

F. Gulf of Maine Cod by R.K. Mayo and L. Col

1.0 Background

The Gulf of Maine Atlantic cod stock was last assessed in 2001 (Mayo *et al.* 2002; NEFSC 2001). All of the methodology applied in the present assessment is the same as in the 2001 assessment as described in Mayo *et al.* (2002). In the 2001 assessment, fully recruited fishing mortality (ages 4+) in 2000 was estimated to be 0.73, and the 1999 F was estimated to be 0.77. Spawning stock biomass was estimated to have declined to 11,100 mt in 1999, a decline from a recent high of 14,600 mt in 1995 and a series high of 24,200 mt in 1990. The strength of the most recent recruiting year classes was estimated to be very low. The 1993, 1994 and 1995 year classes continue to be estimated as the lowest in the VPA series dating back to 1982 (1981 year class). The recruit/SSB survival ratios for these most recent year classes were also estimated to be very low compared to previous year classes. NEFSC spring and autumn research vessel bottom trawl survey indices for Gulf of Maine cod had declined to record low levels in the mid-1990s; indices from both surveys fluctuated at relatively low levels but have been increasing in 2001 and 2002. The 1994-1996 year classes derived from the NEFSC and Commonwealth of Massachusetts surveys were also among the lowest in the respective series, but the Mass. DMF survey and the 2001 and 2002 NEFSC surveys indicate that the 1998 year class may be larger than the recent average.

2.0 The Fishery

Commercial landings of Gulf of Maine cod declined to 1,636 metric tons (mt) in 1999, a 61 % decline from 1998 (Table F1; Figure F1). Commercial landings have since increased to 3,730 mt in 2000 and 4,416 mt in 2001. Discard estimates have been derived on a gear-quarter basis from 1989 through 2001 based on NEFSC Observer Program data; these results indicate a substantial increase in the overall discard /kept ratio in 1999 compared to previous years. Ratios calculated for 2000 and 2001 are lower than the 1999 ratio, but substantially greater than the pre-1999 ratios. Discards estimated from the Observer Program data equaled 2,600, 1,200 and 1,600 mt in 1999, 2000 and 2001, respectively. Discards have also been estimated based on Vessel Trip Reports, filtered to exclude vessels which do not report discards. Discards based on these data have been estimated to be 2,800, 2,200 and 1,600 mt in 1999, 2000, and 2001, respectively.

During the review of the 2001 assessment at SAW33, it was agreed that the discard estimates from both Sea Sample and VTR data could be accepted with reservation. It was then concluded that only approximations of the actual estimates in 500 mt increments were considered. For the purposes of the present assessment, the procedure agreed at SAW33 was employed for the 2001 data. Full details are given in Mayo *et al.* (2002). Discards as derived in this manner are given below:

| Year | Landings | Discard SS | Estimates VTR | SARC 33 As Used | Commercial Catch |
|------|----------|---------------|------------------|--------------------|---------------------|
| 1999 | 1,636 | 2,630 | 2,822 | 2,500 | 4,136 |
| 2000 | 3,730 | 1,170 | 2,246 | 1,000 | 4,730 |
| 2001 | 4,416 | 1,619 | 1,600 | 1,500* | 5,916 |

* SARC approach carried forward for 2001

The estimated recreational catch of Gulf of Maine cod (retained component only) remained the same in 1999 as in 1998 at approximately 822-824 mt, but increased to 1,100 mt in 2000 and 2,600 mt in 2001. For input to VPA, the landings at age were raised by the ratio of total catch (including discards) to landings under the assumption that high discarding in 1999-2001 was due to trip limits, resulting in discarding of all sizes in the same proportion as landings.

The number of commercial port samples for this stock declined from 78 in 1997 to 46 in 1998 to 15 in 1999. Port sampling has since improved, increasing to 61 samples in 2000 and 113 samples in 2001 (Table F2). Sampling was not well distributed among quarters and market categories in 1999 and 2000, as only 1 biological sample was taken in the 3rd and 4th quarter of 1999, requiring substantial pooling over quarter. In 1999 and 2000 samples from each market category were pooled on an annual basis, but improved sampling in 2001 allowed a return to the traditional quarterly pooling of samples within each market category. In 2001, sampling was approximately proportional to the distribution of the landings by market category (Table F3). As has generally been the case, the landings at age in 1999-2001 were dominated by age 3 and 4 cod (Table F4).

3.0 Research Vessel Surveys

NEFSC research vessel bottom trawl survey abundance and biomass indices for Gulf of Maine cod remained relatively low through autumn 1999 and spring 2000 (Table F5; Figure F2). The autumn 1999 indices increased slightly over 1998, while the spring 2000 indices decreased slightly from the 1999 values. However, biomass indices increased substantially in 2001 and spring 2002 over the 1999-2000 values.

Autumn biomass indices were also partitioned into inshore (strata 26 and 27; area 1,734 square miles) and offshore (strata 28-30, 36-40; 16,158 square miles) Gulf of Maine regions. When expressed in this manner, stratified mean weight per tow indices may be seen to represent comparative biomass density rather than indices of absolute biomass.

However, when appropriate weighting by area is applied to the respective inshore and offshore indices to allow comparison of absolute biomass between regions, the weighted indices provide a perspective on trends in absolute biomass. These results suggest that biomass has declined more precipitously in the offshore regions of the Gulf of Maine, while biomass in the inner region has declined at a lesser rate. Both inshore and offshore biomass indices have been increasing in

recent years, consistent with an expansion of the population to the offshore area. Recruitment indices for the 1994-1997 year classes derived from the NEFSC and Mass. DMF bottom trawl surveys are among the lowest in the respective series, although indices for the 1998 and 1999 year classes appear to be above the recent average. The 2000 year class appears to be the extremely weak.

4.0 Assessment

Input Data and Analyses

The present assessment represents a one-year update to the previous assessment (Mayo *et al.* 2002; NEFSC 2001). The same VPA formulation used in the previous assessment was employed in the present update, except that current year (2002) spring survey data were available. Catch at age data were updated for 2001 with the inclusion of commercial discards (1,500 mt in 2001) and recreational catch at age. NEFSC and Mass. DMF survey abundance indices (stratified mean number per tow at age) were updated through spring 2002. As in recent VPAs, commercial CPUE indices were included only through 1993.

Precision of the 2001 spawning stock biomass and fully recruited fishing mortality was derived from 1,000 bootstrap replicates of the VPA based on resampling of survey residuals. A retrospective analysis of terminal year estimates of stock sizes, fully recruited fishing mortality and SSB were also carried out. Projections through 2009 were also completed.

Assessment Results

Fully recruited fishing mortality (ages 4+) in 2001 is estimated at 0.47 (Table F6; Figure F3), and spawning stock biomass is estimated to have increased to 22,000 mt in 2001 (Table F6; Figure F4). The 1998 year class is estimated to be equivalent to the 1992 year class (approximately 9-10 million fish), while all intervening year classes are below the long term geometric mean (5.9 million fish). The 1999 year class is slightly below average, the 2000 year class (< 1 million fish) is by far the poorest of those estimated by the VPA, and the 1993-1995 year classes are about ½ the long term average.

VPA Diagnostics

Based on the variability indicated by the survey residuals, the bootstrap analysis suggests that there is a 90% probability that 2001 fully recruited fishing mortality is greater than 0.38, and 2001 SSB is less than 25,600 mt. With the current VPA formulation, a retrospective pattern is evident in the estimates of terminal F whereby fully recruited F appears to have been overestimated in 1999 and 2000 and underestimated from 1994-1997 (Figure F5). The opposite pattern is evident for SSB, although to a lesser extent. Terminal year estimates of the strength of the 1994-1996 year classes in 1995-1997 were considerably lower than the retrospective estimates, but recent year classes appear to have been well estimated in the terminal year

VPA Sensitivity Runs

The sensitivity of the VPA calibration process to various assumptions of changes in survey catchability during 2000 to 2002 was examined. Specifically, the 2000-2002 NEFSC spring and autumn age-specific indices were arbitrarily raised by 10%, 25%, and 100%, and the VPA calibration process was repeated. Bootstrapping each of the VPAs provided a series of overlap plots based on the 80% confidence intervals (80% CI). These results suggest considerable overlap between the 10% and 25% adjustment VPAs and the base VPA, with the 100% adjustment VPA exhibiting considerable distance from all others (Figure F6). Further details are presented in section 4.2 of this report.

5.0 Projections

Catch and stock size projections were performed with F_{2002} assumed equal to 85% of F_{2001} (0.40), and $F_{2003-2009}$ determined by iterating a revised estimate of $F_{rebuild}$ until there was a 50% probability that SSB was equal to SSB_{MSY} in 2009. The estimate of $F_{rebuild}$ based on the present VPA results is 0.114. Input data and projection results are given in Table F7 and Figure F7.

Medium term projections suggest that SSB will increase to SSB_{msy} (82,830 mt) by 2009 with at least a 50% probability if F is held at $F_{rebuild}$ (0.114) between 2003 and 2009 (Figure F7). Short term projections of catch for 2003 indicate that total catch (including commercial landings and discard, and recreational landings) should not exceed 2,479 mt if the revised estimate of $F_{rebuild}$ (0.114) is to be achieved in 2003.

6.0 Biological Reference Points

The following biological reference points were obtained from an age-structured production model (NEFSC 2002) performed on yield and SSB/recruit analyses and the VPA estimates of SSB and age 1 recruitment obtained from the 2001 assessment (Mayo *et al.* 2002):

| | |
|-------------|-------------------------|
| MSY | 16,600 mt |
| SSB_{MSY} | 82,830 mt |
| F_{MSY} | 0.225 (fully recruited) |

At that time, the fishing mortality required to rebuild SSB to SSB_{MSY} by 2009 was determined to be 0.165, based on starting conditions in 2001. The fishing mortality to rebuild to the same SSB_{MSY} was re-estimated from the results of the present assessment as 0.114, based on starting conditions in 2002. The differences are primarily due to the use of 85% of F_{2001} (0.40) in 2002 in the present analysis versus an assumption of F_{max} (0.258) in 2002 in the previous analysis, and the inclusion of the weak 2000 year class as part of the starting stock sizes in 2002 versus the geometric mean in the previous analysis. In addition the geometric mean recruitment applied in 2002 (5.9 million fish at age 1) is somewhat lower than the previous estimate (6.6 million) applied in 2001.

7.0 Conclusions

In 2001, SSB was less than $\frac{1}{2}$ SSB_{MSY} and fully recruited fishing mortality was about 2 times F_{MSY} . Therefore the stock is overfished and overfishing is occurring.

8.0 Summary

Fishing mortality appears to have declined considerably in 2001 compared to earlier years, and spawning biomass is continuing to increase. The SSB estimate for 2001 (22,000 mt) is close to the high values of 1982 and 1989-1991. However, the apparent improvement in the condition of the stock is dependent to a large extent on the incoming 1998 year class. The strength of subsequent year classes, however, is either just below average (1999 year class) or extremely low (2000 year class).

Although recent surveys have indicated a marked increase in biomass, especially spring 2001 and 2002 and autumn 2001, there appears to have been a catchability effect associated with the spring 2002 survey in which abundance indices at age for most cohorts increased over the previous year.

Overall, there is accumulating evidence that the biomass of Gulf of Maine cod has been increasing in 2001 and 2002. Further increases in biomass may occur if fishing mortality is reduced to maximize the contribution of the 1998 year class to the spawning stock. Based on the current maturity ogive, this year class will be fully mature at age 4 in 2002. However, given the expected relatively poor strength of the 1999 and 2000 year classes, rebuilding of the stock may plateau unless additional average or above average year classes recruit in the next several years.

9.0 GARM Panel Comments

The Panel commented that the stock distribution had collapsed into a small area within Massachusetts Bay; however, there is now some evidence that the stock is starting to expand towards the outer Gulf of Maine. The Panel observed that the 2000 year class was estimated to be the weakest in the time series but, at this time, it is premature to draw final conclusions regarding the strength of this year class given the retrospective pattern in recruitment estimates (i.e. in future assessments, the 2000 year class may not be as low as currently estimated). The Panel noted that the 2000 fishing mortality rate is lower than the estimate in the last assessment and this result is consistent with the retrospective pattern for fishing mortality which revealed a tendency to overestimate F in 2000.

Similarly, the Panel noted that the tuned 2001 F in the present assessment is considerably lower than the 2001 projected F (NEFSC 2002). This is due to several factors. The Projected 2001 F was based on stock conditions obtained from the 2001 VPA which was calibrated with research vessel survey data collected through autumn 2000. The present assessment utilizes 3 additional NEFSC surveys (2001 and 2002 spring and 2001 autumn), all of which indicated year over year increases in stock abundance, as well as corresponding Massachusetts surveys used to calibrate

stock size estimates of recruiting ages.

Sources of Uncertainty

- Discard estimates included in the assessment in 1999-2001 based on the approach recommended by the 33rd SAW are likely to have underestimated the actual discards because they were rounded down to the nearest lower 500 ton bin.
- The estimate of the size of the incoming 2000 year class in 2001 is uncertain, but its influence on the projections is substantial. In the past, estimates of low recruitment were revised upward as data from the fishery were included, but the final estimates still indicated that they were lowest in the VPA series. Subsequent estimates of the strength of the 2000 year class may also increase.

10.0 Research Recommendations

- Explore a VPA formulation where autumn tuning indices are adjusted back to Jan 1, instead of shifted forward one year and one age.
- Explore the use of the state of Maine survey as a tuning indices.
- Given the overall truncation in the age composition, investigate possible trends in size/age composition of the inshore versus offshore areas.
- Request the Methods Working Group to investigate means of deriving an appropriate sampling intensity for commercial landings.

11.0 References

Mayo, R.K., E.M. Thunberg, S.E. Wigley and S.X. Cadrin. 2002. The 2001 Assessment of the Gulf of Maine Atlantic Cod Stock. NMFS/NEFSC, Woods Hole Laboratory Ref. Doc. 02-02.

NEFSC. 2001. 33rd Northeast Regional Stock Assessment Workshop (33rd SAW). Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NMFS/NEFSC, Reference Document 01-18.

NEFSC 2002. Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. NMFS/NEFSC, Reference Document 02-04, 254p.

Table F1. Commercial landings (metric tons, live) of Atlantic cod from the Gulf of Maine (NAFO Division 5Y), 1960 - 2001.¹

| Year | Gulf of Maine | | | | Total |
|-------|---------------|--------|------|-------|-------|
| | USA | Canada | USSR | Other | |
| 1960 | 3448 | 129 | - | - | 3577 |
| 1961 | 3216 | 18 | - | - | 3234 |
| 1962 | 2989 | 83 | - | - | 3072 |
| 1963 | 2595 | 3 | 133 | - | 2731 |
| 1964 | 3226 | 25 | - | - | 3251 |
| 1965 | 3780 | 148 | - | - | 3928 |
| 1966 | 4008 | 384 | - | - | 4392 |
| 1967 | 5676 | 297 | - | - | 5973 |
| 1968 | 6360 | 61 | - | - | 6421 |
| 1969 | 8157 | 59 | - | 268 | 8484 |
| 1970 | 7812 | 26 | - | 423 | 8261 |
| 1971 | 7380 | 119 | - | 163 | 7662 |
| 1972 | 6776 | 53 | 11 | 77 | 6917 |
| 1973 | 6069 | 68 | - | 9 | 6146 |
| 1974 | 7639 | 120 | - | 5 | 7764 |
| 1975 | 8903 | 86 | - | 26 | 9015 |
| 1976 | 10172 | 16 | - | - | 10188 |
| 1977 | 12426 | - | - | - | 12426 |
| 1978 | 12426 | - | - | - | 12426 |
| 1979 | 11680 | - | - | - | 11680 |
| 1980 | 13528 | - | - | - | 13528 |
| 1981 | 12534 | - | - | - | 12534 |
| 1982 | 13582 | - | - | - | 13582 |
| 1983 | 13981 | - | - | - | 13981 |
| 1984 | 10806 | - | - | - | 10806 |
| 1985 | 10693 | - | - | - | 10693 |
| 1986 | 9664 | - | - | - | 9664 |
| 1987 | 7527 | - | - | - | 7527 |
| 1988 | 7958 | - | - | - | 7958 |
| 1989 | 10397 | - | - | - | 10397 |
| 1990 | 15154 | - | - | - | 15154 |
| 1991 | 17781 | - | - | - | 17781 |
| 1992 | 10891 | - | - | - | 10891 |
| 1993 | 8287 | - | - | - | 8287 |
| 1994* | 7877 | - | - | - | 7877 |
| 1995* | 6798 | - | - | - | 6798 |
| 1996* | 7194 | - | - | - | 7194 |
| 1997* | 5421 | - | - | - | 5421 |
| 1998* | 4156 | - | - | - | 4156 |
| 1999* | 1636 | - | - | - | 1636 |
| 2000* | 3730 | - | - | - | 3730 |
| 2001* | 4416 | - | - | - | 4416 |

* Provisional

¹ USA 1960-1993 landings from NMFS, NEFSC Detailed Weighout Files and Canvass data.

² USA 1994-2001 landings estimated by prorating NMFS, NEFSC Detailed Weighout data by Vessel Trip Reports.

Table F2. USA sampling of commercial Atlantic cod landings from the Gulf of Maine cod stock (NAFO Division 5Y), 1982 - 2001.

| 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. | No. Fish Measured | No. | No. Fish Aged | Q1 | Q2 | Q3 | Q4 | Σ | Q1 | Q2 | Q3 | Q4 | Σ | Q1 | Q2 | Q3 | Q4 | Σ | Scrod | Market | Large | Σ |
| 1982 | 48 | 3848 | 48 | 866 | 6 | 7 | 6 | 6 | 25 | 4 | 3 | 7 | 4 | 18 | 0 | 2 | 1 | 2 | 5 | 134 | 348 | 792 | 266 |
| 1983 | 71 | 5241 | 67 | 1348 | 14 | 10 | 10 | 4 | 38 | 4 | 10 | 6 | 2 | 22 | 1 | 3 | 5 | 2 | 11 | 106 | 294 | 318 | 197 |
| 1984 | 55 | 3925 | 55 | 1224 | 7 | 5 | 6 | 7 | 25 | 4 | 3 | 5 | 6 | 18 | 1 | 6 | 3 | 2 | 12 | 85 | 319 | 245 | 193 |
| 1985 | 69 | 5426 | 66 | 1546 | 5 | 6 | 7 | 5 | 23 | 8 | 6 | 7 | 4 | 25 | 7 | 5 | 3 | 6 | 21 | 95 | 229 | 132 | 155 |
| 1986 | 53 | 3970 | 51 | 1160 | 5 | 5 | 6 | 3 | 19 | 5 | 6 | 8 | 2 | 21 | 1 | 5 | 4 | 3 | 13 | 124 | 242 | 170 | 182 |
| 1987 | 43 | 3184 | 42 | 939 | 4 | 4 | 3 | 4 | 15 | 5 | 5 | 3 | 5 | 18 | 4 | 2 | 3 | 1 | 10 | 83 | 224 | 225 | 175 |
| 1988 | 34 | 2669 | 33 | 741 | 4 | 3 | 4 | 4 | 15 | 1 | 5 | 3 | 5 | 14 | 1 | 2 | 2 | 0 | 5 | 147 | 271 | 391 | 234 |
| 1989 | 32 | 2668 | 32 | 714 | 3 | 3 | 3 | 3 | 12 | 4 | 1 | 5 | 4 | 14 | 2 | 2 | 1 | 1 | 6 | 209 | 430 | 311 | 325 |
| 1990 | 39 | 2982 | 38 | 789 | 3 | 7 | 3 | 5 | 18 | 4 | 7 | 4 | 3 | 18 | 0 | 2 | 1 | 0 | 3 | 300 | 378 | 966 | 387 |
| 1991 | 56 | 4519 | 56 | 1152 | 2 | 10 | 4 | 3 | 19 | 5 | 11 | 11 | 3 | 30 | 0 | 3 | 3 | 1 | 7 | 250 | 313 | 519 | 318 |
| 1992 | 51 | 4086 | 51 | 1002 | 2 | 8 | 6 | 3 | 19 | 6 | 7 | 7 | 3 | 23 | 3 | 1 | 1 | 4 | 9 | 104 | 232 | 375 | 214 |
| 1993 | 23 | 1753 | 23 | 447 | 3 | 3 | 3 | 1 | 10 | 1 | 2 | 4 | 1 | 8 | 1 | 1 | 2 | 1 | 5 | 177 | 453 | 527 | 360 |
| 1994 | 30 | 2696 | 33 | 665 | 0 | 2 | 2 | 4 | 8 | 1 | 4 | 4 | 6 | 15 | 0 | 2 | 3 | 2 | 7 | 180 | 284 | 272 | 263 |
| 1995 | 31 | 2568 | 32 | 662 | 4 | 2 | 2 | 4 | 12 | 2 | 7 | 1 | 2 | 12 | 0 | 5 | 0 | 2 | 7 | 133 | 300 | 202 | 219 |
| 1996 | 77 | 7027 | 71 | 1483 | 6 | 5 | 7 | 9 | 27 | 7 | 9 | 10 | 12 | 38 | 1 | 3 | 3 | 5 | 12 | 62 | 116 | 79 | 93 |
| 1997 | 78 | 6657 | 74 | 1521 | 7 | 10 | 3 | 9 | 29 | 11 | 9 | 9 | 7 | 36 | 1 | 8 | 2 | 2 | 13 | 37 | 91 | 71 | 69 |
| 1998 | 46 | 4205 | 46 | 912 | 4 | 7 | 0 | 3 | 14 | 8 | 9 | 9 | 3 | 29 | 0 | 0 | 2 | 1 | 3 | 53 | 81 | 321 | 90 |
| 1999 | 15 | 1305 | 16 | 350 | 6 | 0 | 1 | 0 | 7 | 4 | 2 | 0 | 0 | 6 | 2 | 0 | 0 | 0 | 2 | 36 | 144 | 245 | 109 |
| 2000 | 61 | 4687 | 57 | 1300 | 12 | 5 | 3 | 4 | 24 | 12 | 14 | 4 | 6 | 36 | 0 | 0 | 0 | 1 | 1 | 14 | 62 | 1131 | 61 |
| 2001 | 113 | 7326 | 105 | 2436 | 4 | 4 | 4 | 7 | 19 | 7 | 9 | 8 | 15 | 39 | 3 | 16 | 18 | 18 | 55 | 18 | 58 | 32 | 39 |

Source: 1982-1985 from Serchuk and wigley (1986); 1986-2001 from NEFSC files.

Table F3. Percentage (by weight) of USA commercial Atlantic cod landings from the Gulf of Maine (NAFO Division 5Y), by market category, 1964 - 2001.

| Year | Gulf of Maine | | | Total [a] |
|------|---------------|--------|-------|-----------|
| | Large | Market | Scrod | |
| 1964 | 29 | 59 | 12 | 100 |
| 1965 | 39 | 54 | 7 | 100 |
| 1966 | 42 | 48 | 10 | 100 |
| 1967 | 41 | 41 | 17 | 100 |
| 1968 | 47 | 43 | 9 | 100 |
| 1969 | 35 | 55 | 9 | 100 |
| 1970 | 43 | 52 | 6 | 100 |
| 1971 | 52 | 42 | 6 | 100 |
| 1972 | 58 | 35 | 7 | 100 |
| 1973 | 52 | 36 | 11 | 100 |
| 1974 | 39 | 33 | 28 | 100 |
| 1975 | 32 | 42 | 26 | 100 |
| 1976 | 29 | 45 | 20 | 100 |
| 1977 | 33 | 42 | 22 | 100 |
| 1978 | 38 | 44 | 17 | 100 |
| 1979 | 37 | 49 | 14 | 100 |
| 1980 | 36 | 45 | 19 | 100 |
| 1981 | 29 | 45 | 22 | 100 |
| 1982 | 29 | 45 | 24 | 100 |
| 1983 | 25 | 45 | 28 | 100 |
| 1984 | 26 | 51 | 19 | 100 |
| 1985 | 25 | 51 | 20 | 100 |
| 1986 | 22 | 51 | 23 | 100 |
| 1987 | 29 | 52 | 16 | 100 |
| 1988 | 26 | 45 | 23 | 100 |
| 1989 | 17 | 55 | 23 | 100 |
| 1990 | 34 | 43 | 19 | 100 |
| 1991 | 26 | 51 | 20 | 100 |
| 1992 | 31 | 49 | 18 | 100 |
| 1993 | 32 | 44 | 21 | 100 |
| 1994 | 24 | 54 | 18 | 100 |
| 1995 | 21 | 53 | 23 | 100 |
| 1996 | 13 | 61 | 23 | 100 |
| 1997 | 17 | 60 | 20 | 100 |
| 1998 | 23 | 57 | 18 | 100 |
| 1999 | 29 | 53 | 16 | 100 |
| 2000 | 30 | 59 | 9 | 100 |
| 2001 | 40 | 51 | 8 | 100 |

[a] Includes landings of 'mixed' cod.

Table F4a. Total (commercial and recreational) landings at age (thousands of fish; metric tons) of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2001. (Input data for Virtual Population Analysis)

| Year | Age | | | | | | | Total |
|---|-----|------|------|-------|------|------|------|-------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7+ | |
| Total Landings at Age in Numbers (000's) | | | | | | | | |
| 1982 | 88 | 1995 | 2350 | 1386 | 717 | 75 | 242 | 6853 |
| 1983 | 14 | 1337 | 2896 | 1184 | 685 | 448 | 169 | 6733 |
| 1984 | 24 | 813 | 1572 | 1636 | 469 | 205 | 142 | 4861 |
| 1985 | 49 | 989 | 2111 | 1122 | 665 | 133 | 137 | 5206 |
| 1986 | 26 | 208 | 2750 | 929 | 275 | 197 | 190 | 4575 |
| 1987 | 41 | 907 | 1418 | 1525 | 330 | 79 | 97 | 4397 |
| 1988 | 6 | 520 | 2140 | 1149 | 434 | 51 | 34 | 4334 |
| 1989 | 5 | 530 | 2284 | 1698 | 485 | 91 | 61 | 5154 |
| 1990 | 7 | 294 | 4195 | 2373 | 488 | 167 | 105 | 7629 |
| 1991 | 5 | 447 | 1349 | 4948 | 946 | 151 | 85 | 7931 |
| 1992 | - | 350 | 600 | 526 | 2184 | 218 | 86 | 3962 |
| 1993 | 1 | 152 | 1998 | 787 | 140 | 481 | 39 | 3597 |
| 1994 | 1 | 57 | 1380 | 1228 | 315 | 74 | 88 | 3143 |
| 1995 | - | 279 | 1152 | 1324 | 204 | 14 | 34 | 3007 |
| 1996 | - | 86 | 688 | 1943 | 368 | 46 | 10 | 3141 |
| 1997 | - | 61 | 494 | 466 | 894 | 72 | 8 | 1995 |
| 1998 | - | 110 | 485 | 616 | 180 | 211 | 11 | 1614 |
| 1999 ¹ | 1 | 8 | 563 | 566 | 267 | 78 | 104 | 1586 |
| 2000 ² | - | 97 | 485 | 934 | 211 | 96 | 25 | 1849 |
| 2000 ³ | - | 56 | 1000 | 666 | 370 | 104 | 87 | 2281 |
| Total Landings at Age in Weight (Tons) | | | | | | | | |
| 1982 | 50 | 2151 | 3735 | 3719 | 3392 | 494 | 2738 | 16279 |
| 1983 | 6 | 1421 | 4664 | 2891 | 2568 | 2691 | 1680 | 15921 |
| 1984 | 12 | 820 | 2551 | 4412 | 1710 | 1192 | 1462 | 12169 |
| 1985 | 18 | 1007 | 3442 | 3121 | 2929 | 725 | 1327 | 12549 |
| 1986 | 11 | 213 | 4946 | 2679 | 1252 | 1186 | 2225 | 12512 |
| 1987 | 13 | 917 | 2185 | 4752 | 1564 | 547 | 998 | 10976 |
| 1988 | 1 | 513 | 3764 | 2736 | 2204 | 321 | 363 | 9902 |
| 1989 | 3 | 628 | 3922 | 4979 | 1861 | 386 | 726 | 12575 |
| 1990 | 1 | 299 | 6941 | 5414 | 2046 | 1266 | 1424 | 17391 |
| 1991 | 1 | 507 | 2045 | 12204 | 3807 | 1093 | 944 | 20601 |
| 1992 | - | 536 | 1149 | 1432 | 6684 | 1080 | 911 | 11793 |
| 1993 | 1 | 172 | 3650 | 1903 | 594 | 2927 | 428 | 9675 |
| 1994 | - | 78 | 2568 | 3790 | 1047 | 449 | 868 | 8799 |
| 1995 | - | 452 | 2132 | 3531 | 1033 | 100 | 455 | 7703 |
| 1996 | - | 142 | 1440 | 4537 | 1321 | 340 | 109 | 7889 |
| 1997 | - | 105 | 1088 | 1382 | 2807 | 328 | 71 | 5781 |
| 1998 | - | 147 | 1023 | 1809 | 744 | 871 | 109 | 4701 |
| 1999 ¹ | - | 10 | 1036 | 1573 | 1093 | 449 | 801 | 4963 |
| 2000 ² | - | 156 | 1103 | 3090 | 905 | 559 | 181 | 5996 |
| 2000 ³ | - | 104 | 2387 | 2143 | 1784 | 661 | 705 | 7780 |

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

Table F4b. Mean weight (kg) and mean length (cm) at age of total landings (commercial and recreational) of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 2001. (Input data for Virtual Population Analysis)

| Year | Age | | | | | | | Average |
|---|-------|-------|-------|-------|-------|-------|--------|---------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7+ | |
| Total Landings Mean Weight (kg) at Age | | | | | | | | |
| 1982 | 0.568 | 1.078 | 1.589 | 2.683 | 4.731 | 6.587 | 11.314 | 2.375 |
| 1983 | 0.429 | 1.063 | 1.610 | 2.442 | 3.749 | 6.007 | 9.941 | 2.365 |
| 1984 | 0.500 | 1.009 | 1.623 | 2.697 | 3.646 | 5.815 | 10.296 | 2.503 |
| 1985 | 0.367 | 1.018 | 1.621 | 2.782 | 4.405 | 5.451 | 9.686 | 2.410 |
| 1986 | 0.423 | 1.024 | 1.799 | 2.884 | 4.553 | 6.020 | 11.711 | 2.735 |
| 1987 | 0.317 | 1.011 | 1.541 | 3.116 | 4.739 | 6.924 | 10.289 | 2.496 |
| 1988 | 0.167 | 0.987 | 1.759 | 2.381 | 5.078 | 6.294 | 10.676 | 2.285 |
| 1989 | 0.600 | 1.185 | 1.717 | 2.932 | 3.837 | 4.242 | 11.902 | 2.440 |
| 1990 | 0.143 | 1.017 | 1.655 | 2.282 | 4.193 | 7.581 | 13.562 | 2.280 |
| 1991 | 0.171 | 1.134 | 1.516 | 2.466 | 4.024 | 7.238 | 11.106 | 2.598 |
| 1992 | 0.468 | 1.531 | 1.915 | 2.722 | 3.060 | 5.000 | 10.593 | 2.977 |
| 1993 | 1.000 | 1.132 | 1.627 | 2.418 | 4.243 | 6.085 | 10.974 | 2.690 |
| 1994 | 0.418 | 1.368 | 1.861 | 3.086 | 3.324 | 6.068 | 9.864 | 2.800 |
| 1995 | 0.418 | 1.620 | 1.851 | 2.667 | 5.064 | 7.143 | 13.382 | 2.562 |
| 1996 | 0.418 | 1.651 | 2.093 | 2.335 | 3.590 | 7.391 | 10.900 | 2.512 |
| 1997 | 0.418 | 1.721 | 2.202 | 2.966 | 3.140 | 4.556 | 8.875 | 2.898 |
| 1998 | 0.466 | 1.336 | 2.109 | 2.937 | 4.133 | 4.128 | 9.909 | 2.913 |
| 1999 | 0.331 | 1.250 | 1.841 | 2.776 | 4.100 | 5.736 | 7.702 | 3.129 |
| 2000 | 0.418 | 1.600 | 2.274 | 3.310 | 4.291 | 5.811 | 7.307 | 3.243 |
| 2001 | 0.418 | 1.868 | 2.388 | 3.215 | 4.817 | 6.370 | 8.103 | 3.411 |
| Total Landings Mean Length (cm) at Age | | | | | | | | |
| 1982 | 37.1 | 46.6 | 52.7 | 62.6 | 76.5 | 85.6 | 101.4 | 57.4 |
| 1983 | 33.5 | 46.6 | 53.1 | 61.0 | 70.5 | 82.5 | 95.6 | 58.0 |
| 1984 | 28.5 | 45.5 | 53.3 | 63.1 | 69.5 | 81.2 | 98.1 | 59.3 |
| 1985 | 32.0 | 45.4 | 53.3 | 64.1 | 74.5 | 79.9 | 96.6 | 58.5 |
| 1986 | 33.7 | 45.1 | 55.3 | 64.6 | 75.0 | 82.4 | 105.9 | 61.1 |
| 1987 | 26.4 | 45.1 | 52.1 | 66.4 | 76.2 | 86.4 | 98.4 | 58.8 |
| 1988 | 26.2 | 45.0 | 54.7 | 60.6 | 78.1 | 83.2 | 100.5 | 58.1 |
| 1989 | 38.4 | 48.5 | 54.6 | 65.1 | 71.2 | 77.5 | 103.1 | 60.0 |
| 1990 | 23.7 | 46.2 | 54.1 | 60.0 | 73.2 | 89.7 | 108.9 | 58.3 |
| 1991 | 24.9 | 47.5 | 51.9 | 61.3 | 71.8 | 88.1 | 100.7 | 61.1 |
| 1992 | 31.3 | 52.9 | 56.4 | 62.9 | 65.5 | 76.9 | 100.1 | 64.1 |
| 1993 | 38.0 | 47.4 | 55.9 | 60.8 | 73.5 | 83.2 | 101.7 | 61.4 |
| 1994 | 26.3 | 50.3 | 56.1 | 66.0 | 67.2 | 82.4 | 97.5 | 62.8 |
| 1995 | 31.2 | 53.8 | 56.0 | 62.4 | 78.0 | 87.2 | 107.1 | 60.9 |
| 1996 | 31.2 | 54.0 | 58.3 | 60.3 | 68.9 | 88.9 | 103.5 | 61.2 |
| 1997 | 31.2 | 54.6 | 59.4 | 65.0 | 66.3 | 74.8 | 104.6 | 64.4 |
| 1998 | 35.0 | 50.7 | 58.4 | 64.8 | 72.4 | 72.1 | 95.1 | 63.9 |
| 1999 | 33.0 | 47.4 | 56.0 | 63.9 | 72.1 | 80.7 | 89.9 | 64.9 |
| 2000 | 31.2 | 53.4 | 59.4 | 65.6 | 73.7 | 82.3 | 88.1 | 66.4 |
| 2001 | 31.2 | 56.3 | 60.9 | 66.8 | 76.9 | 84.5 | 91.3 | 66.9 |

Table F5. 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 - 2002 [a,b,c].

| Year | Spring | | Autumn | |
|------|--------|--------|--------|--------|
| | No/Tow | Wt/Tow | No/Tow | Wt/Tow |
| 1963 | - | - | 5.92 | 17.9 |
| 1964 | - | - | 4.00 | 22.8 |
| 1965 | - | - | 4.49 | 12.0 |
| 1966 | - | - | 3.78 | 12.9 |
| 1967 | - | - | 2.56 | 9.2 |
| 1968 | 5.44 | 17.9 | 4.39 | 19.4 |
| 1969 | 3.25 | 13.2 | 2.76 | 15.4 |
| 1970 | 2.21 | 11.1 | 4.90 | 16.4 |
| 1971 | 1.43 | 7.0 | 4.37 | 16.5 |
| 1972 | 2.06 | 8.0 | 9.31 | 13.0 |
| 1973 | 7.54 | 18.8 | 4.46 | 8.7 |
| 1974 | 2.91 | 7.4 | 4.33 | 9.0 |
| 1975 | 2.51 | 6.0 | 6.15 | 8.6 |
| 1976 | 2.78 | 7.6 | 2.15 | 6.7 |
| 1977 | 3.88 | 8.5 | 3.08 | 10.2 |
| 1978 | 2.06 | 7.7 | 5.75 | 12.9 |
| 1979 | 4.27 | 9.5 | 3.49 | 17.5 |
| 1980 | 2.15 | 6.2 | 7.04 | 14.2 |
| 1981 | 4.86 | 10.8 | 2.42 | 8.1 |
| 1982 | 3.75 | 8.6 | 7.77 | 16.1 |
| 1983 | 3.91 | 10.5 | 4.22 | 8.8 |
| 1984 | 3.40 | 5.8 | 2.42 | 8.8 |
| 1985 | 2.52 | 7.7 | 2.92 | 8.5 |
| 1986 | 1.96 | 3.6 | 1.95 | 5.1 |
| 1987 | 1.68 | 3.0 | 2.98 | 3.4 |
| 1988 | 3.13 | 3.3 | 5.90 | 6.6 |
| 1989 | 2.26 | 2.5 | 4.65 | 4.6 |
| 1990 | 2.36 | 3.1 | 2.99 | 4.9 |
| 1991 | 2.39 | 2.9 | 1.25 | 2.8 |
| 1992 | 2.41 | 8.7 | 1.43 | 2.4 |
| 1993 | 2.50 | 5.9 | 1.23 | 1.0 |
| 1994 | 1.27 | 2.4 | 2.14 | 2.7 |
| 1995 | 1.91 | 2.4 | 2.01 | 3.7 |
| 1996 | 2.46 | 5.4 | 1.32 | 2.4 |
| 1997 | 2.19 | 5.6 | 0.87 | 1.9 |
| 1998 | 1.71 | 4.2 | 0.84 | 1.5 |
| 1999 | 2.30 | 5.1 | 1.81 | 3.5 |
| 2000 | 3.08 | 3.2 | 2.60 | 4.7 |
| 2001 | 2.15 | 6.2 | 1.98 | 7.3 |
| 2002 | 3.72 | 10.9 | | |

[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 ALBATROSS IV equivalents. Conversion coefficients 0.79 (number) and 0.67 (weight) were used in this standardization (NEFSC 1991).

Table F6. Final VPA Results for Gulf of Maine Cod, 1982-2002.

| STOCK NUMBERS (Jan 1) in thousands - | | | | | | | |
|--------------------------------------|-------|-------|-------|-------|-------|-------|-------|
| | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
| 1 | 7769 | 7539 | 10464 | 7004 | 10161 | 12538 | 25198 |
| 2 | 10891 | 6281 | 6160 | 8545 | 5690 | 8296 | 10228 |
| 3 | 5359 | 7112 | 3933 | 4307 | 6101 | 4471 | 5971 |
| 4 | 3026 | 2262 | 3202 | 1797 | 1616 | 2507 | 2377 |
| 5 | 1796 | 1223 | 780 | 1142 | 456 | 483 | 673 |
| 6 | 170 | 822 | 382 | 214 | 333 | 125 | 97 |
| 7 | 541 | 305 | 260 | 216 | 315 | 150 | 63 |
| 1+ | 29552 | 25543 | 25180 | 23227 | 24674 | 28569 | 44607 |
| | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
| 1 | 4302 | 4021 | 6994 | 6419 | 9373 | 3383 | 3457 |
| 2 | 20625 | 3518 | 3286 | 5721 | 5255 | 7673 | 2769 |
| 3 | 7903 | 16407 | 2614 | 2286 | 4368 | 4165 | 6231 |
| 4 | 2953 | 4404 | 9637 | 920 | 1328 | 1768 | 2161 |
| 5 | 907 | 881 | 1459 | 3413 | 277 | 376 | 336 |
| 6 | 158 | 303 | 280 | 338 | 818 | 100 | 22 |
| 7 | 104 | 188 | 155 | 132 | 65 | 116 | 53 |
| 1+ | 36952 | 29721 | 24423 | 19228 | 21485 | 17581 | 15030 |
| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
| 1 | 3377 | 5055 | 5183 | 10078 | 4564 | 566 | 00 |
| 2 | 2830 | 2765 | 4138 | 4243 | 8250 | 3737 | 463 |
| 3 | 2014 | 2239 | 2208 | 3289 | 3467 | 6667 | 3009 |
| 4 | 4059 | 1027 | 1386 | 1369 | 2183 | 2399 | 4554 |
| 5 | 572 | 1565 | 419 | 578 | 609 | 942 | 1362 |
| 6 | 91 | 135 | 473 | 180 | 231 | 308 | 437 |
| 7 | 19 | 15 | 24 | 237 | 60 | 255 | 289 |
| 1+ | 12962 | 12800 | 13832 | 19974 | 19364 | 14874 | 10113 |
| FISHING MORTALITY - | | | | | | | |
| | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
| 1 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| 2 | 0.23 | 0.27 | 0.16 | 0.14 | 0.04 | 0.13 | 0.06 |
| 3 | 0.66 | 0.60 | 0.58 | 0.78 | 0.69 | 0.43 | 0.50 |
| 4 | 0.71 | 0.86 | 0.83 | 1.17 | 1.01 | 1.12 | 0.76 |
| 5 | 0.58 | 0.96 | 1.09 | 1.03 | 1.10 | 1.41 | 1.25 |
| 6 | 0.67 | 0.92 | 0.90 | 1.16 | 1.06 | 1.20 | 0.87 |
| 7 | 0.67 | 0.92 | 0.90 | 1.16 | 1.06 | 1.20 | 0.87 |
| 4-5,u | 0.64 | 0.91 | 0.96 | 1.10 | 1.05 | 1.26 | 1.01 |
| | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.03 | 0.10 | 0.16 | 0.07 | 0.03 | 0.01 | 0.12 |
| 3 | 0.38 | 0.33 | 0.84 | 0.34 | 0.70 | 0.46 | 0.23 |
| 4 | 1.01 | 0.91 | 0.84 | 1.00 | 1.06 | 1.46 | 1.13 |
| 5 | 0.89 | 0.95 | 1.26 | 1.23 | 0.82 | 2.62 | 1.11 |
| 6 | 1.01 | 0.94 | 0.91 | 1.22 | 1.05 | 1.70 | 1.17 |
| 7 | 1.01 | 0.94 | 0.91 | 1.22 | 1.05 | 1.70 | 1.17 |
| 4-5,u | 0.95 | 0.93 | 1.05 | 1.11 | 0.94 | 2.04 | 1.12 |

Table F6 (Continued).

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | |
|--|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 2 | 0.03 | 0.02 | 0.03 | 0.00 | 0.01 | 0.02 | |
| 3 | 0.47 | 0.28 | 0.28 | 0.21 | 0.17 | 0.18 | |
| 4 | 0.75 | 0.70 | 0.68 | 0.61 | 0.64 | 0.37 | |
| 5 | 1.24 | 1.00 | 0.64 | 0.71 | 0.48 | 0.57 | |
| 6 | 0.82 | 0.89 | 0.68 | 0.65 | 0.61 | 0.47 | |
| 7 | 0.82 | 0.89 | 0.68 | 0.65 | 0.61 | 0.47 | |
| 4-5,u | 1.00 | 0.85 | 0.66 | 0.66 | 0.56 | 0.47 | |
| Jan 1 BIOMASS (using Jan 1 mean weights) | | | | | | | |
| | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
| 1 | 3224 | 2111 | 3662 | 1541 | 2784 | 2257 | 1588 |
| 2 | 9606 | 4880 | 4053 | 6093 | 3488 | 5426 | 5717 |
| 3 | 6871 | 9367 | 5164 | 5509 | 8255 | 5615 | 7966 |
| 4 | 6869 | 4455 | 6674 | 3819 | 3495 | 5937 | 4552 |
| 5 | 7542 | 3880 | 2328 | 3935 | 1624 | 1785 | 2676 |
| 6 | 948 | 4381 | 1782 | 956 | 1715 | 701 | 528 |
| 7 | 6122 | 3030 | 2678 | 2097 | 3690 | 1543 | 678 |
| 1+ | 41181 | 32104 | 26341 | 23950 | 25051 | 23263 | 23705 |
| | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
| 1 | 1983 | 205 | 399 | 1630 | 8014 | 717 | 726 |
| 2 | 9178 | 2747 | 1324 | 2929 | 3616 | 8978 | 2279 |
| 3 | 10290 | 22969 | 3247 | 3369 | 7303 | 6044 | 9913 |
| 4 | 6705 | 8716 | 19466 | 1868 | 2859 | 4197 | 4816 |
| 5 | 2741 | 3089 | 4420 | 9375 | 941 | 1065 | 1330 |
| 6 | 734 | 1636 | 1541 | 1517 | 3530 | 508 | 109 |
| 7 | 1238 | 2544 | 1720 | 1396 | 714 | 1141 | 714 |
| 1+ | 32869 | 41906 | 32116 | 22085 | 26976 | 22649 | 19887 |
| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | |
| 1 | 696 | 1183 | 1254 | 1522 | 1114 | 138 | |
| 2 | 2352 | 2345 | 3091 | 3068 | 6006 | 2679 | |
| 3 | 3708 | 4270 | 4207 | 5157 | 5845 | 11261 | |
| 4 | 8439 | 2558 | 3526 | 3314 | 5390 | 5939 | |
| 5 | 1769 | 4238 | 1467 | 2005 | 2102 | 3467 | |
| 6 | 556 | 546 | 1701 | 877 | 1129 | 1565 | |
| 7 | 212 | 131 | 241 | 1827 | 435 | 2066 | |
| 1+ | 17731 | 15272 | 15487 | 17768 | 22021 | 27114 | |

Table F6 (Continued).

| SSB AT THE START OF THE SPAWNING SEASON -MALES AND FEMALES (MT) (using SSB mean weights) | | | | | | | |
|--|-------|-------|-------|-------|-------|-------|-------|
| | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
| 1 | 218 | 143 | 248 | 60 | 108 | 87 | 61 |
| 2 | 2326 | 1174 | 993 | 2765 | 1608 | 2465 | 2629 |
| 3 | 3630 | 5002 | 2764 | 4445 | 6762 | 4801 | 6729 |
| 4 | 5197 | 3283 | 4945 | 3039 | 2857 | 4768 | 3877 |
| 5 | 6421 | 3100 | 1821 | 3204 | 1308 | 1365 | 2102 |
| 6 | 820 | 3633 | 1483 | 763 | 1390 | 554 | 442 |
| 7 | 5296 | 2513 | 2229 | 1672 | 2991 | 1221 | 567 |
| 1+ | 23908 | 18848 | 14484 | 15947 | 17024 | 15262 | 16406 |
| | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
| 1 | 77 | 22 | 42 | 173 | 853 | 28 | 28 |
| 2 | 4241 | 732 | 349 | 784 | 974 | 3295 | 821 |
| 3 | 8868 | 11771 | 1528 | 1724 | 3517 | 4822 | 8214 |
| 4 | 5481 | 5872 | 13262 | 1239 | 1876 | 3151 | 3820 |
| 5 | 2284 | 2372 | 3221 | 6871 | 739 | 666 | 1069 |
| 6 | 599 | 1327 | 1255 | 1173 | 2809 | 370 | 87 |
| 7 | 1012 | 2104 | 1430 | 1101 | 580 | 831 | 568 |
| 1+ | 22561 | 24200 | 21088 | 13065 | 11347 | 13163 | 14608 |
| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | |
| 1 | 27 | 46 | 49 | 59 | 43 | 05 | |
| 2 | 859 | 858 | 1131 | 1127 | 2203 | 982 | |
| 3 | 2950 | 3509 | 3458 | 4286 | 4892 | 9405 | |
| 4 | 7127 | 2181 | 3016 | 2866 | 4639 | 5350 | |
| 5 | 1391 | 3471 | 1274 | 1721 | 1875 | 3049 | |
| 6 | 469 | 455 | 1469 | 761 | 986 | 1400 | |
| 7 | 179 | 109 | 208 | 1585 | 380 | 1848 | |
| 1+ | 13001 | 10630 | 10604 | 12405 | 15019 | 22040 | |

Table F7a. Starting conditions and input data for short-term (2002-2004) stochastic stock biomass and catch projections for Gulf of Maine cod.

Input for Projections:

Number of Years: 3; Initial Year: 2002; Final Year: 2004
Number of Ages : 7; Age at Recruitment: 1; Last Age: 7
Natural Mortality is assumed Constant over time at: .200
Proportion of F before spawning: .1667
Proportion of M before spawning: .1667
Last age is a PLUS group;

Age-specific Input data for Projection # 1

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

Table F7b. Results of short-term stochastic stock biomass and catch projections for Gulf of Maine cod.

Projections for 2002-2004;
F2002=0.40 Basis: 85% of Status quo 2001 point estimate.

Recruitment (age 1) 2002 and 2003 year classes derived from Beverton-Holts spawning stock-recruitment relationship based on 1981-1999 year classes.

SSB was estimated to be 22,000 mt in 2001.

| | 2002 | | 2003 | | | 2004 | | |
|------|------|-------|------|-----------------------------|-------|-------|-------|-------|
| | F | Catch | SSB | F | Catch | SSB | Catch | SSB |
| 0.40 | 7786 | 23616 | | F _{rebuild} =0.114 | 2479 | 22831 | 2916 | 31544 |

Gulf of Maine Cod Total Commercial Landings

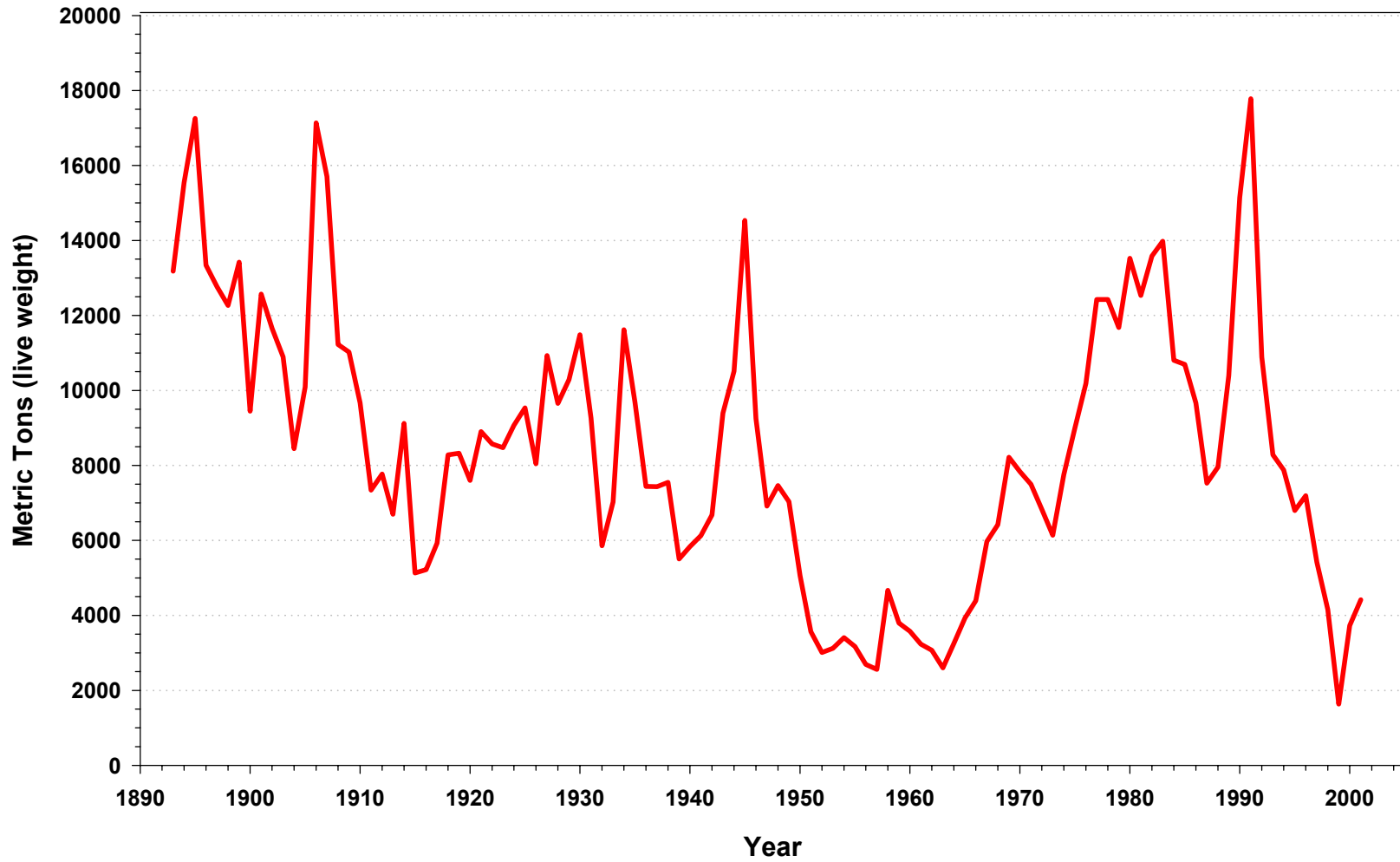


Figure F1. Total commercial landings of Gulf of Maine cod (NAFO Div. 5Y), 1893-2001.

Gulf of Maine Cod NEFSC Spring and Autumn Biomass Indices

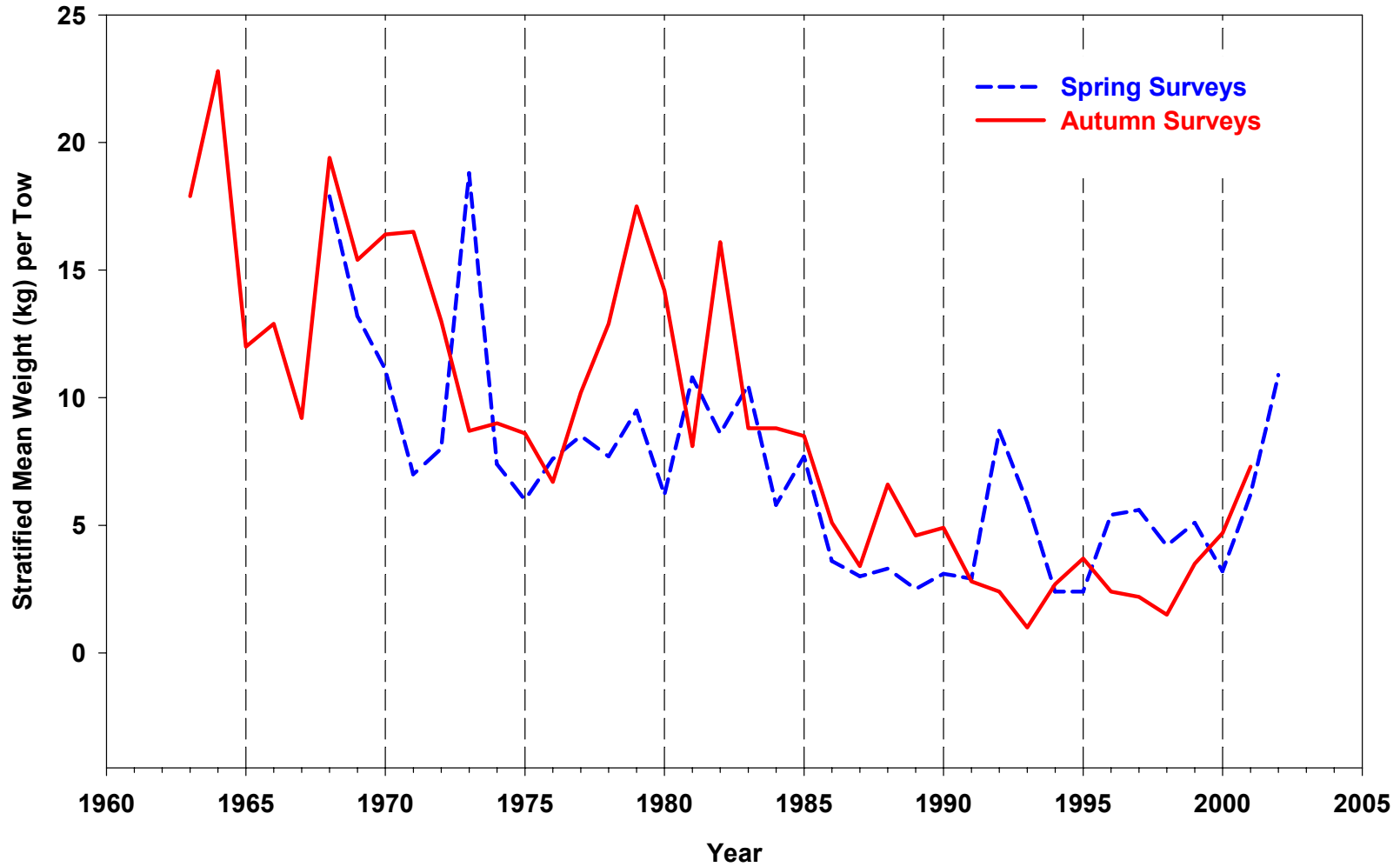


Figure F2. Biomass indices (stratified mean weight per tow) for Gulf of Maine cod from NEFSC autumn bottom trawl surveys.

Gulf of Maine Cod Trends in Landings and Fishing Mortality

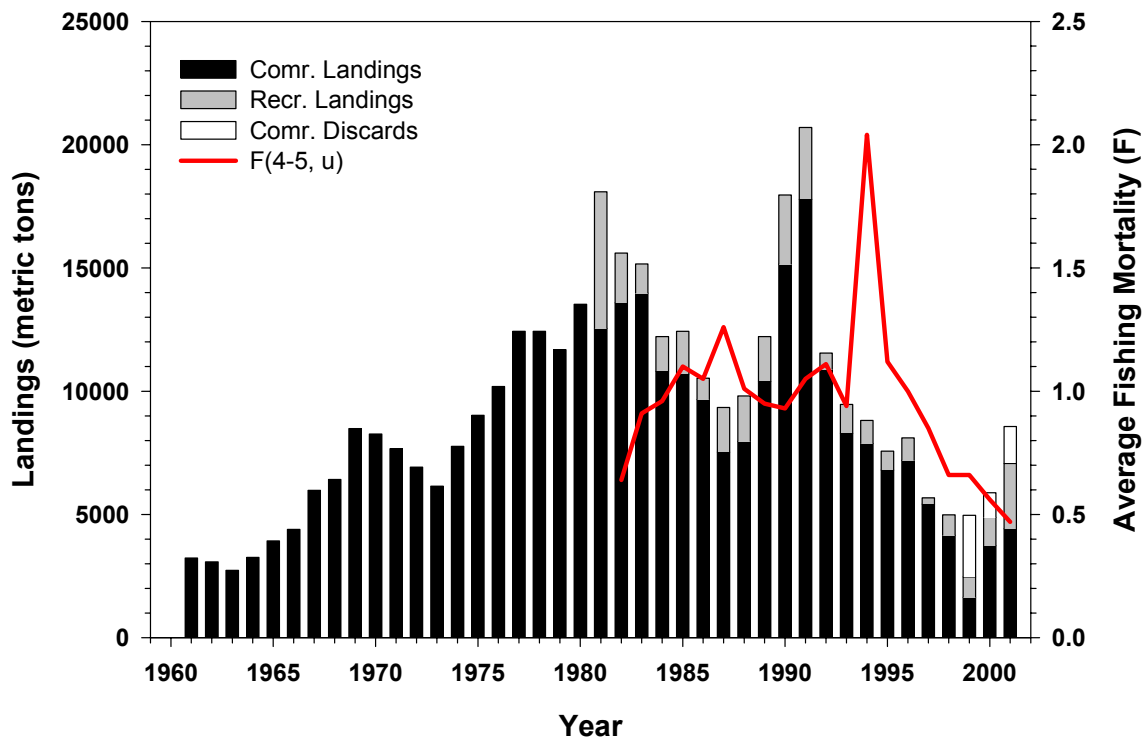


Figure F3. Trends in landings and fishing mortality for Gulf of Maine cod.

Gulf of Maine Cod Trends in Recruitment and Biomass

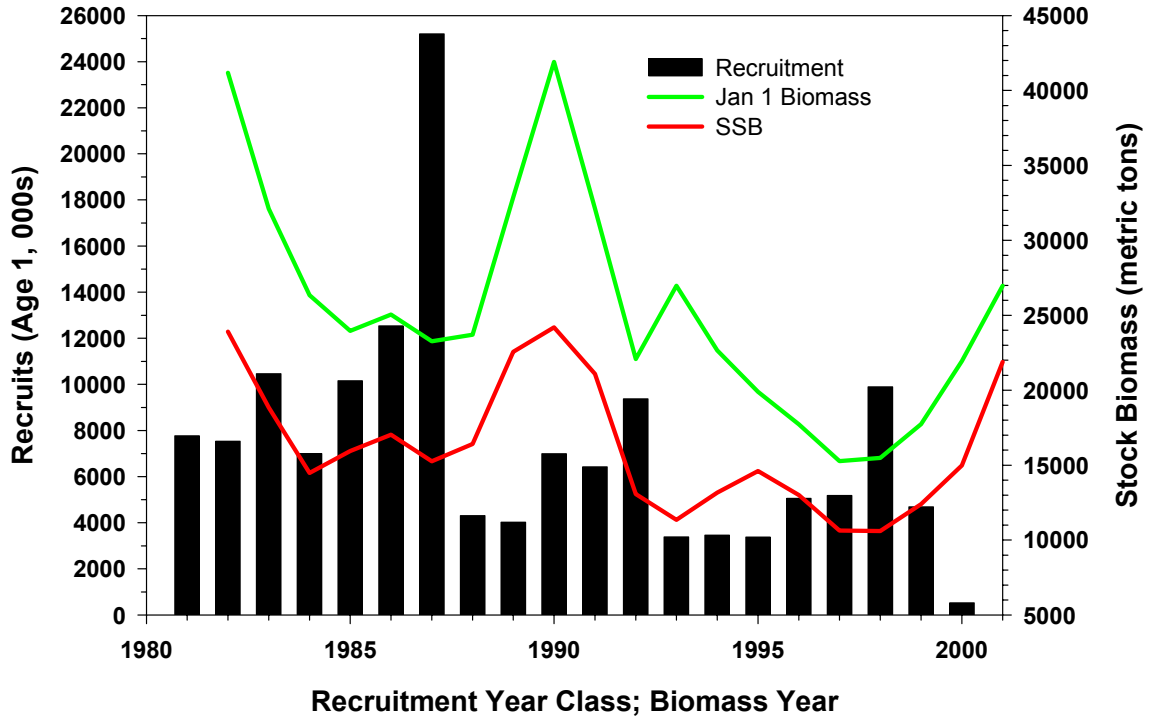


Figure F4. Trends in recruitment (age 1) and biomass for Gulf of Maine cod.

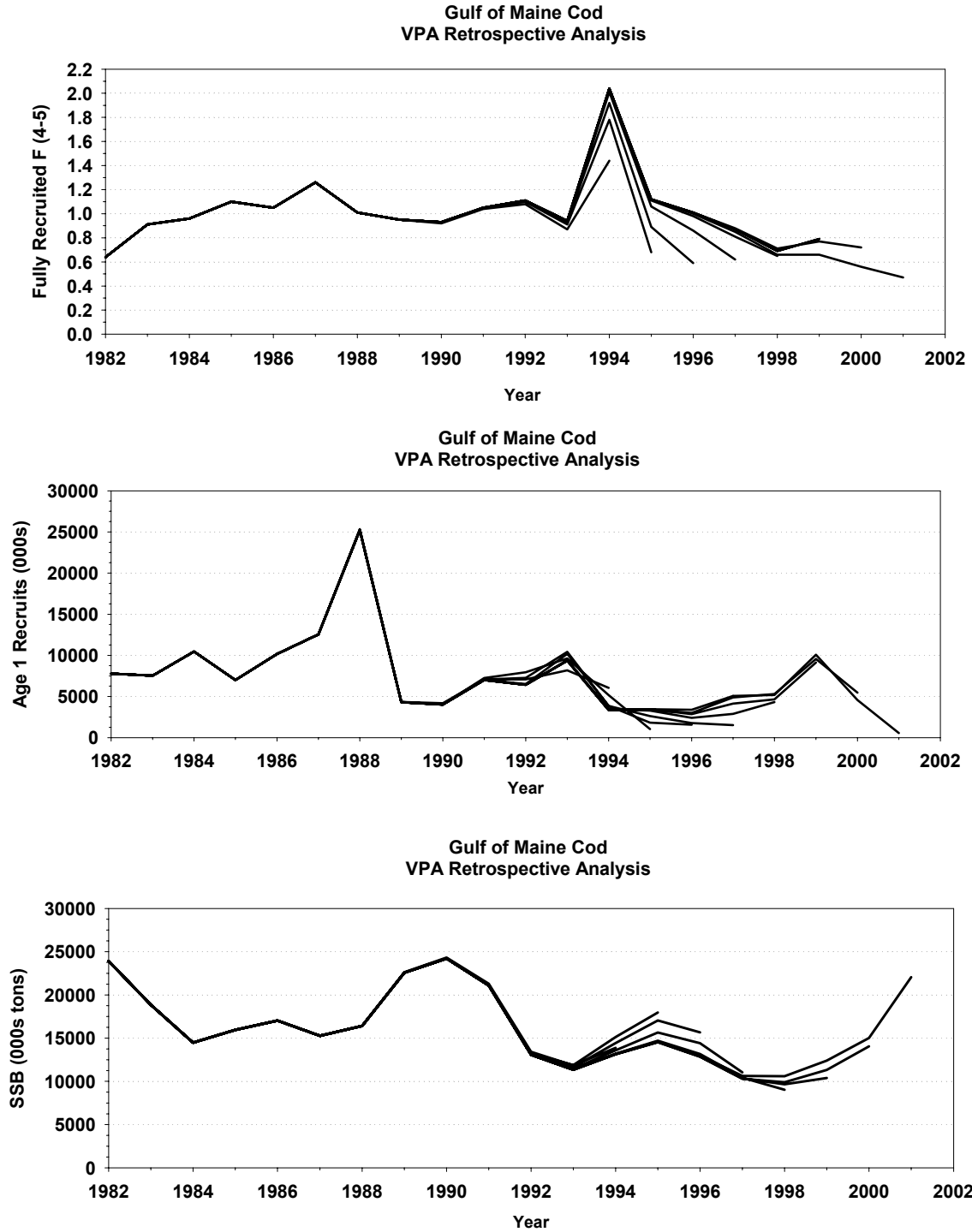


Figure F5. Retrospective analysis of estimates of terminal year F, recruitment and SSB from the VPA for Gulf of Maine Cod.

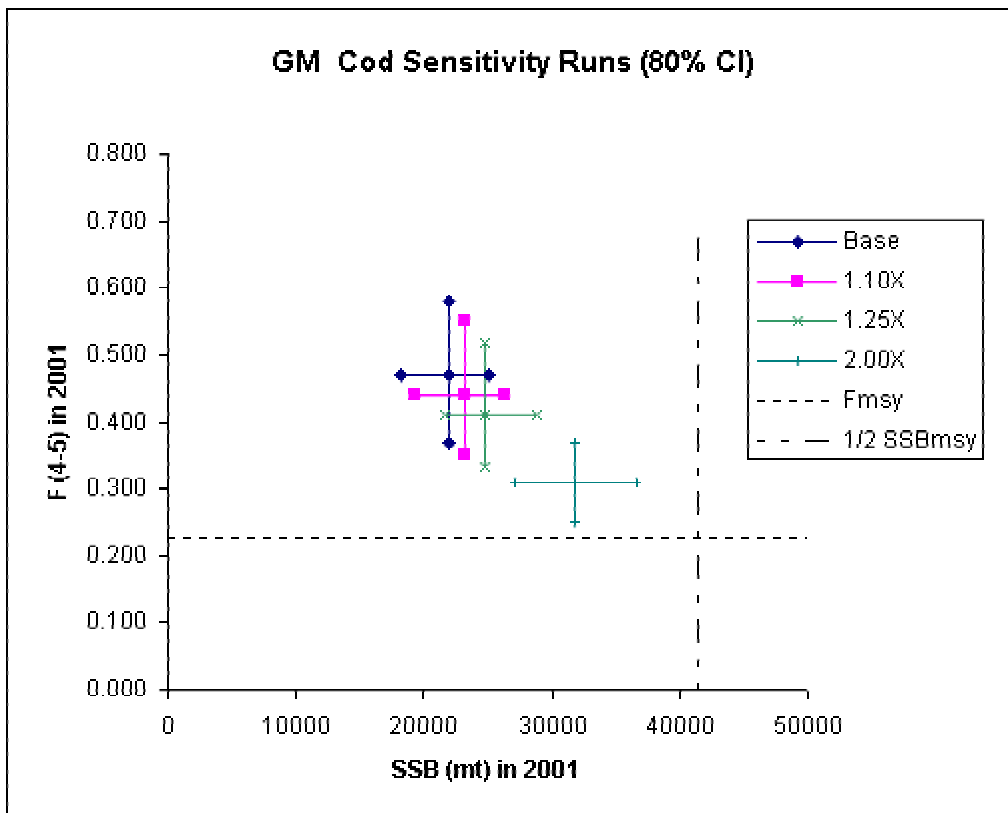


Figure F6. Sensitivity of VPA estimates of F and SSB in 2001 to presumed differences in survey catchability during 2000-2002 based on 1000 bootstrap replications (median and 80% CI) of the base VPA.

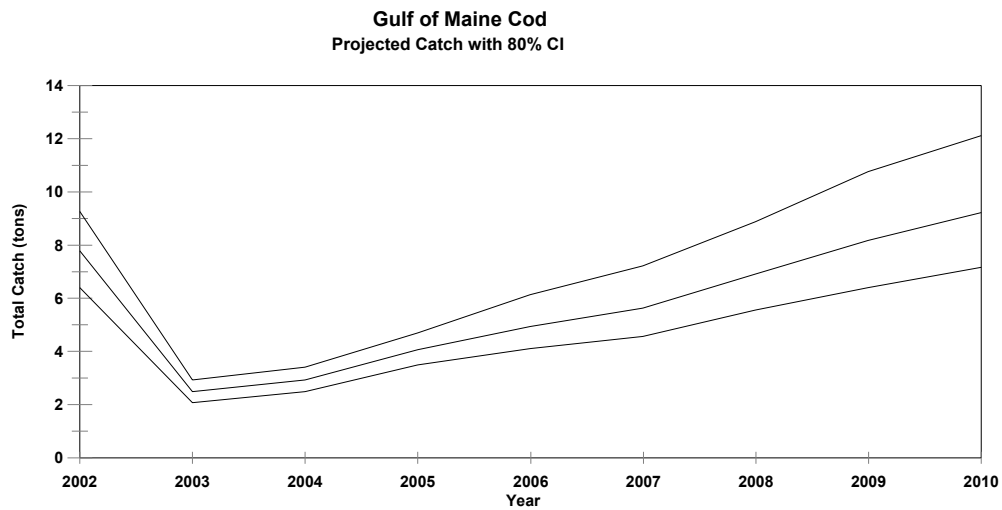
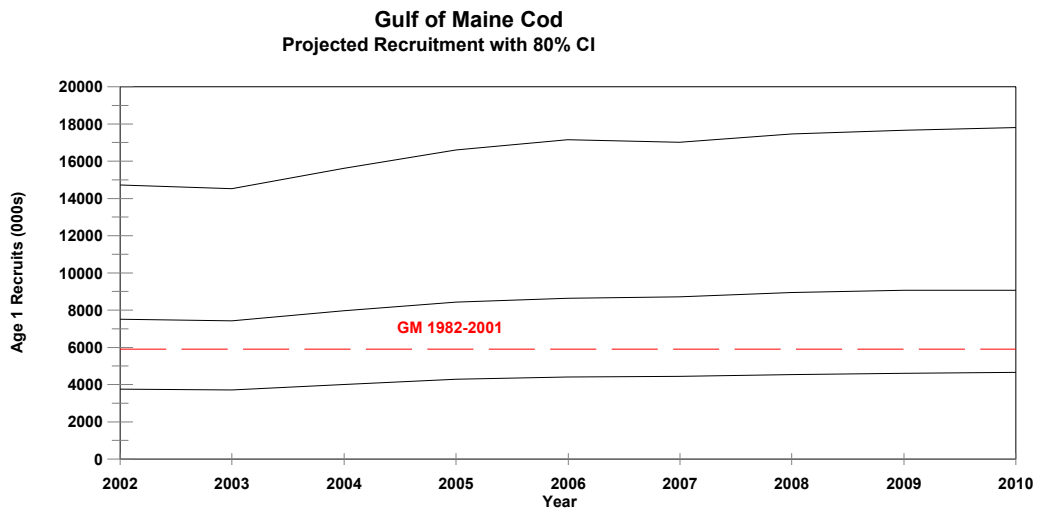
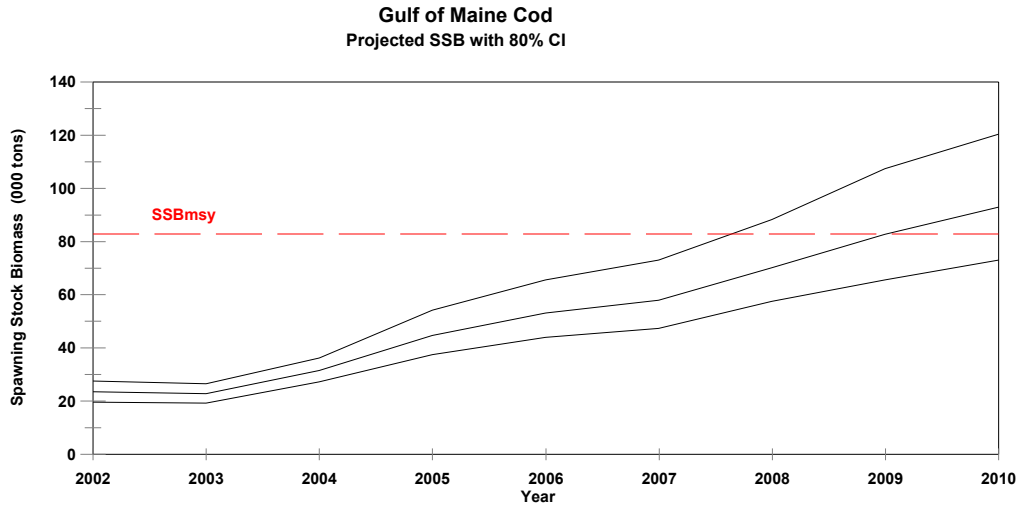


Figure F7. Projected SSB, recruitment and catch for Gulf of Maine cod. $F_{rebuild}=0.115$.