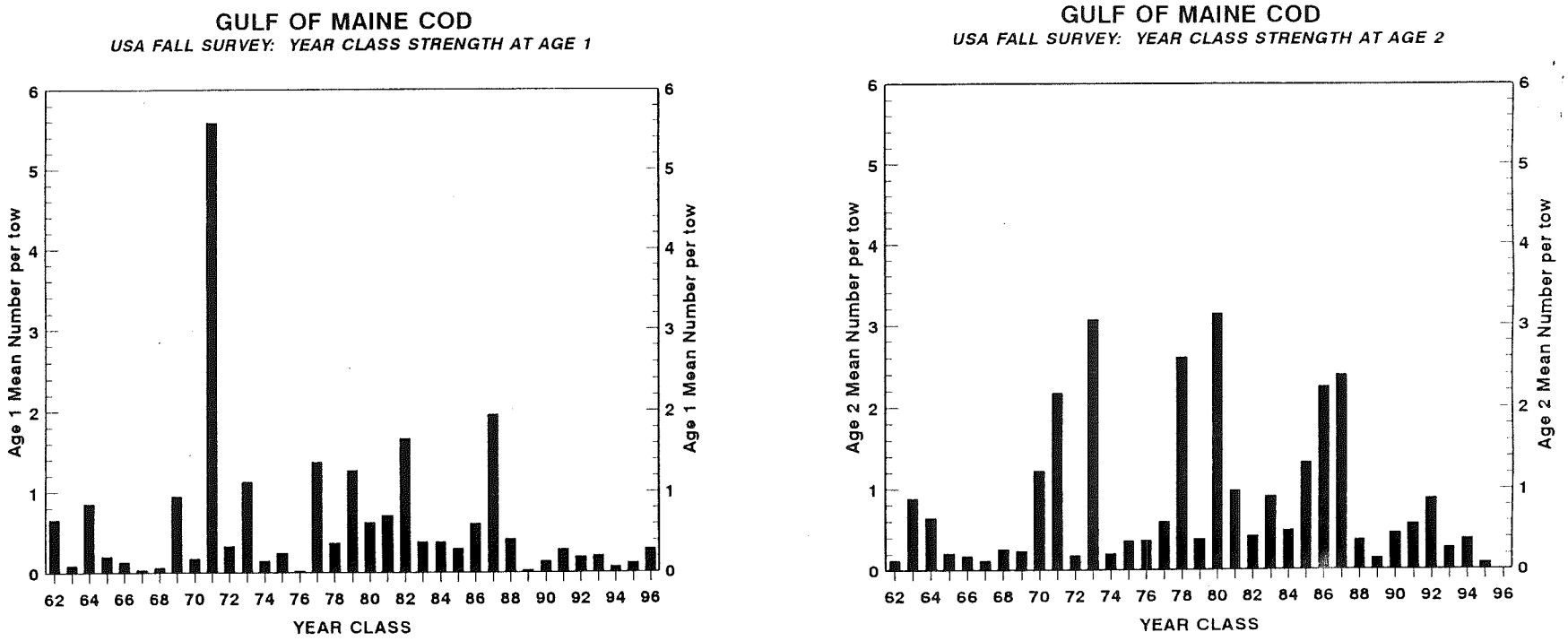


Figure 5. Relative year class strengths of Atlantic cod at age 1 and age 2 based on standardized stratified mean catch (number) per tow indices from NEFSC autumn research vessel bottom trawl surveys in the Gulf of Maine, 1963 - 1997.

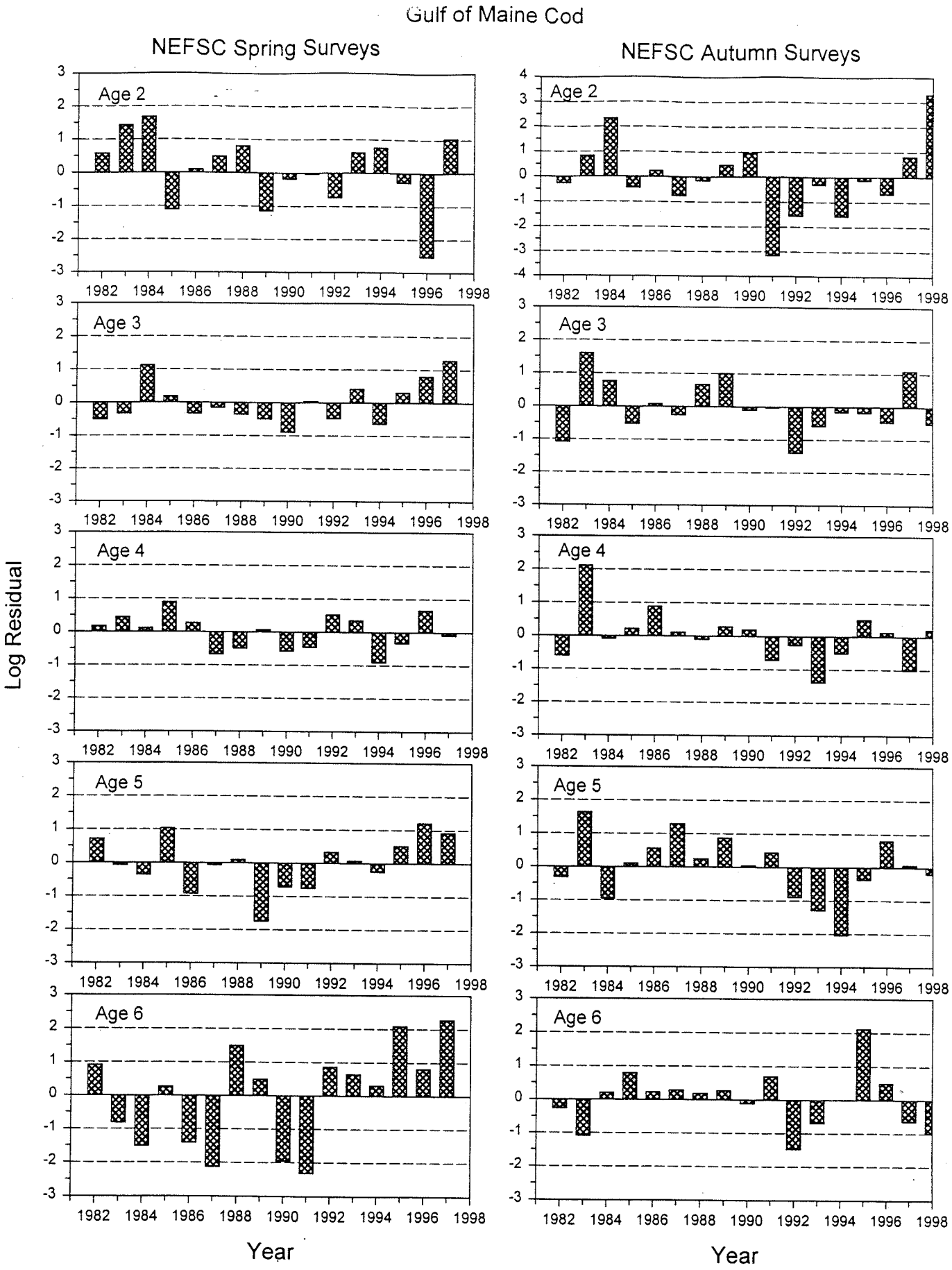


Figure 6. Residual patterns from final VPA formulation for Gulf of Maine Cod.

Gulf of Maine Cod

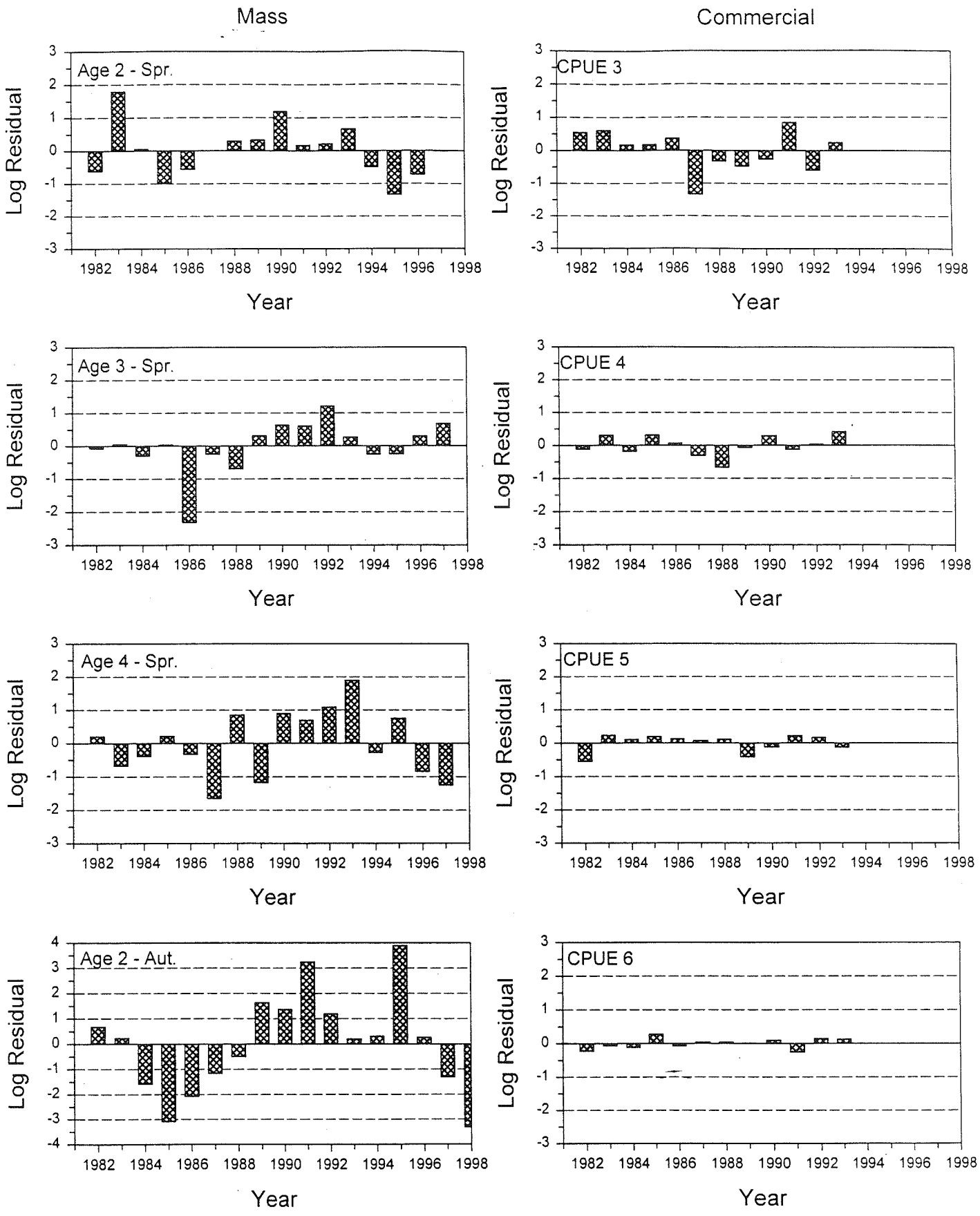


Figure 6. (Continued)

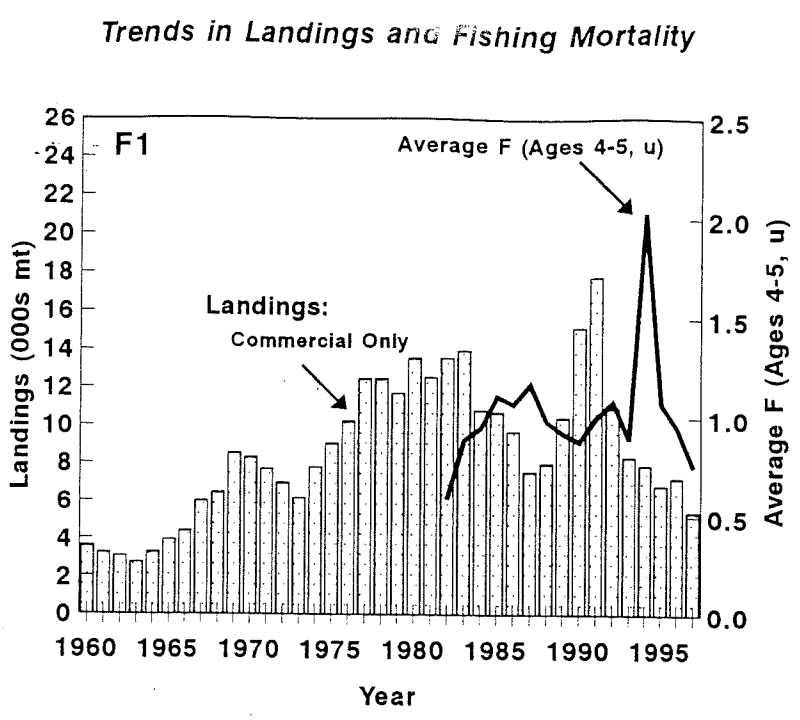


Figure 7. Trends in commercial landings (1960-1997) and fishing mortality (1982-1997) for Gulf of Maine cod.

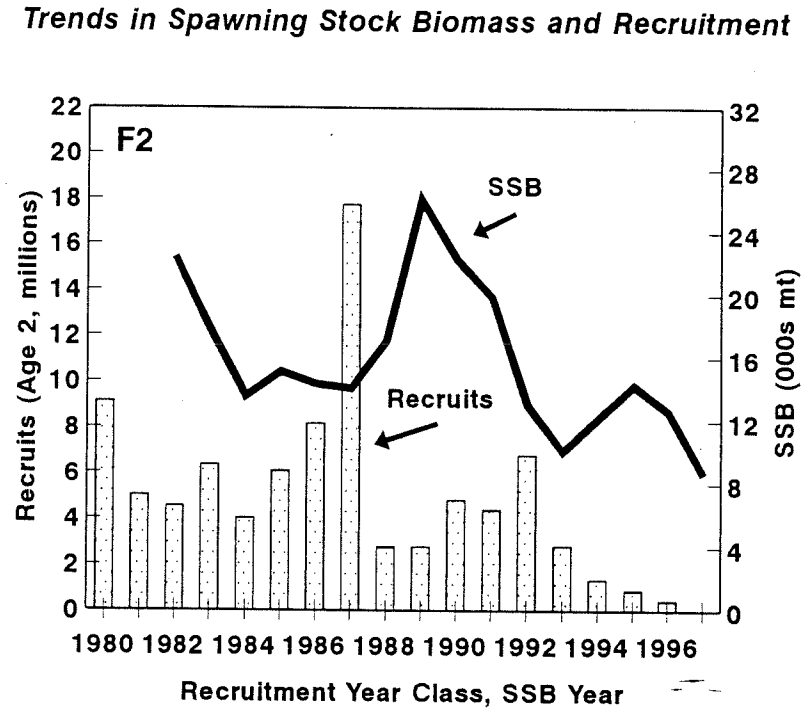


Figure 8. Trends in spawning stock biomass and recruitment for Gulf of Maine cod.

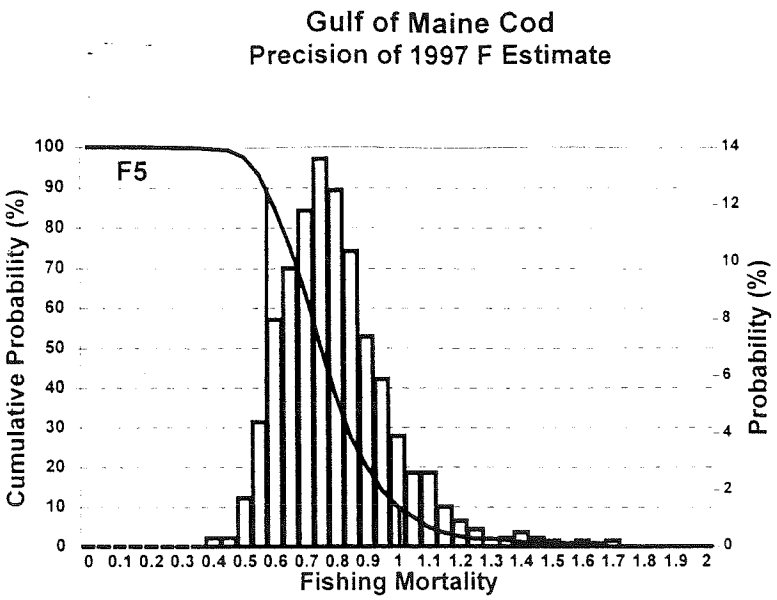


Figure 9. Precision estimates of the instantaneous rate of fishing mortality (F) on the fully recruited ages (ages 4+) in 1997 for Gulf of Maine cod. The vertical bars display both the range of the estimator and the probability of individual values within the range. The solid line gives the probability that F is greater than any selected value on the X-axis. The precision estimates were derived from 1,000 bootstrap replicates of the final ADAPT VPA formulation.

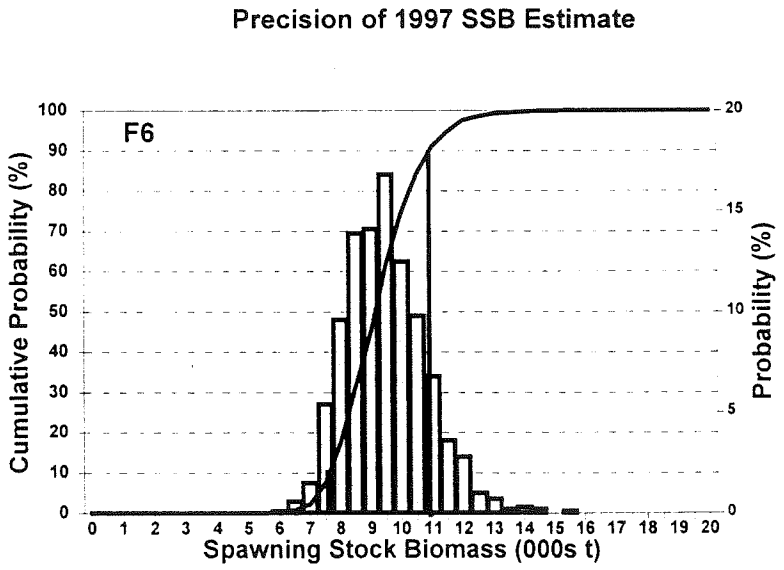


Figure 10. Precision estimates of the instantaneous rate of fishing mortality (F) on the fully recruited ages (ages 4+) in 1997 for Gulf of Maine cod. The vertical bars display both the range of the estimator and the probability of individual values within the range. The solid line gives the probability that F is greater than any selected value on the X-axis. The precision estimates were derived from 1,000 bootstrap replicates of the final ADAPT VPA formulation.

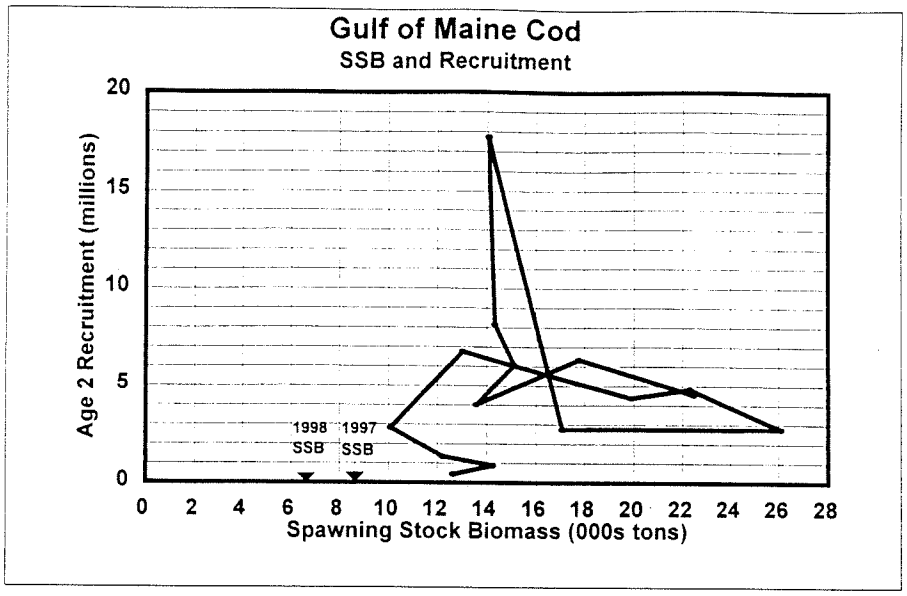


Figure 11. Relationship between spawning stock biomass (000s tons) and recruitment at age 2 (millions of fish) for Gulf of Maine cod as derived from VPA.

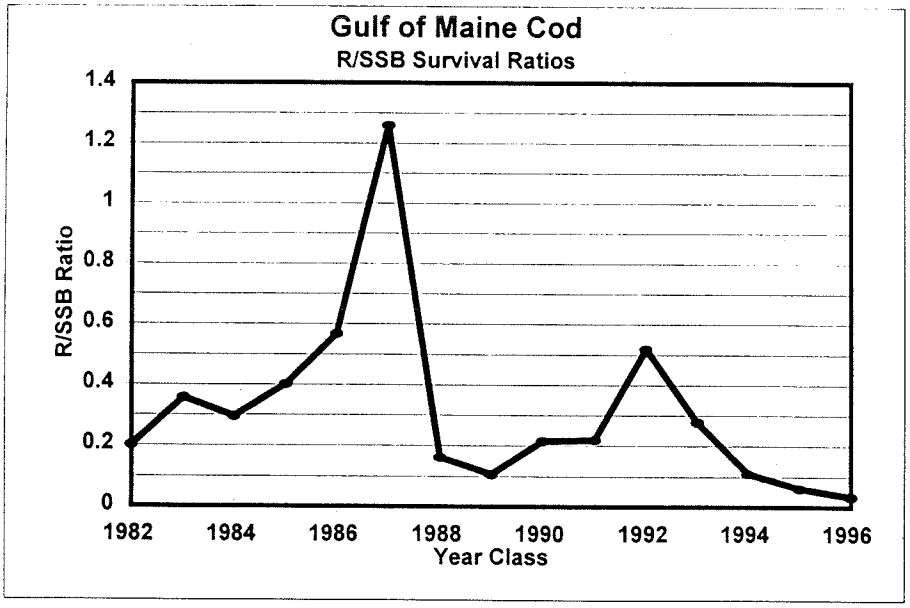


Figure 12. Survival ratios (R/SSB) estimated as the ratio of recruits at age 2 over the spawning stock biomass which produced the recruits. The survival ratios plotted for each year class from 1982 through 1996.

Yield and Spawning Stock Biomass per Recruit

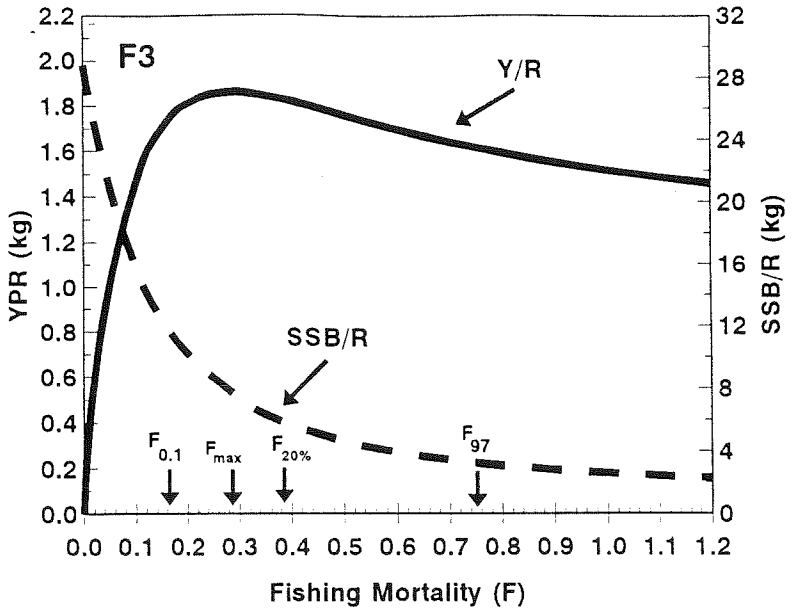


Figure 13. Yield per recruit (Y/R) and spawning stock biomass per recruit (SSB/R) for Gulf of Maine cod.

Short-Term Commercial Landings and Spawning Stock Biomass

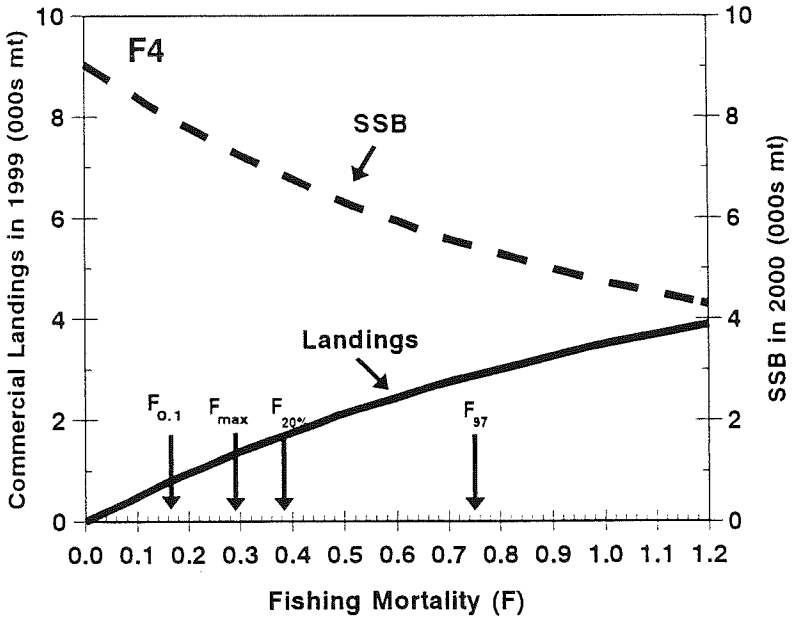


Figure 14. Predicted catches in 1999 and spawning stock biomassin 2000 for Gulf of Maine cod over a range of fishing mortality rates in 1999 from F=0.0 to F=1.2.

Appendix 1. Discard Estimates for Gulf of Maine cod derived from NEFSC Sea Sampling data, 1989-1997.

Table 1. Gulf of Maine cod discard estimates for otter trawl gear.
Figure 1. Gulf of Maine cod discard estimates for otter trawl gear.

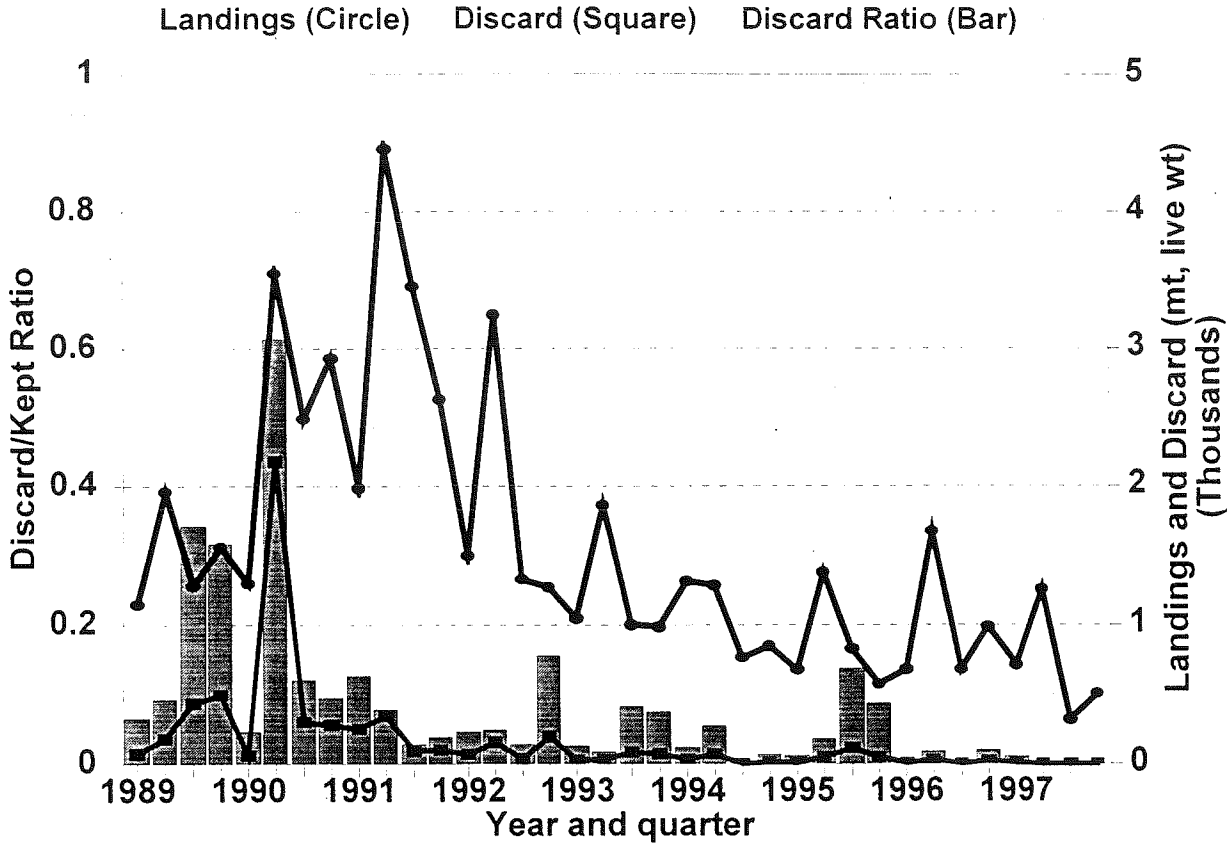
Table 2. Gulf of Maine cod discard estimates for shrimp trawl gear.
Figure 2. Gulf of Maine cod discard estimates for shrimp trawl gear.

Table 3. Gulf of Maine cod discard estimates for sink gillnet gear.
Figure 3. Gulf of Maine cod discard estimates for sink gillnet gear.

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

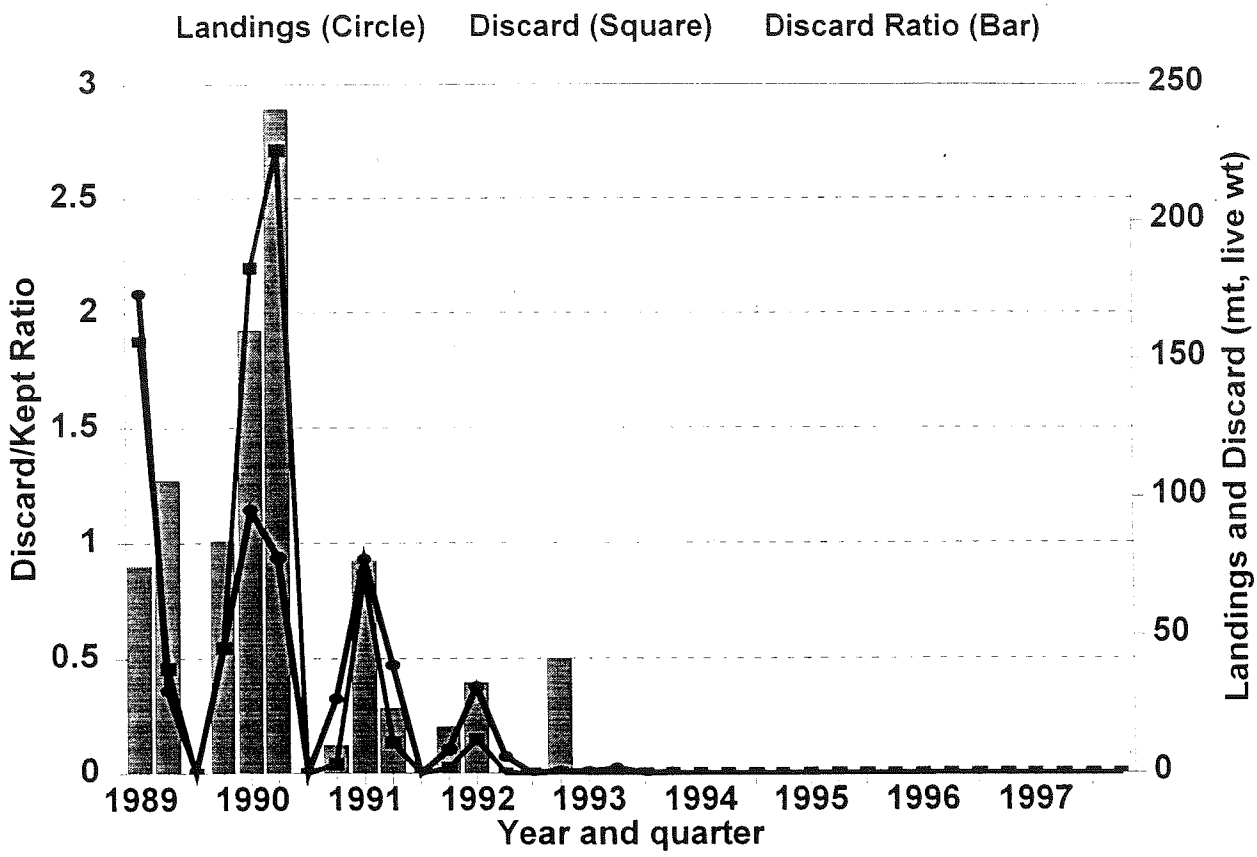
Appendix 1: Figure 1. Gulf of Maine Cod
Gear: Otter Trawl



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			
	2	3	0.000		0.0	0.0			
	3	0			0.0	0.0			
	4	4	0.000		0.0	0.0	0.0	0.0	0.0
1995	1	30	0.000		0.0	0.0			
	2	1	0.000		0.0	0.0			
	3	0			0.0	0.0			
	4	4	0.000		0.0	0.0	0.0	0.0	0.0
1996	1	20	0.000		0.0	0.0			
	2	2	0.000		0.0	0.0			
	3	0			0.0	0.0			
	4	6	0.000		0.0	0.0	0.0	0.0	0.0
1997	1	16	0.000		0.0	0.0			
	2	0			0.0	0.0			
	3	0			0.0	0.0			
	4				0.0	0.0	0.0	0.0	0.0

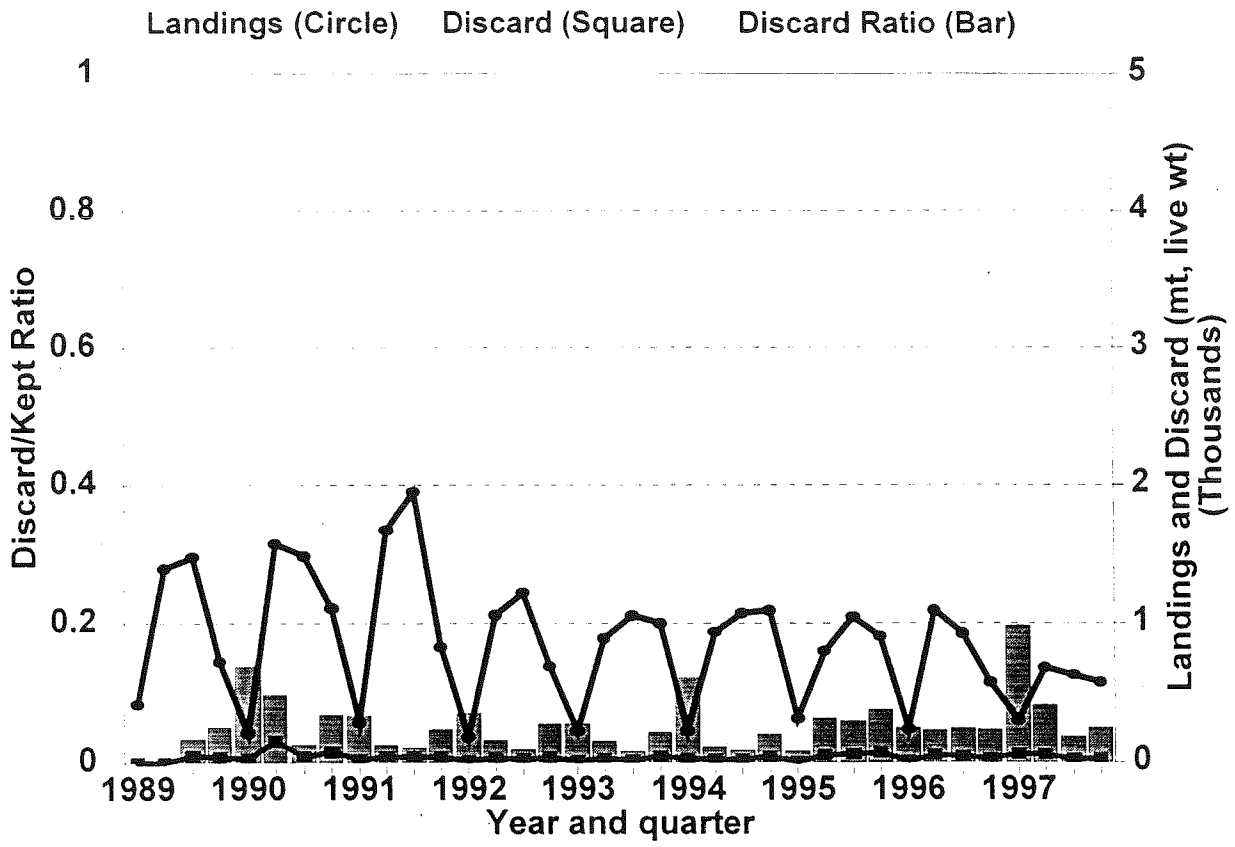
Appendix 1: Figure 2. Gulf of Maine Cod
Gear: Shrimp Trawl



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

				Quarterly Totals Gear=100			Annual Totals Gear=100		
Year	Quarter	Num Sets	D/K Ratio	Landings	DIscard	Catch	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	44	0.082	677.0	55.5	732.5			
	3	46	0.037	624.0	23.1	647.1			
	4	5	0.050	574.0	28.7	602.7	2176.0	166.3	2342.3

Appendix 1: Figure 3. Gulf of Maine Cod
Gear: Sink Gill Net



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 - 1997.

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, 1963-1997.

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 - 1997.

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 - 1997. [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 [c]																		
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	3.0
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	3.3
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	3.7
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.
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.
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.
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.
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.
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.
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

[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.

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

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																		
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	3.43
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	6.6
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	6.8
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	7.3
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	4.1
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	2.4
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	1.5
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

[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, 1963-1997. [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
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	7.66
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	3.66
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	3.03
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	3.33
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	2.55
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	2.88
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	8.42
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	5.55
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	2.30
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	2.10
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	5.12
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	5.47

[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.

[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	1.8

[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 - 1997. [a]

Year	Age Group 0	1	2	3	4	5	6	7	8	9	10+	Totals 0+	1+	2+	3+	Stratified Mean Weight (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	6.40	1.29	0.97	2.11	0.81	0.36	0.00	0.00	0.00	0.00	0.00	11.96	5.56	4.27	3.30	4.06
1997	10.40	3.66	1.00	1.34	0.20	0.42	0.00	0.00	0.00	0.00	0.00	17.09	6.69	3.03	2.03	2.97
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

[a] Massachusetts sampling strata 25-36.

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

Estimates of 1998 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.

Woods Hole Assessment Toolbox GoM Cod 1998 Base Run Run Number 11 6/29/98 10:21:10 AM
GoM Cod 1998 Base Run 1982 - 1998
Input Parameters and Options Selected

Natural mortality is 0.2
Oldest age (not in the plus group) is 6
For all years prior to the terminal year (1997), 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

Stock size of the 7 + group is then calculated using
the following method: CATCH EQUATION
Partial recruitment estimate for 1998

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 not used
Biomass estimates (other than SSB) reflect mean stock sizes.
SSB calculated as in the NEFSC projection program
(see note below SSB table for description of the algorithm).
Initial estimates of parameters for the Marquardt algorithm
and lower and upper bounds on the parameter estimates:

Par.	Initial Est	Lower Bnd	Upper Bnd
N 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 WHSpr 2	1.00E-02	0.00E+00	1.00E+00
q WHSpr 3	1.00E-02	0.00E+00	1.00E+00
q WHSpr 4	1.00E-02	0.00E+00	1.00E+00
q WHSpr 5	1.00E-02	0.00E+00	1.00E+00
q WHSpr 6	1.00E-02	0.00E+00	1.00E+00
q WHAut 2	1.00E-02	0.00E+00	1.00E+00
q WHAut 3	1.00E-02	0.00E+00	1.00E+00
q WHAut 4	1.00E-02	0.00E+00	1.00E+00
q WHAut 5	1.00E-02	0.00E+00	1.00E+00
q WHAut 6	1.00E-02	0.00E+00	1.00E+00
q MASpr 2	1.00E-02	0.00E+00	1.00E+00
q MASpr 3	1.00E-02	0.00E+00	1.00E+00
q MASpr 4	1.00E-02	0.00E+00	1.00E+00
q MAAut 2	1.00E-02	0.00E+00	1.00E+00
q CM_CPE 3	1.00E-02	0.00E+00	1.00E+00
q CM_CPE 4	1.00E-02	0.00E+00	1.00E+00
q CM_CPE 5	1.00E-02	0.00E+00	1.00E+00
q CM_CPE 6	1.00E-02	0.00E+00	1.00E+00

The following indices of abundance are available

1	WHSpr 2
2	WHSpr 3
3	WHSpr 4
4	WHSpr 5
5	WHSpr 6
6	WHAut 2
7	WHAut 3
8	WHAut 4
9	WHAut 5
10	WHAut 6
11	MASpr 2
12	MASpr 3
13	MASpr 4
14	MAAut 1
15	MAAut 2
16	MAAut 3
17	CM_CPE 2
18	CM_CPE 3
19	CM_CPE 4
20	CM_CPE 5
21	CM_CPE 6

The Indices that will be used in this run are:

WHSpr 2
WHSpr 3
WHSpr 4
WHSpr 5
WHSpr 6
WHAut 2
WHAut 3
WHAut 4
WHAut 5
WHAut 6
MASpr 2
MASpr 3
MASpr 4
MAAut 2
CM_CPE 3
CM_CPE 4
CM_CPE 5
CM_CPE 6

Obs Indices (before transformation) by index and year; with Index means

	1982	1983	1984	1985	1986	1987	1988
WHSpr 2	1.02	0.98	1.03	0.24	0.33	0.64	1.05
WHSpr 3	0.52	0.83	1.15	0.62	0.65	0.49	0.63
WHSpr 4	0.69	0.64	0.74	0.67	0.39	0.30	0.36
WHSpr 5	0.86	0.36	0.19	0.68	0.07	0.13	0.22
WHSpr 6	0.12	0.18	0.05	0.10	0.05	0.01	0.09
WHAut 2	0.62	0.70	1.66	0.38	0.38	0.30	0.60
WHAut 3	0.38	3.14	0.98	0.42	0.91	0.49	1.32
WHAut 4	0.55	2.47	0.85	0.57	0.76	0.65	0.60
WHAut 5	0.47	1.17	0.14	0.40	0.21	0.33	0.26
WHAut 6	0.09	0.25	0.26	0.22	0.22	0.09	0.06
MASpr 2	7.06	18.57	5.41	3.82	3.22	7.00	11.36
MASpr 3	3.42	5.33	2.27	2.79	0.89	2.27	2.51
MASpr 4	1.15	0.50	0.87	0.69	0.43	0.26	1.37
MAAut 2	5.65	2.35	0.65	0.34	0.42	1.15	2.39
CM_CPE 3	0.07	0.11	0.04	0.04	0.07	0.02	0.05
CM_CPE 4	0.05	0.04	0.04	0.03	0.02	0.03	0.02
CM_CPE 5	0.02	0.02	0.01	0.02	0.01	0.01	0.01
CM_CPE 6	0.00	0.01	0.01	0.00	0.00	0.00	0.00

	1989	1990	1991	1992	1993	1994	1995
WHSpr 2	0.65	0.19	0.21	0.23	0.50	0.32	0.18
WHSpr 3	0.79	1.33	0.36	0.24	0.80	0.39	1.12
WHSpr 4	0.63	0.63	1.48	0.28	0.33	0.21	0.37
WHSpr 5	0.09	0.17	0.27	1.31	0.09	0.10	0.15
WHSpr 6	0.08	0.03	0.02	0.22	0.48	0.05	0.03
WHAut 2	1.95	0.42	0.03	0.14	0.29	0.20	0.21
WHAut 3	2.25	2.39	0.37	0.14	0.45	0.57	0.88
WHAut 4	0.96	1.36	1.64	0.22	0.14	0.36	0.83
WHAut 5	0.53	0.29	0.62	0.63	0.04	0.03	0.09
WHAut 6	0.11	0.17	0.28	0.08	0.33	0.00	0.05
MASpr 2	25.26	6.89	3.56	6.35	7.76	5.67	1.36
MASpr 3	6.58	17.77	2.54	3.58	3.60	2.46	3.89
MASpr 4	0.46	2.64	5.03	0.65	1.45	0.52	1.20
MAAut 2	20.49	2.70	9.13	4.20	2.01	3.32	14.13
CM_CPE 3	0.06	0.16	0.04	0.02	0.05	0.00	0.00
CM_CPE 4	0.04	0.08	0.14	0.01	0.02	0.00	0.00
CM_CPE 5	0.01	0.01	0.02	0.05	0.00	0.00	0.00
CM_CPE 6	0.00	0.01	0.00	0.01	0.01	0.00	0.00

	1996	1997	1998	Average
WHSpr 2	0.02	0.13	0.00	0.482
WHSpr 3	0.59	0.40	0.00	0.681
WHSpr 4	1.33	0.26	0.00	0.582
WHSpr 5	0.40	0.88	0.00	0.372
WHSpr 6	0.06	0.24	0.00	0.113
WHAut 2	0.07	0.12	0.30	0.492
WHAut 3	0.28	0.38	0.09	0.908
WHAut 4	1.23	0.19	0.16	0.797
WHAut 5	0.33	0.54	0.18	0.369
WHAut 6	0.08	0.06	0.15	0.156
MASpr 2	0.97	1.00	0.00	7.204
MASpr 3	2.11	1.34	0.00	3.959
MASpr 4	0.81	0.20	0.00	1.139
MAAut 2	0.64	0.15	0.02	4.102
CM_CPE 3	0.00	0.00	0.00	0.062
CM_CPE 4	0.00	0.00	0.00	0.044
CM_CPE 5	0.00	0.00	0.00	0.016
CM_CPE 6	0.00	0.00	0.00	0.005

Catch at age (thousands) - C:\ASSESS\Whatzip\gmcod\Gmcod98.12

	1982	1983	1984	1985	1986	1987	1988
1	30	00	04	00	00	02	00
2	1380	866	446	407	84	216	160
3	1633	2357	1240	1445	2164	595	1443
4	1143	1058	1500	991	813	1109	953
5	633	638	437	630	250	277	406
6	69	422	194	128	177	66	43
7	230	155	136	136	95	79	30
1+	5118	5496	3957	3737	3583	2344	3035

	1989	1990	1991	1992	1993	1994	1995
1	00	00	00	00	00	00	00
2	337	205	344	313	76	29	218
3	1583	3425	934	530	1487	1016	880
4	1454	2064	4161	484	641	1135	1153
5	449	430	851	2018	129	288	194
6	81	157	143	202	457	72	12
7	56	99	79	84	36	86	34
1+	3960	6380	6512	3631	2826	2626	2491

	1996	1997
1	00	00
2	65	53
3	584	438
4	1738	435
5	347	832
6	45	68
7	10	08
1+	2789	1834

CAA Summary for ages 4 - 7

1982	1983	1984	1985	1986	1987	1988
2075	2273	2267	1885	1335	1531	1432

1989	1990	1991	1992	1993	1994	1995
2040	2750	5234	2788	1263	1581	1393

1996	1997
2140	1343

Weight at age (mid year) in kg - C:\ASSESS\Whatzip\gmcod\Gmcod98.12

	1982	1983	1984	1985	1986	1987	1988
1	0.900	0.900	0.900	0.900	0.900	0.900	0.900
2	1.156	1.164	1.159	1.260	1.304	1.313	1.268
3	1.664	1.660	1.670	1.746	1.837	1.684	1.881
4	2.764	2.475	2.721	2.840	2.923	3.283	2.426
5	4.770	3.778	3.677	4.466	4.619	4.831	5.166
6	6.739	5.962	5.898	5.525	6.067	6.824	6.767
7	11.330	9.755	10.176	9.721	10.295	10.241	11.233

	1989	1990	1991	1992	1993	1994	1995
1	0.900	0.900	0.900	0.900	0.900	0.900	0.900
2	1.247	1.071	1.130	1.533	1.293	1.450	1.652
3	1.776	1.692	1.568	1.922	1.889	1.943	1.921
4	2.993	2.271	2.512	2.714	2.513	3.151	2.775
5	3.864	4.265	4.136	3.061	4.356	3.444	5.142
6	4.872	7.645	7.309	5.000	6.174	6.132	8.290
7	12.200	13.747	11.449	10.614	11.063	10.018	12.969

	1996	1997
1	0.900	0.900
2	1.687	1.733
3	2.136	2.233
4	2.376	3.007
5	3.648	3.193
6	7.376	4.649
7	11.647	12.479

Biomass Weights - C:\ASSESS\Whatzip\gmcod\Gmcod98.12

	1982	1983	1984	1985	1986	1987	1988
1	0.791	0.793	0.761	0.748	0.745	0.758	0.765
2	0.965	1.024	1.021	1.065	1.083	1.087	1.068
3	1.364	1.385	1.394	1.423	1.521	1.482	1.572
4	2.364	2.029	2.125	2.178	2.259	2.456	2.021
5	4.267	3.231	3.017	3.486	3.622	3.758	4.118
6	5.670	5.333	4.720	4.507	5.205	5.614	5.718
7	11.330	9.755	10.176	9.721	10.295	10.241	11.233

	1989	1990	1991	1992	1993	1994	1995
1	0.825	0.803	0.690	0.751	0.709	0.664	0.657
2	1.059	0.982	1.008	1.175	1.079	1.142	1.219
3	1.501	1.453	1.296	1.474	1.702	1.585	1.669
4	2.373	2.008	2.062	2.063	2.198	2.440	2.322
5	3.062	3.573	3.065	2.773	3.438	2.942	4.025
6	5.017	5.435	5.583	4.548	4.347	5.168	5.343
7	12.200	13.747	11.449	10.614	11.063	10.018	12.969

	1996	1997
1	0.649	0.649
2	1.232	1.249
3	1.878	1.941
4	2.136	2.534
5	3.182	2.754
6	6.159	4.118
7	11.647	12.479

SSB Weights - C:\ASSESS\Whatzip\gmcod\Gmcod98.12

	1982	1983	1984	1985	1986	1987	1988
1	0.791	0.793	0.761	0.748	0.745	0.758	0.765
2	0.965	1.024	1.021	1.065	1.083	1.087	1.068
3	1.364	1.385	1.394	1.423	1.521	1.482	1.572
4	2.364	2.029	2.125	2.178	2.259	2.456	2.021
5	4.267	3.231	3.017	3.486	3.622	3.758	4.118
6	5.670	5.333	4.720	4.507	5.205	5.614	5.718
7	11.330	9.755	10.176	9.721	10.295	10.241	11.233

	1989	1990	1991	1992	1993	1994	1995
1	0.825	0.803	0.690	0.751	0.709	0.664	0.657
2	1.059	0.982	1.008	1.175	1.079	1.142	1.219
3	1.501	1.453	1.296	1.474	1.702	1.585	1.669
4	2.373	2.008	2.062	2.063	2.198	2.440	2.322
5	3.062	3.573	3.065	2.773	3.438	2.942	4.025
6	5.017	5.435	5.583	4.548	4.347	5.168	5.343
7	12.200	13.747	11.449	10.614	11.063	10.018	12.969

	1996	1997
1	0.649	0.649
2	1.232	1.249
3	1.878	1.941
4	2.136	2.534
5	3.182	2.754
6	6.159	4.118
7	11.647	12.479

Complete Jan 1 Weights - C:\ASSESS\Whatzip\gmcod\Gmcod98.12

	1982	1983	1984	1985	1986	1987	1988
1	0.791	0.793	0.761	0.748	0.745	0.758	0.765
2	0.965	1.024	1.021	1.065	1.083	1.087	1.068
3	1.364	1.385	1.394	1.423	1.521	1.482	1.572
4	2.364	2.029	2.125	2.178	2.259	2.456	2.021
5	4.267	3.231	3.017	3.486	3.622	3.758	4.118
6	5.670	5.333	4.720	4.507	5.205	5.614	5.718
7	11.330	9.755	10.176	9.721	10.295	10.241	11.233

	1989	1990	1991	1992	1993	1994	1995
1	0.825	0.803	0.690	0.751	0.709	0.664	0.657
2	1.059	0.982	1.008	1.175	1.079	1.142	1.219
3	1.501	1.453	1.296	1.474	1.702	1.585	1.669
4	2.373	2.008	2.062	2.063	2.198	2.440	2.322
5	3.062	3.573	3.065	2.773	3.438	2.942	4.025
6	5.017	5.435	5.583	4.548	4.347	5.168	5.343
7	12.200	13.747	11.449	10.614	11.063	10.018	12.969

	1996	1997	1998
1	0.649	0.649	0.733
2	1.232	1.249	1.249
3	1.878	1.941	2.405
4	2.136	2.534	2.569
5	3.182	2.754	3.568
6	6.159	4.118	3.701
7	11.647	12.479	12.479

Percent Mature (females)- C:\ASSESS\Whatzip\gmcod\Gmcod98.12

	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
1	04	04
2	38	38
3	89	89
4	99	99
5	100	100
6	100	100
7	100	100

Sex Ratio (Percent Female) - C:\ASSESS\Whatzip\gmcod\Gmcod98.12

	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
1	0.5	0.5
2	0.5	0.5
3	0.5	0.5
4	0.5	0.5
5	0.5	0.5
6	0.5	0.5
7	0.5	0.5

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pF is 0.1667
pM is 0.1667

```
Residual Sum of Squares from Marquardt Algorithm
Number  1
RSS            3185.77107695341
Lambda        1.00E-02

Number  2
RSS            2459.77896612456
Lambda        1.00E-03

Number  3
RSS            1928.56171031362
Lambda        1.00E-01

Number  4
RSS            1563.46680105437
Lambda        1.00E-02

Number  5
RSS            1404.18448676987
Lambda        1.00E+00

Number  6
RSS            1118.83917632579
Lambda        1.00E-01

Number  7
RSS            1011.44484033882
Lambda        1.00E+01

Number  8
RSS             823.959795855405
Lambda        1.00E+00

Number  9
RSS             749.673700051719
Lambda        1.00E+02

Number  10
RSS             622.455181422881
Lambda        1.00E+01

Number  11
RSS             131.484237711332
Lambda        1.00E+00

Number  12
RSS             109.177603385249
Lambda        1.00E+02

Number  13
RSS             107.15734642242
Lambda        1.00E+01

Number  14
RSS             107.051424839737
Lambda        1.00E+00

Number  15
RSS             107.045147955526
Lambda        1.00E+02

Number  16
RSS             107.044891475974
Lambda        1.00E+01

Number  17
RSS             107.044885373016
Lambda        1.00E+00

RESULTS
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Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 107.044885373016
Mean Square Residuals: 0.42144

	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 2	4.28E+02	2.04E+02	2.10E+00	0.48
N 3	6.68E+02	2.13E+02	3.14E+00	0.32
N 4	4.56E+02	1.81E+02	2.52E+00	0.40
N 5	5.86E+02	2.20E+02	2.67E+00	0.38
N 6	4.47E+02	2.33E+02	1.92E+00	0.52
q WHSpr 2	1.59E-04	2.63E-05	6.05E+00	0.17
q WHSpr 3	2.45E-04	4.01E-05	6.09E+00	0.16
q WHSpr 4	4.00E-04	6.56E-05	6.10E+00	0.16
q WHSpr 5	8.79E-04	1.44E-04	6.10E+00	0.16
q WHSpr 6	3.46E-03	5.67E-04	6.10E+00	0.16
q WHAut 2	1.64E-04	2.67E-05	6.14E+00	0.16
q WHAut 3	1.97E-04	3.16E-05	6.24E+00	0.16
q WHAut 4	3.83E-04	6.16E-05	6.22E+00	0.16
q WHAut 5	9.53E-04	1.53E-04	6.22E+00	0.16
q WHAut 6	4.09E-03	6.96E-04	5.87E+00	0.17
q MASpr 2	1.60E-04	2.64E-05	6.05E+00	0.17
q MASpr 3	2.09E-04	3.42E-05	6.09E+00	0.16
q MASpr 4	3.31E-04	5.42E-05	6.10E+00	0.16
q MAAut 2	9.79E-05	1.59E-05	6.14E+00	0.16
q CM_CPE 3	2.75E-04	5.18E-05	5.31E+00	0.19
q CM_CPE 4	6.16E-04	1.16E-04	5.31E+00	0.19
q CM_CPE 5	1.64E-03	3.08E-04	5.31E+00	0.19
q CM_CPE 6	5.20E-03	9.80E-04	5.31E+00	0.19

Catchability Estimates in Original Units

	Estimate	Std.Err.	C.V.
q WHSpr 2	7.67E-05	1.27E-05	0.17
q WHSpr 3	1.66E-04	2.73E-05	0.16
q WHSpr 4	2.33E-04	3.82E-05	0.16
q WHSpr 5	3.27E-04	5.37E-05	0.16
q WHSpr 6	3.89E-04	6.39E-05	0.16
q WHAut 2	8.08E-05	1.31E-05	0.16
q WHAut 3	1.79E-04	2.87E-05	0.16
q WHAut 4	3.05E-04	4.91E-05	0.16
q WHAut 5	3.52E-04	5.65E-05	0.16
q WHAut 6	6.38E-04	1.09E-04	0.17
q MASpr 2	1.15E-03	1.90E-04	0.17
q MASpr 3	8.26E-04	1.36E-04	0.16
q MASpr 4	3.77E-04	6.17E-05	0.16
q MAAut 2	4.02E-04	6.54E-05	0.16
q CM_CPE 3	1.69E-05	3.19E-06	0.19
q CM_CPE 4	2.69E-05	5.06E-06	0.19
q CM_CPE 5	2.65E-05	4.98E-06	0.19
q CM_CPE 6	2.69E-05	5.07E-06	0.19

Summary of Residuals

WHSpr
Tuned to: 1-Jan
For ages: 2

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	1.019	1.450	0.748	0.371	1	0.377	0.581	9108
1983	0.978	0.799	0.707	-0.225	1	0.932	1.436	5018
1984	1.033	0.721	0.762	-0.327	1	1.089	1.677	4530
1985	0.238	1.009	-0.706	0.009	1	-0.715	-1.101	6339
1986	0.330	0.640	-0.379	-0.446	1	0.067	0.103	4023
1987	0.638	0.966	0.280	-0.035	1	0.315	0.485	6067
1988	1.053	1.297	0.781	0.260	1	0.521	0.803	8148
1989	0.649	2.821	0.297	1.037	1	-0.740	-1.140	17724
1990	0.190	0.440	-0.931	-0.821	1	-0.110	-0.170	2764
1991	0.209	0.442	-0.836	-0.817	1	-0.019	-0.030	2777
1992	0.230	0.767	-0.740	-0.266	1	-0.475	-0.731	4817
1993	0.500	0.696	0.036	-0.363	1	0.399	0.614	4372
1994	0.316	1.075	-0.423	0.073	1	-0.495	-0.763	6756
1995	0.180	0.448	-0.985	-0.803	1	-0.182	-0.280	2813
1996	0.020	0.214	-3.183	-1.542	1	-1.640	-2.526	1344
1997	0.132	0.139	-1.296	-1.973	1	0.677	1.043	874
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.506

WHSpr
Tuned to: 1-Jan
For ages: 3

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.516	1.058	-0.277	0.057	1	-0.334	-0.514	4328
1983	0.833	1.518	0.202	0.417	1	-0.216	-0.332	6208
1984	1.147	0.813	0.522	-0.207	1	0.729	1.123	3325
1985	0.622	0.808	-0.090	-0.213	1	0.123	0.189	3306
1986	0.647	1.179	-0.051	0.165	1	-0.215	-0.332	4821
1987	0.486	0.787	-0.337	-0.240	1	-0.097	-0.150	3218
1988	0.633	1.167	-0.073	0.154	1	-0.227	-0.350	4772
1989	0.790	1.596	0.149	0.467	1	-0.319	-0.491	6526
1990	1.327	3.474	0.667	1.245	1	-0.578	-0.890	14206
1991	0.355	0.508	-0.651	-0.677	1	0.026	0.041	2077
1992	0.240	0.480	-1.043	-0.734	1	-0.308	-0.475	1962
1993	0.800	0.895	0.161	-0.111	1	0.272	0.419	3661
1994	0.387	0.858	-0.565	-0.153	1	-0.412	-0.635	3511
1995	1.120	1.346	0.498	0.297	1	0.201	0.309	5505
1996	0.590	0.515	-0.143	-0.664	1	0.521	0.802	2106
1997	0.399	0.255	-0.534	-1.368	1	0.834	1.284	1041
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.176

WHSpr
Tuned to: 1-Jan
For ages: 4

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.694	1.067	0.177	0.065	1	0.112	0.172	2666
1983	0.641	0.827	0.097	-0.190	1	0.287	0.442	2066
1984	0.741	1.181	0.242	0.166	1	0.076	0.117	2950
1985	0.665	0.640	0.134	-0.446	1	0.580	0.893	1600
1986	0.387	0.560	-0.407	-0.580	1	0.173	0.266	1399
1987	0.300	0.796	-0.662	-0.228	1	-0.434	-0.669	1989
1988	0.355	0.839	-0.494	-0.176	1	-0.318	-0.490	2096
1989	0.632	1.041	0.083	0.040	1	0.043	0.066	2601
1990	0.627	1.565	0.075	0.448	1	-0.373	-0.574	3911
1991	1.477	3.415	0.932	1.228	1	-0.296	-0.456	8532
1992	0.280	0.342	-0.731	-1.072	1	0.341	0.525	856
1993	0.330	0.451	-0.567	-0.796	1	0.230	0.354	1127
1994	0.213	0.661	-1.005	-0.414	1	-0.591	-0.910	1652
1995	0.370	0.782	-0.452	-0.245	1	-0.207	-0.319	1955
1996	1.330	1.485	0.827	0.396	1	0.432	0.665	3711
1997	0.264	0.479	-0.790	-0.737	1	-0.053	-0.082	1196
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.118

WHSpr
Tuned to: 1-Jan
For ages: 5

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.864	1.461	0.843	0.379	1	0.464	0.714	1661
1983	0.357	1.010	-0.041	0.010	1	-0.051	-0.079	1149
1984	0.190	0.646	-0.672	-0.437	1	-0.235	-0.361	734
1985	0.677	0.930	0.599	-0.072	1	0.671	1.033	1058
1986	0.074	0.363	-1.615	-1.012	1	-0.603	-0.929	413
1987	0.128	0.360	-1.067	-1.021	1	-0.046	-0.071	410
1988	0.217	0.550	-0.539	-0.598	1	0.059	0.091	625
1989	0.090	0.751	-1.419	-0.287	1	-1.133	-1.745	854
1990	0.167	0.716	-0.801	-0.334	1	-0.467	-0.719	814
1991	0.268	1.174	-0.328	0.160	1	-0.488	-0.752	1334
1992	1.310	2.832	1.259	1.041	1	0.218	0.335	3220
1993	0.090	0.231	-1.419	-1.466	1	0.046	0.071	263
1994	0.095	0.301	-1.365	-1.200	1	-0.166	-0.255	343
1995	0.150	0.286	-0.908	-1.251	1	0.343	0.528	325
1996	0.400	0.490	0.072	-0.713	1	0.785	1.210	557
1997	0.876	1.289	0.856	0.254	1	0.603	0.928	1466
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.272

WHSpr
Tuned to: 1-Jan
For ages: 6

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.117	0.575	0.038	-0.554	1	0.592	0.912	166
1983	0.181	2.722	0.474	1.001	1	-0.527	-0.812	787
1984	0.053	1.256	-0.754	0.228	1	-0.982	-1.512	363
1985	0.095	0.712	-0.170	-0.340	1	0.170	0.262	206
1986	0.046	1.024	-0.895	0.024	1	-0.919	-1.416	296
1987	0.011	0.388	-2.326	-0.947	1	-1.379	-2.125	112
1988	0.087	0.293	-0.258	-1.226	1	0.968	1.491	85
1989	0.077	0.500	-0.380	-0.693	1	0.313	0.482	145
1990	0.032	1.012	-1.258	0.012	1	-1.271	-1.957	293
1991	0.024	0.959	-1.546	-0.042	1	-1.504	-2.317	277
1992	0.220	1.115	0.670	0.109	1	0.560	0.863	323
1993	0.480	2.803	1.450	1.031	1	0.419	0.645	811
1994	0.047	0.340	-0.874	-1.079	1	0.205	0.316	98
1995	0.030	0.069	-1.323	-2.675	1	1.352	2.082	20
1996	0.060	0.314	-0.630	-1.158	1	0.529	0.814	91
1997	0.242	0.492	0.765	-0.709	1	1.474	2.270	142
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.957

WHAut
Tuned to: 1-Jan
For ages: 2

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.619	1.495	0.230	0.402	1	-0.173	-0.266	9108
1983	0.700	0.824	0.353	-0.194	1	0.546	0.842	5018
1984	1.660	0.744	1.216	-0.296	1	1.512	2.329	4530
1985	0.384	1.041	-0.248	0.040	1	-0.288	-0.443	6339
1986	0.378	0.660	-0.264	-0.415	1	0.151	0.233	4023
1987	0.301	0.996	-0.491	-0.004	1	-0.487	-0.751	6067
1988	0.599	1.338	0.197	0.291	1	-0.094	-0.145	8148
1989	1.951	2.910	1.378	1.068	1	0.310	0.477	17724
1990	0.416	0.454	-0.168	-0.790	1	0.622	0.959	2764
1991	0.029	0.456	-2.831	-0.786	1	-2.046	-3.151	2777
1992	0.142	0.791	-1.243	-0.235	1	-1.008	-1.553	4817
1993	0.290	0.718	-0.529	-0.332	1	-0.197	-0.303	4372
1994	0.198	1.109	-0.910	0.104	1	-1.014	-1.562	6756
1995	0.210	0.462	-0.851	-0.772	1	-0.079	-0.122	2813
1996	0.070	0.221	-1.950	-1.512	1	-0.438	-0.675	1344
1997	0.120	0.143	-1.411	-1.942	1	0.531	0.817	874
1998	0.297	0.070	-0.505	-2.656	1	2.151	3.313	428

Partial Variance: 0.943

WHAut
Tuned to: 1-Jan
For ages: 3

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.382	0.853	-0.866	-0.159	1	-0.706	-1.088	4328
1983	3.142	1.223	1.241	0.201	1	1.040	1.602	6208
1984	0.977	0.655	0.073	-0.423	1	0.496	0.765	3325
1985	0.421	0.651	-0.769	-0.429	1	-0.340	-0.523	3306
1986	0.910	0.950	0.002	-0.052	1	0.054	0.083	4821
1987	0.490	0.634	-0.617	-0.456	1	-0.161	-0.248	3218
1988	1.324	0.940	0.377	-0.062	1	0.439	0.676	4772
1989	2.245	1.286	0.905	0.251	1	0.654	1.007	6526
1990	2.391	2.799	0.968	1.029	1	-0.061	-0.094	14206
1991	0.367	0.409	-0.906	-0.893	1	-0.012	-0.019	2077
1992	0.142	0.387	-1.855	-0.951	1	-0.905	-1.394	1962
1993	0.450	0.721	-0.702	-0.327	1	-0.375	-0.578	3661
1994	0.569	0.692	-0.467	-0.369	1	-0.099	-0.152	3511
1995	0.880	1.084	-0.031	0.081	1	-0.112	-0.173	5505
1996	0.280	0.415	-1.176	-0.880	1	-0.297	-0.457	2106
1997	0.380	0.205	-0.871	-1.584	1	0.713	1.098	1041
1998	0.086	0.132	-2.357	-2.029	1	-0.328	-0.506	668

Partial Variance: 0.272

WHAut
Tuned to: 1-Jan
For ages: 4

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.549	1.022	-0.373	0.022	1	-0.394	-0.608	2666
1983	2.473	0.792	1.132	-0.233	1	1.366	2.104	2066
1984	0.852	1.131	0.067	0.123	1	-0.056	-0.086	2950
1985	0.565	0.613	-0.344	-0.489	1	0.145	0.223	1600
1986	0.763	0.536	-0.044	-0.623	1	0.580	0.893	1399
1987	0.654	0.763	-0.198	-0.271	1	0.073	0.113	1989
1988	0.600	0.803	-0.284	-0.219	1	-0.065	-0.100	2096
1989	0.960	0.997	0.186	-0.003	1	0.189	0.291	2601
1990	1.356	1.499	0.531	0.405	1	0.127	0.195	3911
1991	1.643	3.270	0.723	1.185	1	-0.461	-0.711	8532
1992	0.221	0.328	-1.283	-1.115	1	-0.168	-0.259	856
1993	0.140	0.432	-1.739	-0.839	1	-0.900	-1.386	1127
1994	0.363	0.633	-0.786	-0.457	1	-0.329	-0.507	1652
1995	0.830	0.749	0.041	-0.289	1	0.329	0.507	1955
1996	1.230	1.422	0.434	0.352	1	0.082	0.126	3711
1997	0.190	0.458	-1.434	-0.780	1	-0.654	-1.007	1196
1998	0.160	0.175	-1.606	-1.744	1	0.138	0.213	456

Partial Variance: 0.265

WHAut
Tuned to: 1-Jan
For ages: 5

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.474	1.583	0.251	0.460	1	-0.209	-0.321	1661
1983	1.167	1.095	1.152	0.091	1	1.061	1.635	1149
1984	0.139	0.700	-0.976	-0.357	1	-0.619	-0.953	734
1985	0.399	1.009	0.079	0.008	1	0.070	0.108	1058
1986	0.209	0.394	-0.568	-0.931	1	0.364	0.560	413
1987	0.333	0.391	-0.102	-0.940	1	0.838	1.291	410
1988	0.257	0.596	-0.361	-0.517	1	0.156	0.241	625
1989	0.528	0.814	0.359	-0.206	1	0.565	0.870	854
1990	0.294	0.776	-0.227	-0.254	1	0.027	0.042	814
1991	0.623	1.272	0.524	0.241	1	0.284	0.437	1334
1992	0.632	3.070	0.539	1.122	1	-0.583	-0.898	3220
1993	0.040	0.250	-2.221	-1.385	1	-0.836	-1.288	263
1994	0.032	0.327	-2.444	-1.119	1	-1.325	-2.042	343
1995	0.090	0.310	-1.410	-1.171	1	-0.239	-0.369	325
1996	0.330	0.531	-0.111	-0.632	1	0.521	0.803	557
1997	0.540	1.397	0.381	0.334	1	0.047	0.073	1466
1998	0.182	0.558	-0.706	-0.583	1	-0.123	-0.189	586

Partial Variance: 0.379

WHAut
Tuned to: 1-Jan
For ages: 6

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.089	0.679	-0.561	-0.387	1	-0.174	-0.269	166
1983	0.248	3.218	0.464	1.169	1	-0.705	-1.086	787
1984	0.264	1.484	0.526	0.395	1	0.131	0.202	363
1985	0.220	0.841	0.344	-0.173	1	0.517	0.796	206
1986	0.218	1.211	0.335	0.191	1	0.144	0.221	296
1987	0.086	0.459	-0.596	-0.780	1	0.184	0.284	112
1988	0.061	0.347	-0.939	-1.059	1	0.120	0.185	85
1989	0.110	0.591	-0.349	-0.526	1	0.177	0.272	145
1990	0.174	1.196	0.109	0.179	1	-0.070	-0.108	293
1991	0.278	1.133	0.578	0.125	1	0.453	0.697	277
1992	0.079	1.318	-0.680	0.276	1	-0.957	-1.474	323
1993	0.330	3.314	0.749	1.198	1	-0.449	-0.691	811
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.050	0.081	-1.138	-2.507	1	1.370	2.110	20
1996	0.080	0.371	-0.668	-0.991	1	0.323	0.498	91
1997	0.060	0.582	-0.956	-0.542	1	-0.414	-0.638	142
1998	0.149	1.827	-0.046	0.603	1	-0.649	-0.999	447

Partial Variance: 0.327

MASpr
Tuned to: 1-Jan
For ages: 2

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	7.060	1.455	-0.020	0.375	1	-0.395	-0.609	9108
1983	18.572	0.802	0.947	-0.221	1	1.168	1.799	5018
1984	5.408	0.724	-0.287	-0.323	1	0.036	0.056	4530
1985	3.822	1.013	-0.634	0.013	1	-0.647	-0.996	6339
1986	3.222	0.643	-0.805	-0.442	1	-0.363	-0.559	4023
1987	6.997	0.969	-0.029	-0.031	1	0.002	0.003	6067
1988	11.356	1.302	0.455	0.264	1	0.191	0.295	8148
1989	25.260	2.832	1.255	1.041	1	0.214	0.329	17724
1990	6.890	0.442	-0.045	-0.817	1	0.773	1.190	2764
1991	3.560	0.444	-0.705	-0.813	1	0.108	0.166	2777
1992	6.350	0.770	-0.126	-0.262	1	0.136	0.209	4817
1993	7.760	0.699	0.074	-0.359	1	0.433	0.667	4372
1994	5.670	1.080	-0.239	0.077	1	-0.316	-0.487	6756
1995	1.360	0.450	-1.667	-0.800	1	-0.868	-1.336	2813
1996	0.970	0.215	-2.005	-1.539	1	-0.466	-0.719	1344
1997	1.000	0.140	-1.975	-1.969	1	-0.006	-0.009	874
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.274

MASpr
Tuned to: 1-Jan
For ages: 3

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	3.418	0.903	-0.147	-0.102	1	-0.045	-0.070	4328
1983	5.331	1.296	0.297	0.259	1	0.039	0.059	6208
1984	2.271	0.694	-0.556	-0.366	1	-0.190	-0.293	3325
1985	2.794	0.690	-0.349	-0.371	1	0.023	0.035	3306
1986	0.887	1.006	-1.496	0.006	1	-1.502	-2.314	4821
1987	2.268	0.671	-0.557	-0.398	1	-0.159	-0.245	3218
1988	2.511	0.996	-0.455	-0.004	1	-0.451	-0.695	4772
1989	6.580	1.362	0.508	0.309	1	0.199	0.307	6526
1990	17.770	2.965	1.501	1.087	1	0.415	0.639	14206
1991	2.540	0.434	-0.444	-0.836	1	0.392	0.604	2077
1992	3.580	0.409	-0.101	-0.893	1	0.792	1.220	1962
1993	3.600	0.764	-0.095	-0.269	1	0.174	0.268	3661
1994	2.460	0.733	-0.476	-0.311	1	-0.165	-0.254	3511
1995	3.890	1.149	-0.018	0.139	1	-0.156	-0.241	5505
1996	2.110	0.440	-0.629	-0.822	1	0.193	0.297	2106
1997	1.340	0.217	-1.083	-1.527	1	0.443	0.683	1041
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.26

MASpr
Tuned to: 1-Jan
For ages: 4

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	1.147	0.882	0.007	-0.125	1	0.133	0.205	2666
1983	0.501	0.684	-0.821	-0.380	1	-0.440	-0.679	2066
1984	0.865	0.976	-0.275	-0.024	1	-0.251	-0.386	2950
1985	0.692	0.529	-0.498	-0.636	1	0.138	0.213	1600
1986	0.426	0.463	-0.983	-0.770	1	-0.213	-0.328	1399
1987	0.257	0.658	-1.488	-0.418	1	-1.070	-1.648	1989
1988	1.370	0.693	0.185	-0.366	1	0.551	0.849	2096
1989	0.458	0.861	-0.911	-0.150	1	-0.760	-1.171	2601
1990	2.640	1.294	0.841	0.258	1	0.583	0.899	3911
1991	5.030	2.823	1.486	1.038	1	0.448	0.690	8532
1992	0.650	0.283	-0.560	-1.262	1	0.701	1.080	856
1993	1.450	0.373	0.242	-0.987	1	1.228	1.892	1127
1994	0.520	0.546	-0.784	-0.604	1	-0.179	-0.276	1652
1995	1.200	0.647	0.053	-0.436	1	0.488	0.752	1955
1996	0.810	1.228	-0.340	0.205	1	-0.546	-0.841	3711
1997	0.200	0.396	-1.739	-0.927	1	-0.812	-1.251	1196
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.417

MAAut
Tuned to: 1-Jan
For ages: 2

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	5.652	0.892	0.320	-0.115	1	0.435	0.670	9108
1983	2.346	0.491	-0.559	-0.711	1	0.152	0.234	5018
1984	0.651	0.443	-1.841	-0.813	1	-1.028	-1.583	4530
1985	0.344	0.620	-2.479	-0.477	1	-2.001	-3.083	6339
1986	0.419	0.394	-2.281	-0.932	1	-1.349	-2.079	4023
1987	1.150	0.594	-1.272	-0.521	1	-0.751	-1.156	6067
1988	2.386	0.798	-0.542	-0.226	1	-0.316	-0.486	8148
1989	20.490	1.735	1.608	0.551	1	1.057	1.629	17724
1990	2.700	0.271	-0.418	-1.307	1	0.889	1.369	2764
1991	9.130	0.272	0.800	-1.303	1	2.103	3.239	2777
1992	4.200	0.472	0.024	-0.752	1	0.775	1.194	4817
1993	2.010	0.428	-0.713	-0.849	1	0.135	0.208	4372
1994	3.320	0.661	-0.212	-0.413	1	0.202	0.311	6756
1995	14.130	0.275	1.237	-1.290	1	2.526	3.892	2813
1996	0.640	0.132	-1.858	-2.029	1	0.171	0.263	1344
1997	0.150	0.086	-3.309	-2.459	1	-0.850	-1.309	874
1998	0.020	0.042	-5.324	-3.173	1	-2.151	-3.313	428

Partial Variance: 1.686

CM_CPE
Tuned to: MidYear
For ages: 3

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.074	0.841	0.182	-0.173	1	0.355	0.547	3059
1983	0.110	1.204	0.580	0.186	1	0.394	0.607	4379
1984	0.045	0.649	-0.318	-0.433	1	0.115	0.178	2358
1985	0.042	0.610	-0.376	-0.495	1	0.119	0.183	2217
1986	0.069	0.880	0.111	-0.128	1	0.239	0.369	3199
1987	0.019	0.720	-1.196	-0.329	1	-0.867	-1.335	2617
1988	0.049	0.984	-0.224	-0.016	1	-0.207	-0.319	3577
1989	0.064	1.405	0.035	0.340	1	-0.305	-0.470	5108
1990	0.160	3.061	0.953	1.119	1	-0.166	-0.256	11129
1991	0.040	0.379	-0.420	-0.971	1	0.551	0.849	1377
1992	0.017	0.414	-1.267	-0.881	1	-0.386	-0.594	1506
1993	0.050	0.694	-0.208	-0.365	1	0.157	0.242	2524
1994	0.000	0.000	0	0	1	0.000	0.000	00
1995	0.000	0.000	0	0	1	0.000	0.000	00
1996	0.000	0.000	0	0	1	0.000	0.000	00
1997	0.000	0.000	0	0	1	0.000	0.000	00
1998	0.000	0.000	0	0	1	0.000	0.000	00

Partial Variance: 0.164

CM_CPE
Tuned to: MidYear
For ages: 4

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.045	1.110	0.032	0.105	0	0.000	-0.112	1802
1983	0.042	0.793	-0.034	-0.232	0	0.000	0.305	1287
1984	0.044	1.137	0.013	0.128	0	0.000	-0.177	1845
1985	0.029	0.540	-0.410	-0.616	0	0.000	0.317	877
1986	0.023	0.496	-0.659	-0.701	0	0.000	0.064	806
1987	0.026	0.726	-0.518	-0.320	0	0.000	-0.304	1179
1988	0.024	0.852	-0.590	-0.160	0	0.000	-0.662	1383
1989	0.040	0.948	-0.095	-0.054	0	0.000	-0.063	1538
1990	0.078	1.476	0.583	0.389	0	0.000	0.299	2396
1991	0.136	3.358	1.134	1.211	0	0.000	-0.120	5452
1992	0.014	0.309	-1.151	-1.174	0	0.000	0.035	502
1993	0.023	0.406	-0.630	-0.902	0	0.000	0.420	659
1994	0.000	0.000	0	0	0	0.000	0.000	00
1995	0.000	0.000	0	0	0	0.000	0.000	00
1996	0.000	0.000	0	0	0	0.000	0.000	00
1997	0.000	0.000	0	0	0	0.000	0.000	00
1998	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.042

CM_CPE
Tuned to: MidYear
For ages: 5

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.022	1.915	0.293	0.650	0	0.000	-0.549	1170
1983	0.021	1.116	0.259	0.110	0	0.000	0.229	682
1984	0.012	0.680	-0.316	-0.386	0	0.000	0.108	415
1985	0.018	0.979	0.103	-0.021	0	0.000	0.192	598
1986	0.007	0.378	-0.894	-0.973	0	0.000	0.121	231
1987	0.006	0.338	-1.039	-1.086	0	0.000	0.072	206
1988	0.009	0.537	-0.551	-0.621	0	0.000	0.109	328
1989	0.011	0.858	-0.423	-0.154	0	0.000	-0.415	524
1990	0.012	0.815	-0.282	-0.204	0	0.000	-0.121	498
1991	0.022	1.166	0.294	0.154	0	0.000	0.217	713
1992	0.051	2.859	1.158	1.050	0	0.000	0.166	1747
1993	0.004	0.274	-1.379	-1.296	0	0.000	-0.128	167
1994	0.000	0.000	0	0	0	0.000	0.000	00
1995	0.000	0.000	0	0	0	0.000	0.000	00
1996	0.000	0.000	0	0	0	0.000	0.000	00
1997	0.000	0.000	0	0	0	0.000	0.000	00
1998	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.028

CM_CPE
Tuned to: MidYear
For ages: 6

Year	Obs.	Pred.	Scd. Obs.	Scd. Pred.	Wt.	Wt. Res.	Std. Res.	Pred. Stk. Sze.
1982	0.003	0.592	-0.669	-0.525	0	0.000	-0.223	114
1983	0.012	2.487	0.867	0.911	0	0.000	-0.069	478
1984	0.006	1.150	0.065	0.140	0	0.000	-0.116	221
1985	0.004	0.585	-0.360	-0.537	0	0.000	0.272	112
1986	0.004	0.869	-0.190	-0.140	0	0.000	-0.077	167
1987	0.002	0.333	-1.073	-1.099	0	0.000	0.040	64
1988	0.001	0.277	-1.259	-1.285	0	0.000	0.041	53
1989	0.002	0.444	-0.807	-0.811	0	0.000	0.007	85
1990	0.005	0.925	-0.015	-0.078	0	0.000	0.098	178
1991	0.004	0.896	-0.273	-0.110	0	0.000	-0.250	172
1992	0.005	0.911	0.003	-0.093	0	0.000	0.148	175
1993	0.014	2.481	0.992	0.909	0	0.000	0.128	477
1994	0.000	0.000	0	0	0	0.000	0.000	00
1995	0.000	0.000	0	0	0	0.000	0.000	00
1996	0.000	0.000	0	0	0	0.000	0.000	00
1997	0.000	0.000	0	0	0	0.000	0.000	00
1998	0.000	0.000	0	0	0	0.000	0.000	00

Partial Variance: 0.01

Partial variance (and proportion of total) by index

0.506	0.176	0.118	0.272	0.957	0.943	0.272	0.265	0.379	0.327	0.274
0.26	0.417	1.686	0.164	0.042	0.028	0.01				
0.071	0.025	0.017	0.038	0.135	0.133	0.038	0.037	0.053	0.046	0.039
0.037	0.059	0.238	0.023	0.006	0.004	0.001				

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

	1982	1983	1984	1985	1986	1987	1988
WHSpr 2	0.581	1.436	1.677	-1.101	0.103	0.485	0.803
WHSpr 3	-0.514	-0.332	1.123	0.189	-0.332	-0.150	-0.350
WHSpr 4	0.172	0.442	0.117	0.893	0.266	-0.669	-0.490
WHSpr 5	0.714	-0.079	-0.361	1.033	-0.929	-0.071	0.091
WHSpr 6	0.912	-0.812	-1.512	0.262	-1.416	-2.125	1.491
WHAut 2	-0.266	0.842	2.329	-0.443	0.233	-0.751	-0.145
WHAut 3	-1.088	1.602	0.765	-0.523	0.083	-0.248	0.676
WHAut 4	-0.608	2.104	-0.086	0.223	0.893	0.113	-0.100
WHAut 5	-0.321	1.635	-0.953	0.108	0.560	1.291	0.241
WHAut 6	-0.269	-1.086	0.202	0.796	0.221	0.284	0.185
MASpr 2	-0.609	1.799	0.056	-0.996	-0.559	0.003	0.295
MASpr 3	-0.070	0.059	-0.293	0.035	-2.314	-0.245	-0.695
MASpr 4	0.205	-0.679	-0.386	0.213	-0.328	-1.648	0.849
MAAut 2	0.670	0.234	-1.583	-3.083	-2.079	-1.156	-0.486
CM_CPE 3	0.547	0.607	0.178	0.183	0.369	-1.335	-0.319
CM_CPE 4	-0.112	0.305	-0.177	0.317	0.064	-0.304	-0.662
CM_CPE 5	-0.549	0.229	0.108	0.192	0.121	0.072	0.109
CM_CPE 6	-0.223	-0.069	-0.116	0.272	-0.077	0.040	0.041
Col Avg	-0.046	0.458	0.060	-0.079	-0.285	-0.356	0.085

	1989	1990	1991	1992	1993	1994	1995
WHSpr 2	-1.140	-0.170	-0.030	-0.731	0.614	-0.763	-0.280
WHSpr 3	-0.491	-0.890	0.041	-0.475	0.419	-0.635	0.309
WHSpr 4	0.066	-0.574	-0.456	0.525	0.354	-0.910	-0.319
WHSpr 5	-1.745	-0.719	-0.752	0.335	0.071	-0.255	0.528
WHSpr 6	0.482	-1.957	-2.317	0.863	0.645	0.316	2.082
WHAut 2	0.477	0.959	-3.151	-1.553	-0.303	-1.562	-0.122
WHAut 3	1.007	-0.094	-0.019	-1.394	-0.578	-0.152	-0.173
WHAut 4	0.291	0.195	-0.711	-0.259	-1.386	-0.507	0.507
WHAut 5	0.870	0.042	0.437	-0.898	-1.288	-2.042	-0.369
WHAut 6	0.272	-0.108	0.697	-1.474	-0.691	0.000	2.110
MASpr 2	0.329	1.190	0.166	0.209	0.667	-0.487	-1.336
MASpr 3	0.307	0.639	0.604	1.220	0.268	-0.254	-0.241
MASpr 4	-1.171	0.899	0.690	1.080	1.892	-0.276	0.752
MAAut 2	1.629	1.369	3.239	1.194	0.208	0.311	3.892
CM_CPE 3	-0.470	-0.256	0.849	-0.594	0.242	0.000	0.000
CM_CPE 4	-0.063	0.299	-0.120	0.035	0.420	0.000	0.000
CM_CPE 5	-0.415	-0.121	0.217	0.166	-0.128	0.000	0.000
CM_CPE 6	0.007	0.098	-0.250	0.148	0.128	0.000	0.000
Col Avg	0.013	0.045	-0.048	-0.089	0.086	-0.555	0.524

	1996	1997	1998
WHSpr 2	-2.526	1.043	0.000
WHSpr 3	0.802	1.284	0.000
WHSpr 4	0.665	-0.082	0.000
WHSpr 5	1.210	0.928	0.000
WHSpr 6	0.814	2.270	0.000
WHAut 2	-0.675	0.817	3.313
WHAut 3	-0.457	1.098	-0.506
WHAut 4	0.126	-1.007	0.213
WHAut 5	0.803	0.073	-0.189
WHAut 6	0.498	-0.638	-0.999
MASpr 2	-0.719	-0.009	0.000
MASpr 3	0.297	0.683	0.000
MASpr 4	-0.841	-1.251	0.000
MAAut 2	0.263	-1.309	-3.313
CM_CPE 3	0.000	0.000	0.000
CM_CPE 4	0.000	0.000	0.000
CM_CPE 5	0.000	0.000	0.000
CM_CPE 6	0.000	0.000	0.000
Col Avg	0.019	0.279	-0.247

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

	1982	1983	1984	1985	1986	1987	1988
WHSpr 2	0.133	0.811	1.108	0.477	0.004	0.093	0.254
WHSpr 3	0.104	0.043	0.496	0.014	0.043	0.009	0.048
WHSpr 4	0.012	0.077	0.005	0.314	0.028	0.176	0.094
WHSpr 5	0.201	0.002	0.051	0.420	0.340	0.002	0.003
WHSpr 6	0.327	0.260	0.900	0.027	0.790	1.777	0.876
WHAut 2	0.028	0.279	2.136	0.077	0.021	0.222	0.008
WHAut 3	0.466	1.011	0.230	0.108	0.003	0.024	0.180
WHAut 4	0.145	1.742	0.003	0.020	0.314	0.005	0.004
WHAut 5	0.041	1.052	0.358	0.005	0.124	0.656	0.023
WHAut 6	0.028	0.464	0.016	0.250	0.019	0.032	0.013
MASpr 2	0.146	1.274	0.001	0.391	0.123	0.000	0.034
MASpr 3	0.002	0.001	0.034	0.000	2.108	0.024	0.190
MASpr 4	0.016	0.181	0.059	0.018	0.042	1.070	0.284
MAAut 2	0.177	0.022	0.987	3.742	1.701	0.526	0.093
CM_CPE 3	0.118	0.145	0.012	0.013	0.054	0.702	0.040
CM_CPE 4	0.005	0.037	0.012	0.040	0.002	0.036	0.173
CM_CPE 5	0.119	0.021	0.005	0.014	0.006	0.002	0.005
CM_CPE 6	0.020	0.002	0.005	0.029	0.002	0.001	0.001
++	2.087	7.425	6.419	5.959	5.723	5.357	2.323

	1989	1990	1991	1992	1993	1994	1995
WHSpr 2	0.512	0.011	0.000	0.210	0.149	0.229	0.031
WHSpr 3	0.095	0.312	0.001	0.089	0.069	0.159	0.038
WHSpr 4	0.002	0.130	0.082	0.108	0.049	0.326	0.040
WHSpr 5	1.198	0.203	0.223	0.044	0.002	0.026	0.110
WHSpr 6	0.092	1.508	2.113	0.293	0.164	0.039	1.707
WHAut 2	0.090	0.362	3.909	0.949	0.036	0.960	0.006
WHAut 3	0.399	0.003	0.000	0.765	0.131	0.009	0.012
WHAut 4	0.033	0.015	0.199	0.026	0.756	0.101	0.101
WHAut 5	0.298	0.001	0.075	0.317	0.653	1.641	0.054
WHAut 6	0.029	0.005	0.191	0.855	0.188	0.000	1.752
MASpr 2	0.043	0.558	0.011	0.017	0.175	0.093	0.703
MASpr 3	0.037	0.161	0.144	0.586	0.028	0.025	0.023
MASpr 4	0.540	0.318	0.187	0.460	1.410	0.030	0.223
MAAut 2	1.045	0.738	4.130	0.561	0.017	0.038	5.962
CM_CPE 3	0.087	0.026	0.284	0.139	0.023	0.000	0.000
CM_CPE 4	0.002	0.035	0.006	0.000	0.069	0.000	0.000
CM_CPE 5	0.068	0.006	0.018	0.011	0.006	0.000	0.000
CM_CPE 6	0.000	0.004	0.025	0.009	0.006	0.000	0.000
++	4.569	4.395	11.598	5.442	3.934	3.677	10.761

	1996	1997	1998	++
WHSpr 2	2.513	0.428	0.000	6.963
WHSpr 3	0.253	0.650	0.000	2.422
WHSpr 4	0.174	0.003	0.000	1.620
WHSpr 5	0.576	0.339	0.000	3.741
WHSpr 6	0.261	2.029	0.000	13.162
WHAut 2	0.180	0.263	4.322	13.848
WHAut 3	0.082	0.475	0.101	4.000
WHAut 4	0.006	0.399	0.018	3.889
WHAut 5	0.254	0.002	0.014	5.568
WHAut 6	0.098	0.160	0.393	4.495
MASpr 2	0.203	0.000	0.000	3.773
MASpr 3	0.035	0.183	0.000	3.581
MASpr 4	0.278	0.616	0.000	5.732
MAAut 2	0.027	0.675	4.322	0.000
CM_CPE 3	0.000	0.000	0.000	24.764
CM_CPE 4	0.000	0.000	0.000	0.000
CM_CPE 5	0.000	0.000	0.000	0.000
CM_CPE 6	0.000	0.000	0.000	1.643
++	4.941	6.222	9.170	100.000

STOCK NUMBERS (Jan 1) in thousands - C:\ASSESS\Whatzip\gmcod\Gmcod98.11

	1982	1983	1984	1985	1986	1987	1988
1	6162	5534	7746	4914	7410	9954	21648
2	9108	5018	4530	6339	4023	6067	8148
3	4328	6208	3325	3306	4821	3218	4772
4	2666	2066	2950	1600	1399	1989	2096
5	1661	1149	734	1058	413	410	625
6	166	787	363	206	296	112	85
7	547	284	250	214	156	132	58
1+	24639	21046	19900	17636	18519	21882	37432

	1989	1990	1991	1992	1993	1994	1995
1	3376	3392	5884	5340	8252	3436	1641
2	17724	2764	2777	4817	4372	6756	2813
3	6526	14206	2077	1962	3661	3511	5505
4	2601	3911	8532	856	1127	1652	1955
5	854	814	1334	3220	263	343	325
6	145	293	277	323	811	98	20
7	98	182	151	131	63	114	55
1+	31324	25561	21032	16649	18547	15910	12315

	1996	1997	1998
1	1067	523	00
2	1344	874	428
3	2106	1041	668
4	3711	1196	456
5	557	1466	586
6	91	142	447
7	20	17	61
1+	8896	5258	2646

FISHING MORTALITY - C:\ASSESS\Whatzip\gmcod\Gmcod98.11

	1982	1983	1984	1985	1986	1987	1988
1	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	0.18	0.21	0.12	0.07	0.02	0.04	0.02
3	0.54	0.54	0.53	0.66	0.69	0.23	0.41
4	0.64	0.83	0.83	1.15	1.03	0.96	0.70
5	0.55	0.95	1.07	1.07	1.10	1.37	1.26
6	0.61	0.90	0.89	1.16	1.08	1.05	0.82
7	0.61	0.90	0.89	1.16	1.08	1.05	0.82

	1989	1990	1991	1992	1993	1994	1995
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.02	0.09	0.15	0.07	0.02	0.00	0.09
3	0.31	0.31	0.69	0.35	0.60	0.39	0.19
4	0.96	0.88	0.77	0.98	0.99	1.42	1.05
5	0.87	0.88	1.22	1.18	0.78	2.64	1.08
6	0.97	0.90	0.84	1.18	0.98	1.66	1.09
7	0.97	0.90	0.84	1.18	0.98	1.66	1.09

	1996	1997
1	0.00	0.00
2	0.05	0.07
3	0.37	0.63
4	0.73	0.51
5	1.16	0.99
6	0.79	0.75
7	0.79	0.75

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

	1982	1983	1984	1985	1986	1987	1988
2,5	0.48	0.64	0.64	0.74	0.71	0.65	0.60
3,5	0.58	0.78	0.81	0.96	0.94	0.85	0.79
4,5	0.59	0.89	0.95	1.11	1.07	1.17	0.98

	1989	1990	1991	1992	1993	1994	1995
2,5	0.54	0.54	0.71	0.65	0.60	1.11	0.60
3,5	0.71	0.69	0.89	0.84	0.79	1.48	0.78
4,5	0.92	0.88	1.00	1.08	0.89	2.03	1.07

	1996	1997
2,5	0.58	0.55
3,5	0.75	0.71
4,5	0.95	0.75

Average F weighted by N for 2,5 3,5 4,5

	1982	1983	1984	1985	1986	1987	1988
2,5	0.37	0.50	0.48	0.46	0.50	0.30	0.28
3,5	0.57	0.66	0.71	0.87	0.78	0.57	0.56
4,5	0.61	0.88	0.87	1.12	1.05	1.03	0.83

	1989	1990	1991	1992	1993	1994	1995
2,5	0.20	0.40	0.68	0.52	0.38	0.38	0.35
3,5	0.53	0.45	0.81	0.88	0.69	0.84	0.45
4,5	0.94	0.88	0.83	1.14	0.95	1.63	1.06

	1996	1997
2,5	0.54	0.61
3,5	0.65	0.73
4,5	0.79	0.77

Average F for weighted by Catch for 2,5 3,5 4,5

	1982	1983	1984	1985	1986	1987	1988
2,5	0.46	0.60	0.67	0.81	0.78	0.72	0.60
3,5	0.58	0.68	0.74	0.90	0.80	0.80	0.63
4,5	0.61	0.88	0.88	1.12	1.05	1.04	0.87

	1989	1990	1991	1992	1993	1994	1995
2,5	0.60	0.53	0.79	0.92	0.70	1.12	0.66
3,5	0.66	0.55	0.82	1.00	0.72	1.14	0.72
4,5	0.94	0.88	0.85	1.14	0.96	1.67	1.06

	1996	1997
2,5	0.69	0.75
3,5	0.71	0.77
4,5	0.80	0.82

BACKCALCULATED PARTIAL RECRUITMENT

	1982	1983	1984	1985	1986	1987	1988
1	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	0.29	0.22	0.11	0.06	0.02	0.03	0.02
3	0.84	0.57	0.50	0.57	0.62	0.17	0.32
4	1.00	0.88	0.77	0.99	0.93	0.70	0.55
5	0.85	1.00	1.00	0.92	1.00	1.00	1.00
6	0.96	0.94	0.83	1.00	0.98	0.76	0.65
7	0.96	0.94	0.83	1.00	0.98	0.76	0.65

	1989	1990	1991	1992	1993	1994	1995
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.02	0.10	0.12	0.06	0.02	0.00	0.08
3	0.32	0.34	0.56	0.30	0.60	0.15	0.18
4	1.00	0.97	0.63	0.83	1.00	0.54	0.96
5	0.90	0.98	1.00	1.00	0.79	1.00	0.98
6	1.00	1.00	0.69	1.00	0.98	0.63	1.00
7	1.00	1.00	0.69	1.00	0.98	0.63	1.00

	1996	1997
1	0.00	0.00
2	0.05	0.07
3	0.31	0.63
4	0.63	0.52
5	1.00	1.00
6	0.68	0.76
7	0.68	0.76

MEAN BIOMASS

	1982	1983	1984	1985	1986	1987	1988
1	5013	4514	6317	4008	6044	8119	17659
2	8746	4788	4504	6987	4701	7081	9266
3	5090	7269	3938	3872	5877	4407	6729
4	4981	3186	5021	2490	2355	3869	3355
5	5582	2577	1528	2672	1067	997	1696
6	766	2849	1303	621	1014	437	360
7	4243	1685	1551	1137	905	770	410
1+	34422	26868	24161	21786	21963	25680	39474

	1989	1990	1991	1992	1993	1994	1995
1	2754	2767	4799	4356	6731	2803	1339
2	19828	2575	2651	6458	5076	8858	4035
3	9071	18830	2160	2895	4769	5163	8739
4	4604	5442	13694	1363	1655	2572	3091
5	2025	2125	2947	5347	728	391	945
6	416	1358	1258	875	2944	274	93
7	708	1515	1072	757	408	519	403
1+	39405	34612	28581	22051	22311	20581	18644

	1996	1997
1	871	426
2	2001	1328
3	3435	1583
4	5742	2570
5	1109	2739
6	425	427
7	147	133
1+	13730	9206

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

	1982	1983	1984	1985	1986	1987	1988
2,5	24399	17820	14990	16021	13999	16354	21046
3,5	15654	13032	10486	9034	9298	9273	11780
4,5	10563	5763	6548	5162	3421	4866	5051

	1989	1990	1991	1992	1993	1994	1995
2,5	35528	28972	21452	16063	12228	16985	16810
3,5	15700	26397	18801	9605	7152	8126	12774
4,5	6629	7567	16642	6710	2384	2963	4035

	1996	1997
2,5	12288	8220
3,5	10287	6892
4,5	6852	5309

Catch BIOMASS

	1982	1983	1984	1985	1986	1987	1988
1	27	00	04	00	00	02	00
2	1603	1013	519	514	110	284	203
3	2746	3955	2093	2555	4027	1008	2737
4	3198	2659	4144	2872	2421	3704	2343
5	3052	2452	1638	2868	1178	1370	2144
6	471	2557	1163	722	1095	459	295
7	2606	1512	1384	1322	978	809	337
1+	13703	14149	10944	10853	9808	7636	8060

	1989	1990	1991	1992	1993	1994	1995
1	00	00	00	00	00	00	00
2	421	220	390	481	99	42	361
3	2831	5835	1484	1026	2841	1990	1699
4	4428	4763	10604	1337	1640	3665	3260
5	1763	1864	3596	6307	570	1033	1017
6	402	1220	1062	1031	2872	454	101
7	683	1361	905	892	398	862	441
1+	10527	15263	18040	11074	8420	8046	6880

	1996	1997
1	00	00
2	110	92
3	1257	990
4	4186	1321
5	1292	2704
6	337	321
7	117	100
1+	7299	5528

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

	1982	1983	1984	1985	1986	1987	1988
2,5	10599	10079	8393	8809	7735	6366	7427
3,5	8996	9066	7874	8295	7625	6082	7224
4,5	6250	5111	5782	5740	3598	5075	4487

	1989	1990	1991	1992	1993	1994	1995
2,5	9443	12681	16074	9151	5150	6730	6337
3,5	9022	12461	15683	8670	5051	6688	5976
4,5	6191	6627	14200	7644	2210	4698	4277

	1996	1997
2,5	6845	5108
3,5	6736	5015
4,5	5478	4026

Jan 1 BIOMASS

	1982	1983	1984	1985	1986	1987	1988
1	4874	4388	5895	3675	5520	7545	16561
2	8789	5138	4626	6751	4357	6595	8702
3	5904	8598	4635	4704	7333	4769	7501
4	6303	4192	6269	3485	3160	4886	4236
5	7088	3711	2215	3688	1497	1540	2575
6	942	4198	1714	927	1542	630	485
7	6202	2775	2549	2082	1605	1350	655
1+	40102	33001	27903	25313	25015	27314	40715

	1989	1990	1991	1992	1993	1994	1995
1	2785	2723	4060	4010	5850	2282	1078
2	18770	2714	2799	5660	4717	7715	3430
3	9796	20642	2692	2892	6231	5565	9188
4	6172	7853	17593	1765	2477	4030	4540
5	2614	2908	4090	8930	903	1008	1309
6	725	1591	1548	1467	3524	508	107
7	1198	2496	1727	1394	694	1144	718
1+	42061	40927	34509	26119	24396	22251	20369

	1996	1997
1	693	339
2	1655	1092
3	3955	2021
4	7926	3030
5	1774	4036
6	559	586
7	232	206
1+	16794	11311

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

	1982	1983	1984	1985	1986	1987	1988
2,5	28083	21640	17744	18628	16347	17789	23014
3,5	19295	16502	13119	11877	11991	11194	14312
4,5	13391	7904	8484	7173	4657	6426	6811

	1989	1990	1991	1992	1993	1994	1995
2,5	37352	34117	27174	19248	14328	18318	18466
3,5	18582	31403	24375	13588	9610	10603	15037
4,5	8786	10761	21683	10695	3380	5038	5849

	1996	1997
2,5	15310	10179
3,5	13655	9088
4,5	9700	7067

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

	1982	1983	1984	1985	1986	1987	1988
1	330	297	399	142	214	292	641
2	2144	1247	1141	3096	2015	3041	4025
3	3184	4633	2503	3872	6011	4218	6440
4	4820	3105	4650	2781	2575	4029	3647
5	6071	2971	1738	2983	1205	1184	2017
6	823	3496	1429	739	1245	511	409
7	5415	2311	2125	1659	1297	1096	552
1+	22786	18061	13984	15272	14561	14371	17732

	1989	1990	1991	1992	1993	1994	1995
1	108	290	432	427	622	88	42
2	8683	725	740	1514	1273	2833	1242
3	8545	10617	1300	1477	3056	4492	7657
4	5085	5317	12114	1174	1645	3043	3646
5	2187	2260	3002	6599	713	627	1058
6	597	1298	1275	1143	2839	373	86
7	987	2079	1451	1108	571	839	579
1+	26192	22586	20314	13441	10719	12296	14309

	1996	1997
1	27	13
2	603	397
3	3203	1568
4	6721	2663
5	1413	3311
6	474	500
7	196	176
1+	12637	8628

Appendix 4.

Precision estimates of the 1998 age-specific stock sizes, catchability coefficients, and 1997 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 1000 bootstrap replications.

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

Appendix 4. Bootstrap results from final formulation of the 1998 Gulf of Maine cod VPA.

The number of bootstraps: 1000

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

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
N 2	428	477	263	0.61
N 3	668	692	209	0.31
N 4	456	478	169	0.37
N 5	586	617	210	0.36
N 6	447	498	236	0.53

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
N 2	49	08	11.39	379	0.692838
N 3	24	07	3.64	643	0.325131
N 4	22	05	4.73	435	0.388703
N 5	31	07	5.37	554	0.379287
N 6	51	07	11.31	397	0.595270

Appendix 4:Table 2. Bootstrap Output Variable: Q_unscaled

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
q WHSpr2	0.0000767	0.0000776	0.0000118	0.15
q WHSpr3	0.0001665	0.0001685	0.0000254	0.15
q WHSpr4	0.0002328	0.0002338	0.0000342	0.15
q WHSpr5	0.0003272	0.0003316	0.0000475	0.15
q WHSpr6	0.0003895	0.0003951	0.0000581	0.15
q WHAut2	0.0000808	0.0000811	0.0000122	0.15
q WHAut3	0.0001789	0.0001817	0.0000261	0.15
q WHAut4	0.0003055	0.0003075	0.0000436	0.14
q WHAut5	0.0003515	0.0003547	0.0000520	0.15
q WHAut6	0.0006376	0.0006458	0.0000999	0.16
q MASpr2	0.0011511	0.0011593	0.0001728	0.15
q MASpr3	0.0008263	0.0008364	0.0001288	0.16
q MASpr4	0.0003767	0.0003807	0.0000607	0.16
q MAAut2	0.0004016	0.0004043	0.0000616	0.15
q CM_CPE3	0.0000169	0.0000171	0.0000028	0.17
q CM_CPE4	0.0000269	0.0000273	0.0000045	0.17
q CM_CPE5	0.0000265	0.0000269	0.0000045	0.17
q CM_CPE6	0.0000269	0.0000270	0.0000046	0.17

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
q WHSpr2	0.00000084	0.000000372	1.097	0.000075905	0.16
q WHSpr3	0.00000204	0.000000804	1.225	0.000164413	0.15
q WHSpr4	0.00000106	0.000001082	0.454	0.000231724	0.15
q WHSpr5	0.00000445	0.000001501	1.361	0.000322743	0.15
q WHSpr6	0.00000565	0.000001838	1.451	0.000383825	0.15
q WHAut2	0.00000037	0.000000385	0.453	0.000080405	0.15
q WHAut3	0.00000280	0.000000824	1.565	0.000176074	0.15
q WHAut4	0.00000199	0.000001377	0.651	0.000303506	0.14
q WHAut5	0.00000317	0.000001645	0.903	0.000348336	0.15
q WHAut6	0.00000816	0.000003158	1.279	0.000629484	0.16
q MASpr2	0.00000823	0.000005464	0.715	0.001142828	0.15
q MASpr3	0.00001015	0.000004073	1.228	0.000816107	0.16
q MASpr4	0.00000397	0.000001918	1.054	0.000372722	0.16
q MAAut2	0.00000278	0.000001947	0.692	0.000398791	0.15
q CM_CPE3	0.00000014	0.000000090	0.846	0.000016778	0.17
q CM_CPE4	0.00000045	0.000000143	1.665	0.000026421	0.17
q CM_CPE5	0.00000046	0.000000143	1.744	0.000025996	0.17
q CM_CPE6	0.00000008	0.000000146	0.284	0.000026857	0.17

Appendix 4 (Continued).

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

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	4394.6	4407.5	164.5	0.0374
Age 2	427.9	476.7	262.7	0.6139
Age 3	667.6	691.9	209.1	0.3133
Age 4	456.2	477.7	168.9	0.3703
Age 5	585.5	617.0	210.2	0.3589
Age 6	447.1	497.7	236.0	0.5279
Age 7	71.1	73.6	22.9	0.3225

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
Age 1	12.84	5.20	0.292	4381.79	0.04
Age 2	48.75	8.31	11.392	379.19	0.69
Age 3	24.30	6.61	3.641	643.27	0.33
Age 4	21.56	5.34	4.727	434.60	0.39
Age 5	31.43	6.65	5.368	554.10	0.38
Age 6	50.58	7.46	11.313	396.51	0.60
Age 7	2.48	0.73	3.493	68.65	0.33

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	0.55
Age 2	0.0694	0.0723	0.0208	0.30
Age 3	0.6253	0.6513	0.1913	0.31
Age 4	0.5142	0.5325	0.1553	0.30
Age 5	0.9872	1.0175	0.3307	0.33
Age 6	0.7507	0.7750	0.1826	0.24
Age 7	0.7507	0.7750	0.1826	0.24

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
Age 1	0.0000002	0.0000000	10.413	0.0000019	0.62
Age 2	0.0028915	0.0006583	4.168	0.0664826	0.31
Age 3	0.0259795	0.0060498	4.155	0.5993248	0.32
Age 4	0.0183099	0.0049105	3.561	0.4958443	0.31
Age 5	0.0302939	0.0104563	3.069	0.9569534	0.35
Age 6	0.0243019	0.0057735	3.237	0.7263989	0.25
Age 7	0.0243019	0.0057735	3.237	0.7263989	0.25

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

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
	0.7507	0.7750	0.1826	0.24

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
	0.02430	0.00577	3.24	0.72640	0.25

Appendix 4:Table 6. Bootstrap Output Variable: SSB spawn t

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
	8896.7301	9227.5537	1301.0066	0.15

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
	330.82	41.14	3.72	8565.91	0.15