F. Gulf of Maine Cod by R.K. Mayo

1.0 Background

The Gulf of Maine cod stock was last assessed in 1999 (Mayo MS 1999; Northern Demersal Working Group 2000) and the 1998 assessment was reviewed by the SARC at SAW 27 (Mayo et. al 1998; NEFSC 1998). In the 1999 assessment, fully recruited fishing mortality (ages 4+) in 1998 was estimated to be 0.64, and the 1997 F, which had been estimated at 0.75 in 1998 was estimated to be 0.85. Spawning stock biomass was estimated to have declined to 8,300 mt in 1998, a decline from a recent high of 14,200 mt in 1995 and a series high of 26,200 mt in 1989.

The strength of the most recent recruiting year classes was estimated to be very low. The 1994, 1995 and 1996 year classes continue to be estimated as the lowest in the VPA series dating back to 1982 (1980 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 continue to fluctuate at relatively low levels. Recruitment indices for 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 indicated 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). Discard estimates have been derived on a gear-quarterly basis from 1989 through 1999; these results indicate a substantial increase in the overall discard /kept ratio in 1999 compared to previous years. 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.

The number of commercial port samples for this stock declined from 74 in 1997 to 46 in 1998 to 16 in 1999. Sampling was not well distributed among quarters and market categories in recent years, as only 1 biological sample was taken in the 3rd and 4th quarter of 1999, requiring substantial pooling over quarter. In 1999 samples from each market category were pooled on an annual basis. As has generally been the case, the landings at age in 1999 were dominated by age 3 and 4 cod.

The seasonal distribution of landings changed somewhat in 1999 compared to previous years. This may have been related to the imposition of very restrictive trip limits beginning in the latter part of the 3rd quarter of 1999. As a result, biological samples weighted toward the first half of the year may still be representative of the overall length and age composition of the landings,

although it is likely that annual numbers landed may have been overestimated. The following table illustrates the shift in the seasonal distribution of commercial landings between 1998 and 1999, and the corresponding trip limit regulations imposed during 1999.

Quarter	Landings % 1998	Landings % 1999	1999 Trip Limit Restrictions
1	26	34	400 lbs Jan-Mar
2	42	42	400 lbs Apr; 200 lbs May, Jun (part); 30 lbs Jun (part)
3	14	10	30 lbs Jul; 30 lbs Aug(part); 100 lbs Aug (part)-Sep
4	18	14	100 lbs Oct-Dec

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 F2; Figure F2). The autumn 1999 indices increased slightly from 1998, while the spring 2000 indices decreased slightly from the 1999, and remain no higher than indices observed in 1996 and 1997.

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 appears to be above the recent average (Figures F3a-b).

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 as indices of absolute biomass (Figure F4a). 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 (Figure F4 b). 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.

4.0 Assessment

Input Data and Analyses

The present assessment represents a one-year update to the previous assessment (Mayo MS 1999; NEFSC 2000). The same VPA formulation used in the previous assessment was employed in the present update, including the addition of current year (2000) spring survey data. Catch at age data for 1999, and NEFSC and Mass. DMF survey abundance indices (stratified mean number per tow at age) were updated through spring 2000. As in the most recent VPAs, commercial CPUE indices were included only through 1993.

Given the uncertainty in the amount of catch to include in the1999 catch at age (due to uncertainty in the magnitude of 1999 discards), no precision estimates of the 2000 stock sizes and 1999 fishing mortality and SSB estimates were derived. No retrospective analysis of terminal year estimates of stock sizes, fully recruited fishing mortality and SSB were carried out. However, the sensitivity of the VPA to terminal year catch assumptions was examined by performing the VPA under several discarding scenarios in 1999. The 1999 catch at age was adjusted upward by the ratio of landings plus discard to landings under various assumptions of discards ranging from 500 mt to 2,500 mt. Preliminary estimates of 1999 discards of Gulf of Maine cod range as high as 2,630 mt when the gear-quarter approach used in previous assessments is applied to 1999 Observer Program data

Assessment Results

Fully recruited fishing mortality (ages 4+) in 1999 is estimated to range from 0.29 (base run, assuming no discards) to 0.76 (assuming 2,500 mt discarded), while estimates of 1999 spawning stock biomass varied only slightly, ranging from 8,700 mt to 9,400 mt in 1999 (Table F12). Biomass-weighted fishing mortality (ages 1+) in 1999 is estimated to range from 0.10 (base run, assuming no discards) to 0.24 (assuming 2,500 mt discarded), while estimates of 1999 mean stock biomass (ages 1+) varied only slightly, ranging from 17,000 mt to 17,100 mt in 1999 (Table F12). However, almost one-half of the increase in age 1+ mean biomass between 1998 and 1999 can be attributed to the recruitment estimate for the 1998 year class at age 1 in 1999. Age 1 fish are not part of the exploitable biomass of Gulf of Maine cod; therefore the increase in age 1+ mean biomass overstates the apparent increase in the exploitable portion of the stock.

Regardless of the discard assumption employed in the analyses, recent recruiting year classes are estimated to be poor (Table F12). The 1993, 1994, 1995 and 1996 year classes are still estimated to be the lowest in the VPA series dating back to 1982.

VPA Diagnostics

No bootstrap runs or retrospective analyses were performed.

5.0 Forecasts

No forecasts of stock size and landings were performed.

6.0 Harvest Control Rule

According to the SFA control rule for Gulf of Maine cod, when the mean stock biomass is between 1/4 and ½ Bmsy (8,250-16,500 mt), a 5-year rebuilding period may be appropriate. The control rule and stock rebuilding harvest plan are based on the relation between mean biomass and biomass-weighted fishing mortality for ages 1+. Given that only ages 2 and older

are represented in the catch throughout the VPA series, a more appropriate control rule should be based on mean biomass and biomass-weighted F for ages 2+.

7.0 Conclusions

Given the uncertainty in the amount of discarding in 1999, it is not possible at this point to determine current fishing mortality. However, it may be considered that the fully recruited F and the biomass-weighted F derived from the base run (assuming no discards in 1999) may be considered as minimum estimates for these measures of 1999 fishing mortality. However, the maximum values for these measures of fishing mortality in 1999 is uncertain.

8.0 Sources of Uncertainty

- A substantial discarding event is likely to have occurred in 1999, but the magnitude is not precisely known. Until further information on effort is available, the degree of uncertainty in the current assessment cannot be determined.

- Poor biological sampling in 1998 and very poor sampling in 1999.

  Incomplete seasonal coverage and apparent incomplete sampling of larger cod may have resulted in an underestimate of the number of larger, relatively older cod in the 1998 and 1999 commercial landings. This would result in an overall lower mean weight, higher numbers landed and a greater dominance of younger fish in the estimated landings. The over-estimate of younger fish may have inflated the size of recruiting year classes in 1998 and 1997. No age 2 cod were detected in the biological samples in 1999, the first time ever.

- The proportion of unaccounted recreational catch in the 'total' catch used to model the dynamics of this stock has increased substantially in recent years.

  The landed component of the recreational catch represented 34% of the total commercial plus recreational landings in 1999, compared to 10-20% prior to 1999. This trend may affect current perceptions of fishing mortality unless all sources of fishing mortality are taken into account.

- Recent retrospective pattern inVPA.

  Fully recruited F has been under-estimated since 1995. Thus, short-term projections are likely to be optimistic if fishing mortality is actually higher in 1998 and 1999 than initially estimated.

9.0 References

Mayo, R.K., L. O'Brien, and S.E. Wigley. 1998. Assessment of the Gulf of Maine Atlantic Cod Stock for 1998. NMFS/NEFSC, Woods Hole Laboratory Ref. Doc. 98-13.

Mayo, R.K.. MS 1999. Assessment of the Gulf of Maine Atlantic Cod Stock for 1999. SAW/Northern Demersal Working Group Working Paper 99/4.

NEFSC. 1998. 27th Northeast Regional Stock Assessment Workshop (27th SAW). Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NMFS/NEFSC, Woods Hole Laboratory Ref. Doc. 98-15.

NDWG (Northern Demersal Working Group, Northeast Regional Stock Assessment Workshop). 2000. Assessment of 11 Northeast Groundfish Stocks through 1999: A Report to the New England Fishery Management Council's Multi-Species Monitoring Committee. NEFSC, Ref. Doc. 00/05.

Table F1. Commercial landings (metric tons, live) of Atlantic cod the Gulf of Maine (NAFO Division 5Y), 1960 - 1999.[1]

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

* Provisional

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

[2] USA 1994-1999 landings estimated by prorating NMFS, NEFSC Detailed Weighout data by Vessel Trip Reports.

Table F2. Standardized stratified mean catch per tow in numbers and weight (kg) for Atlantic cod from NEFSC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine (Strata 26-30 and 36-40), 1963 - 2000 [a,b]

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

[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 F3. VPA results for Gulf of Maine cod under various assumption of 1999 discarding ranging from 0 tons (landings only base run) to 2,500 tons.

Fisheries Assessment Toolbox GoM Cod 1999 Base Run Run Number 1 8/23/2000 9:17:20 AM
FACT Version 1.3.6
GoM Cod 1999 (No Discards)
Input Parameters and Options Selected

RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 131.946102581412
Mean Square Residuals: 0.45499

	PAR. EST.	STD. ERR.	T-STATISTIC C.V.
N 2	5.79E+03	2.02E+03	2.87E+00 0.35
N 3	2.62E+03	6.91E+02	3.79E+00 0.26
N 4	1.41E+03	3.39E+02	4.14E+00 0.24
N 5	4.49E+02	1.33E+02	3.38E+00 0.30
N 6	2.84E+02	9.48E+01	3.00E+00 0.33

STOCK NUMBERS (Jan 1) in thousands - D:\ASSESS\GMCOD\gmcod2000\gmcod2000_base.2

	1996	1997	1998	1999	2000
1	2101	2981	3902	7066	00
2	2371	1720	2441	3195	5785
3	1721	1882	1360	1913	2615
4	3635	881	1145	761	1405
5	531	1404	327	447	449
6	89	121	396	119	284
7	19	14	20	157	169
1+	10467	9002	9592	13658	10709

FISHING MORTALITY - D:\ASSESS\GMCOD\gmcod2000\gmcod2000_base.2

	1996	1997	1998	1999
1	0.00	0.00	0.00	0.00
2	0.03	0.03	0.04	0.00
3	0.47	0.30	0.38	0.11
4	0.75	0.79	0.74	0.33
5	1.28	1.06	0.81	0.25
6	0.82	0.98	0.77	0.29
7	0.82	0.98	0.77	0.29

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

	1996	1997	1998	1999
1+	12222	9420	8053	8656

MEAN BIOMASS (using catch mean weights at age)

	1996	1997	1998	1999
1+	15096	13057	12377	16947
2+	13382	10624	9194	11184

Biomass Weighted F

	1996	1997	1998	1999
1+	0.48	0.42	0.34	0.10
2+	0.54	0.52	0.46	0.15

Table F3 (cont.). VPA results for Gulf of Maine cod under various assumption of 1999 discarding ranging from 0 tons (landings only base run) to 2,500 tons.

Fisheries Assessment Toolbox GoM Cod 1999 Disc500 Run Run Number 1 8/23/2000 9:44:33 AM
FACT Version 1.3.6
GoM Cod 1999 Discards = 500 mt
Input Parameters and Options Selected

RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 132.038584642968
Mean Square Residuals: 0.45531

	PAR. EST.	STD. ERR.	T-STATISTIC C.V.
N 2	5.80E+03	2.03E+03	2.86E+00 0.35
N 3	2.62E+03	6.93E+02	3.79E+00 0.26
N 4	1.39E+03	3.42E+02	4.06E+00 0.25
N 5	4.17E+02	1.31E+02	3.17E+00 0.32
N 6	2.67E+02	9.30E+01	2.87E+00 0.35

STOCK NUMBERS (Jan 1) in thousands - D:\ASSESS\GMCOD\gmcod2000\gmcod2000_disc.2

	1996	1997	1998	1999	2000
1	2147	3039	3914	7088	00
2	2389	1758	2488	3204	5803
3	1725	1897	1391	1952	2623
4	3641	884	1157	786	1388
5	531	1409	330	457	417
6	89	121	400	121	267
7	19	14	20	161	157
1+	10542	9122	9702	13770	10656

FISHING MORTALITY - D:\ASSESS\GMCOD\gmcod2000\gmcod2000_disc.2

	1996	1997	1998	1999
1	0.00	0.00	0.00	0.00
2	0.03	0.03	0.04	0.00
3	0.47	0.29	0.37	0.14
4	0.75	0.79	0.73	0.44
5	1.28	1.06	0.80	0.34
6	0.82	0.97	0.76	0.39
7	0.82	0.97	0.76	0.39

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

	1996	1997	1998	1999
1+	12254	9490	8182	8743

MEAN BIOMASS (using catch mean weights at age)

	1996	1997	1998	1999
1+	15187	13222	12565	16908
2+	13435	10743	9372	11126

Biomass Weighted F

	1996	1997	1998	1999
1+	0.48	0.42	0.33	0.13
2+	0.54	0.52	0.44	0.20

Table F3 (cont.). VPA results for Gulf of Maine cod under various assumption of 1999 discarding ranging from 0 tons (landings only base run) to 2,500 tons.

Fisheries Assessment Toolbox GoM Cod 1999 Disc1000 Run Run Number 2 8/23/2000 9:32:53 AM
FACT Version 1.3.6
GoM Cod 1999 Discards = 1000 mt
Input Parameters and Options Selected

RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 132.133151684434
Mean Square Residuals: 0.45563

	PAR. EST.	STD. ERR.	T-STATISTIC C.V.
N 2	5.82E+03	2.03E+03	2.86E+00 0.35
N 3	2.63E+03	6.96E+02	3.79E+00 0.26
N 4	1.37E+03	3.45E+02	3.98E+00 0.25
N 5	3.87E+02	1.29E+02	2.99E+00 0.33
N 6	2.52E+02	9.11E+01	2.76E+00 0.36

STOCK NUMBERS (Jan 1) in thousands - D:\ASSESS\GMCOD\gmcod2000\gmcod2000_disc.3

	1996	1997	1998	1999	2000
1	2199	3102	3928	7113	00
2	2409	1800	2539	3216	5824
3	1736	1913	1426	1994	2633
4	3650	893	1170	815	1373
5	532	1415	338	468	387
6	89	122	406	127	252
7	19	14	21	166	148
1+	10634	9259	9827	13898	10616

FISHING MORTALITY - D:\ASSESS\GMCOD\gmcod2000\gmcod2000_disc.3

	1996	1997	1998	1999
1	0.00	0.00	0.00	0.00
2	0.03	0.03	0.04	0.00
3	0.46	0.29	0.36	0.17
4	0.75	0.77	0.72	0.54
5	1.27	1.05	0.78	0.42
6	0.82	0.96	0.75	0.48
7	0.82	0.96	0.75	0.48

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

	1996	1997	1998	1999
1+	12307	9587	8345	8865

MEAN BIOMASS (using catch mean weights at age)

	1996	1997	1998	1999
1+	15306	13425	12794	16911
2+	13512	10895	9590	11109

Biomass Weighted F

	1996	1997	1998	1999
1+	0.48	0.41	0.33	0.16
2+	0.54	0.50	0.44	0.24

Table F3 (cont.). VPA results for Gulf of Maine cod under various assumption of 1999 discarding ranging from 0 tons (landings only base run) to 2,500 tons.

Fisheries Assessment Toolbox GoM Cod 1999 Disc1500 Run Run Number 3 8/23/2000 9:39:40 AM
FACT Version 1.3.6
GoM Cod 1999 Discards = 1500 mt
Input Parameters and Options Selected

RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 132.35171912039
Mean Square Residuals: 0.45639

	PAR. EST.	STD. ERR.	T-STATISTIC C.V.
N 2	5.85E+03	2.04E+03	2.86E+00 0.35
N 3	2.64E+03	6.99E+02	3.78E+00 0.26
N 4	1.36E+03	3.48E+02	3.90E+00 0.26
N 5	3.63E+02	1.28E+02	2.84E+00 0.35
N 6	2.38E+02	8.93E+01	2.66E+00 0.38

STOCK NUMBERS (Jan 1) in thousands - D:\ASSESS\GMCOD\gmcod2000\gmcod2000_disc.2

	1996	1997	1998	1999	2000
1	2263	3166	3943	7141	00
2	2434	1853	2592	3228	5846
3	1743	1934	1469	2037	2643
4	3658	899	1187	850	1359
5	533	1423	342	482	363
6	89	123	412	131	238
7	20	14	21	172	139
1+	10741	9411	9966	14040	10588

FISHING MORTALITY - D:\ASSESS\GMCOD\gmcod2000\gmcod2000_disc.2

	1996	1997	1998	1999
1	0.00	0.00	0.00	0.00
2	0.03	0.03	0.04	0.00
3	0.46	0.29	0.35	0.20
4	0.74	0.77	0.70	0.65
5	1.27	1.04	0.76	0.51
6	0.82	0.95	0.73	0.58
7	0.82	0.95	0.73	0.58

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

	1996	1997	1998	1999
1+	12355	9687	8523	9003

MEAN BIOMASS (using catch mean weights at age)

	1996	1997	1998	1999
1+	15436	13646	13043	16933
2+	13590	11064	9827	11108

Biomass Weighted F

	1996	1997	1998	1999
1+	0.47	0.41	0.32	0.19
2+	0.53	0.51	0.42	0.29

Table F3 (cont.). VPA results for Gulf of Maine cod under various assumption of 1999 discarding ranging from 0 tons (landings only base run) to 2,500 tons.

Fisheries Assessment Toolbox GoM Cod 1999 Disc2000 Run Run Number 4 8/23/2000 9:47:12 AM
FACT Version 1.3.6
GoM Cod 1999 Discards = 2000 mt
Input Parameters and Options Selected

RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 132.633682240907
Mean Square Residuals: 0.45736

	PAR. EST.	STD. ERR.	T-STATISTIC C.V.
N 2	5.87E+03	2.05E+03	2.86E+00 0.35
N 3	2.65E+03	7.02E+02	3.78E+00 0.26
N 4	1.35E+03	3.52E+02	3.83E+00 0.26
N 5	3.42E+02	1.26E+02	2.71E+00 0.37
N 6	2.26E+02	8.77E+01	2.58E+00 0.39

STOCK NUMBERS (Jan 1) in thousands - D:\ASSESS\GMCOD\gmcod2000\gmcod2000_disc.2

	1996	1997	1998	1999	2000
1	2336	3234	3959	7171	00
2	2463	1913	2648	3242	5871
3	1752	1957	1518	2083	2654
4	3668	906	1206	890	1347
5	534	1431	348	497	342
6	89	123	419	136	226
7	20	14	21	178	131
1+	10862	9578	10119	14196	10572

FISHING MORTALITY - D:\ASSESS\GMCOD\gmcod2000\gmcod2000_disc.2

	1996	1997	1998	1999
1	0.00	0.00	0.00	0.00
2	0.03	0.03	0.04	0.00
3	0.46	0.28	0.33	0.24
4	0.74	0.76	0.69	0.76
5	1.27	1.03	0.74	0.59
6	0.81	0.94	0.71	0.67
7	0.81	0.94	0.71	0.67

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

	1996	1997	1998	1999
1+	12410	9802	8724	9169

MEAN BIOMASS (using catch mean weights at age)

	1996	1997	1998	1999
1+	15584	13894	13321	16988
2+	13678	11256	10091	11139

Biomass Weighted F

	1996	1997	1998	1999
1+	0.47	0.40	0.32	0.22
2+	0.54	0.49	0.42	0.34

Table F3 (cont.). VPA results for Gulf of Maine cod under various assumption of 1999 discarding ranging from 0 tons (landings only base run) to 2,500 tons.

Fisheries Assessment Toolbox GoM Cod 1999 Disc2500 Run Run Number 5 8/23/2000 9:51:27 AM
FACT Version 1.3.6
GoM Cod 1999 Discards = 2500 mt
Input Parameters and Options Selected

RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 132.976882676815
Mean Square Residuals: 0.45854

	PAR. EST.	STD. ERR.	T-STATISTIC C.V.
N 2	5.90E+03	2.07E+03	2.86E+00 0.35
N 3	2.67E+03	7.06E+02	3.77E+00 0.26
N 4	1.34E+03	3.56E+02	3.76E+00 0.27
N 5	3.25E+02	1.25E+02	2.60E+00 0.38
N 6	2.15E+02	8.61E+01	2.50E+00 0.40

STOCK NUMBERS (Jan 1) in thousands - D:\ASSESS\GMCOD\gmcod2000\gmcod2000_disc.2

	1996	1997	1998	1999	2000
1	2416	3304	3977	7203	00
2	2495	1978	2705	3256	5897
3	1761	1984	1571	2130	2666
4	3680	914	1228	934	1336
5	535	1440	354	515	325
6	90	124	427	141	215
7	20	14	22	186	125
1+	10997	9759	10284	14364	10565

FISHING MORTALITY - D:\ASSESS\GMCOD\gmcod2000\gmcod2000_disc.2

	1996	1997	1998	1999
1	0.00	0.00	0.00	0.00
2	0.03	0.03	0.04	0.00
3	0.46	0.28	0.32	0.27
4	0.74	0.75	0.67	0.85
5	1.26	1.02	0.72	0.67
6	0.81	0.93	0.69	0.76
7	0.81	0.93	0.69	0.76

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

	1996	1997	1998	1999
1+	12475	9933	8947	9356

MEAN BIOMASS (using catch mean weights at age)

	1996	1997	1998	1999
1+	15752	14166	13626	17068
2+	13782	11471	10382	11192

Biomass Weighted F

	1996	1997	1998	1999
1+	0.46	0.39	0.31	0.24
2+	0.53	0.48	0.41	0.37

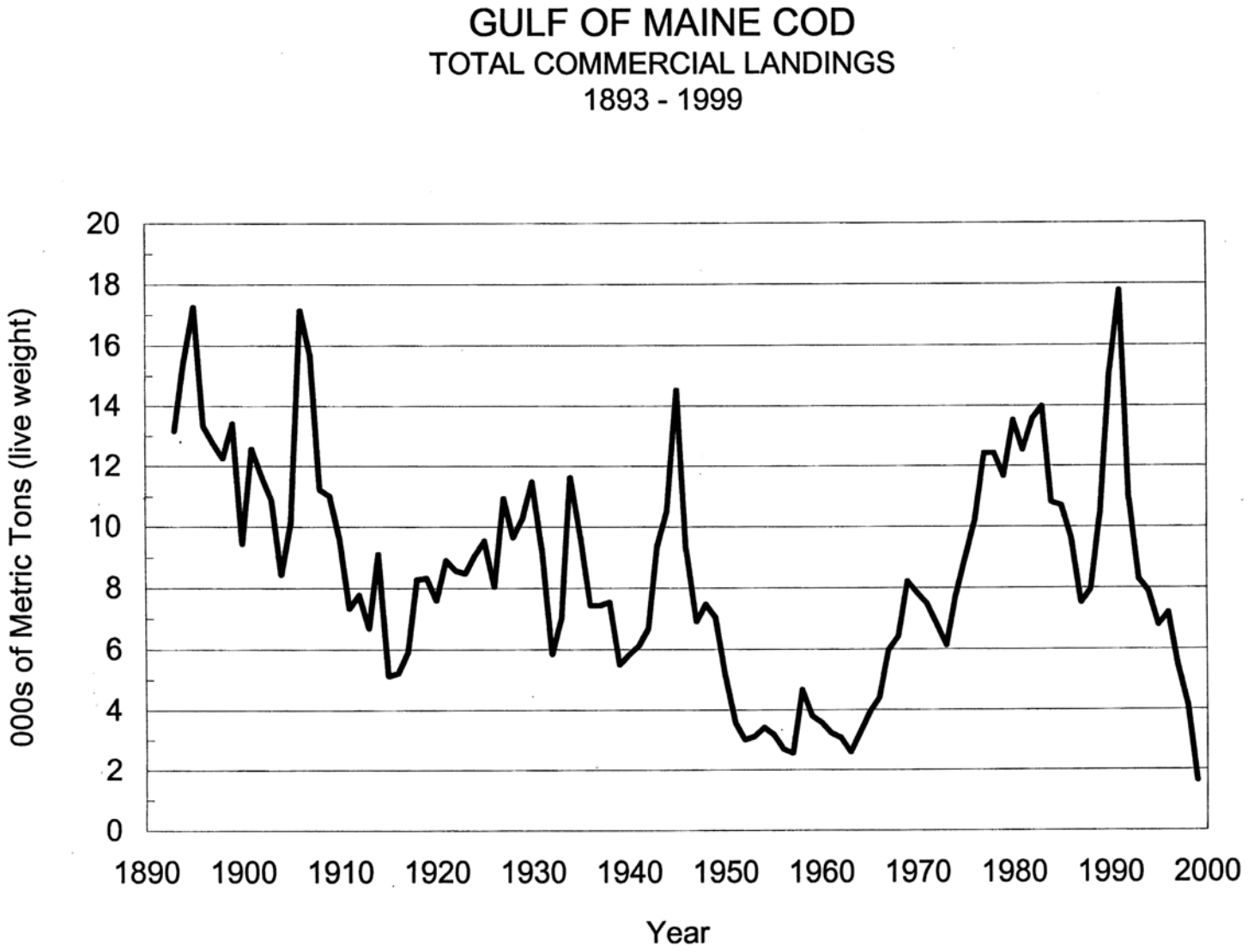


Figure F1. Total commercial landings of Gulf of Maine cod (NAFO Div. 5Y), 1893-1999.

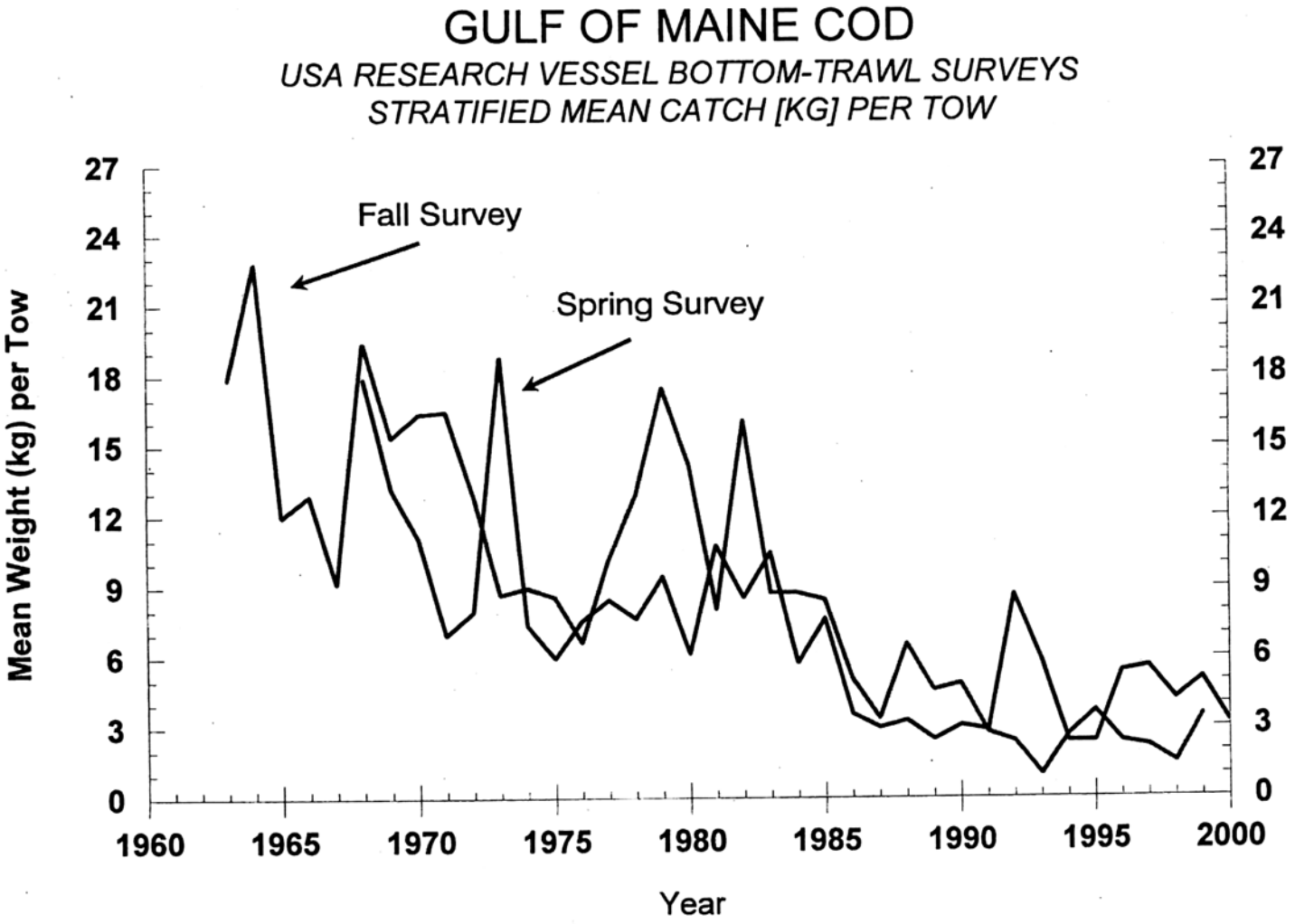
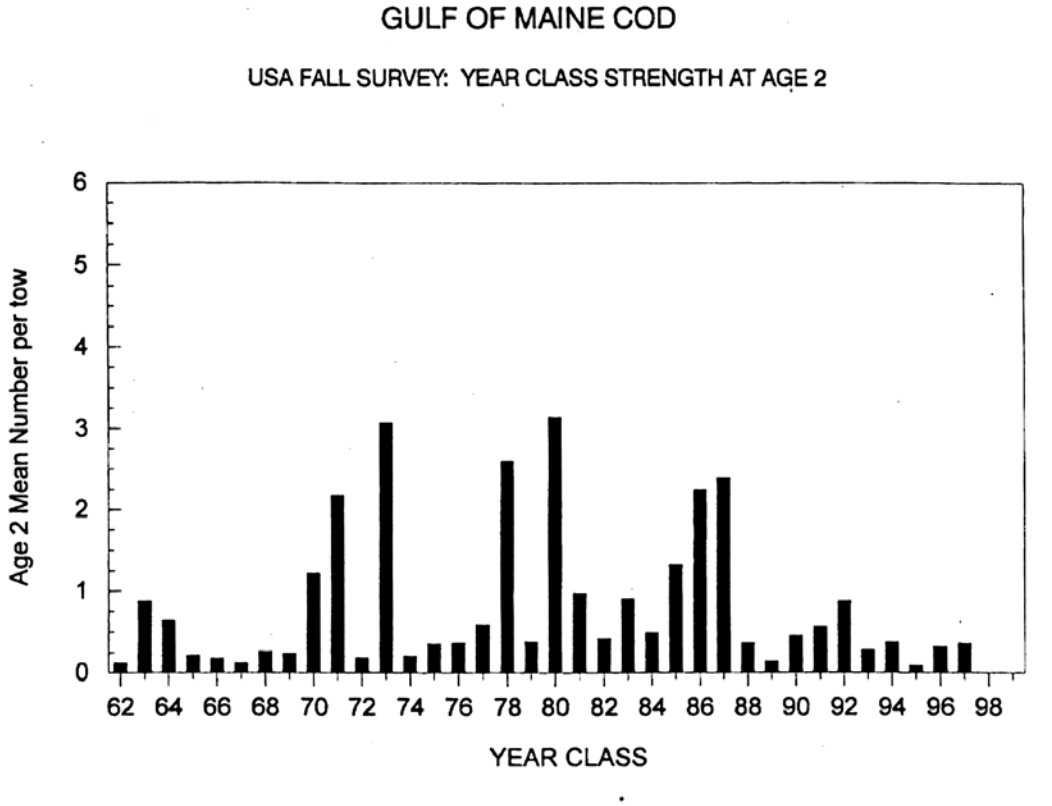


Figure F2 Standardized stratified mean catch (kg) per tow of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys in the Gulf of Maine, 1963-2000.



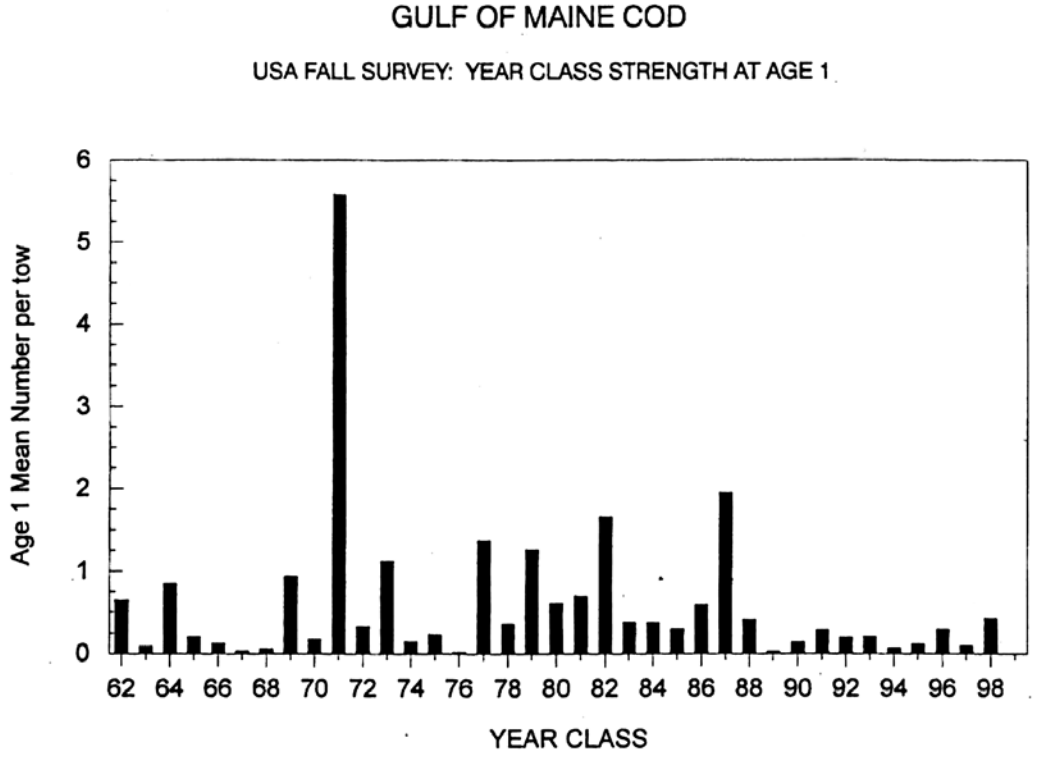
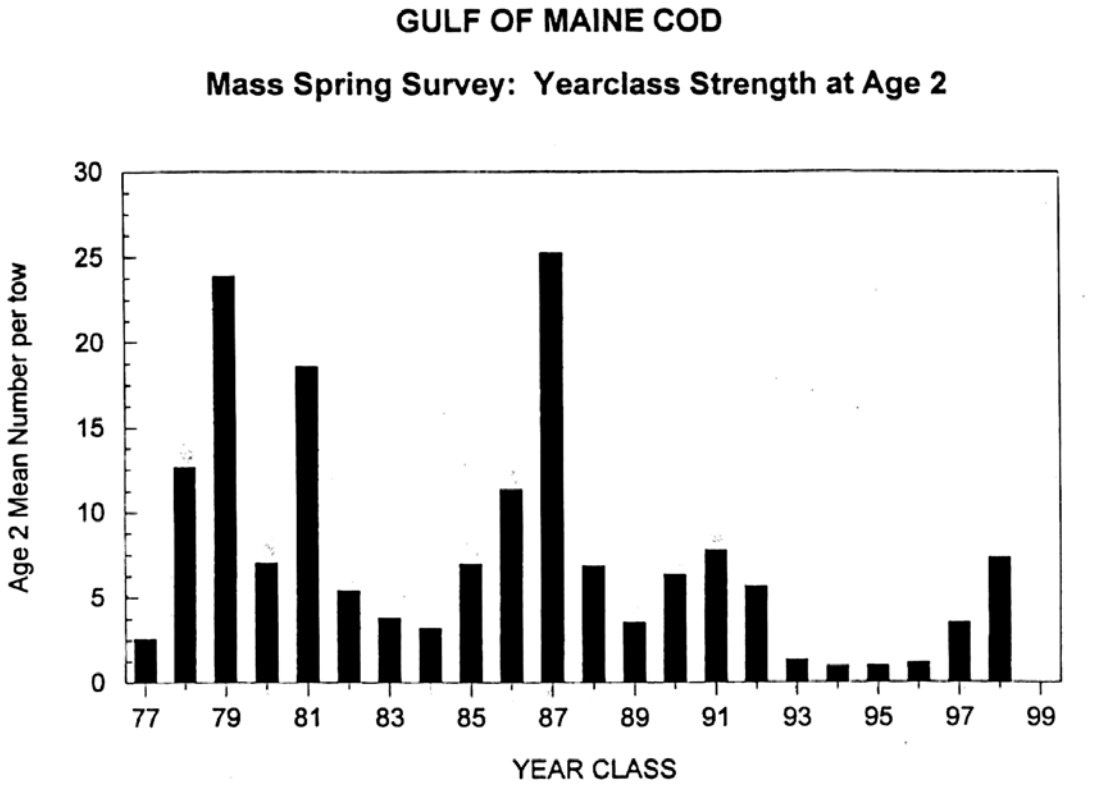


Figure F3a. Recruitment indices from NEFSC autumn surveys.



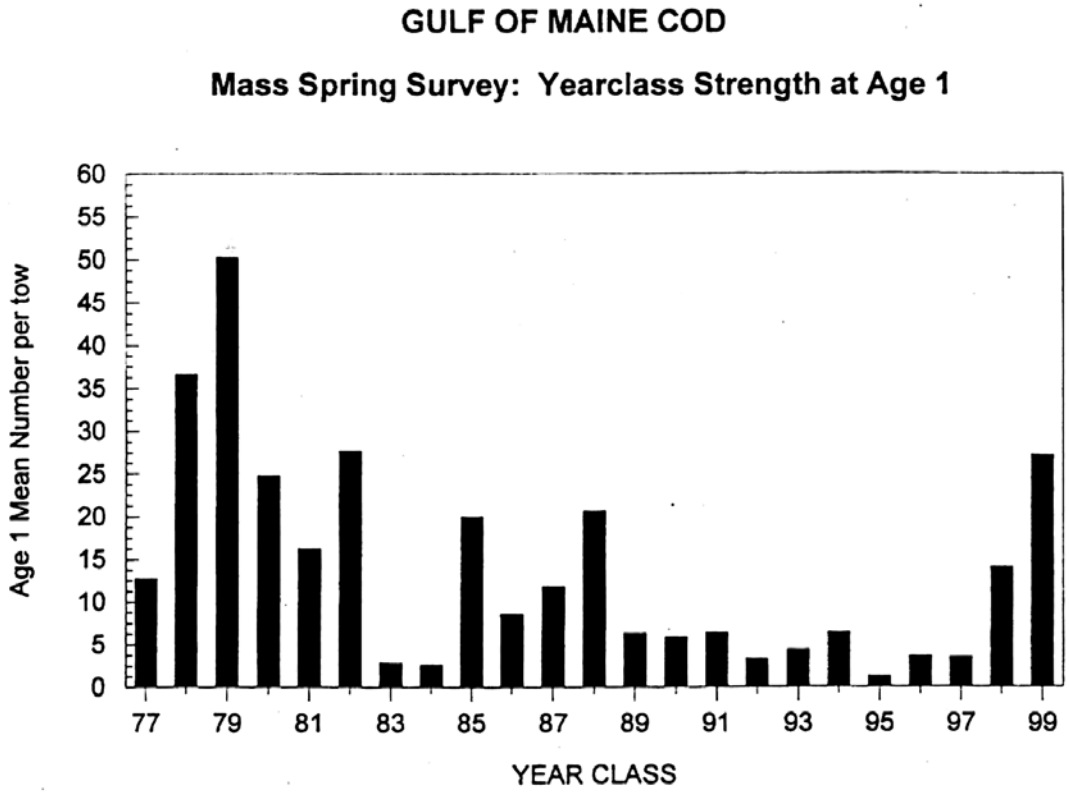


Figure F3b. Recruitment indices from Comm. of Mass. DMF spring surveys.

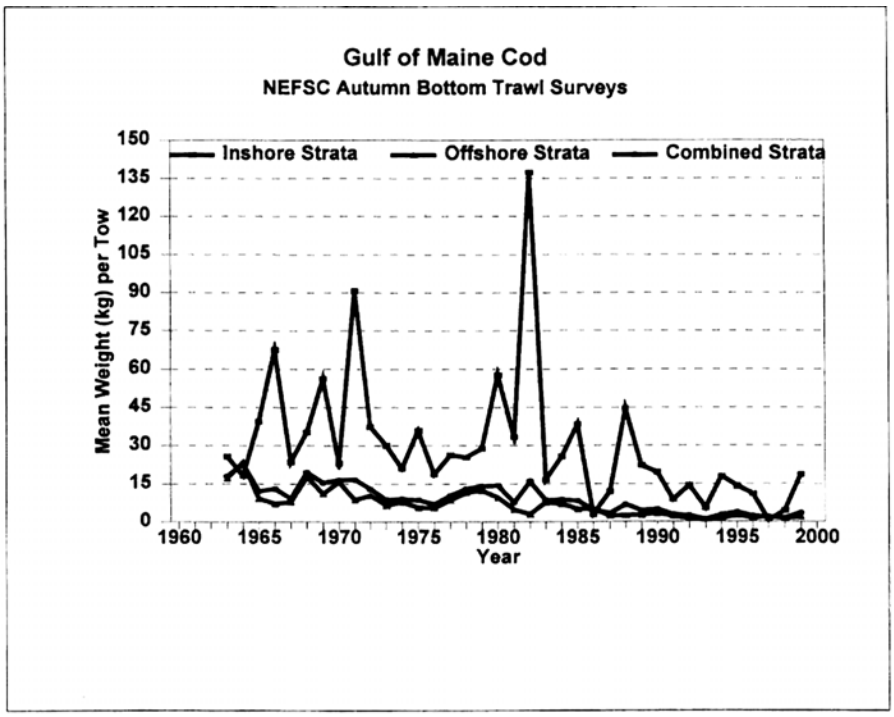


Figure F4a. Stratified mean weight per tow indices for Gulf of Maine cod by Inshore (strata 26 and 27), Offshore (strata 28-30 and 36-40), and Combined (Strata 26-30 and 36-40) regions, providing comparative indices of relative stock biomass density between inshore and off shore regions.

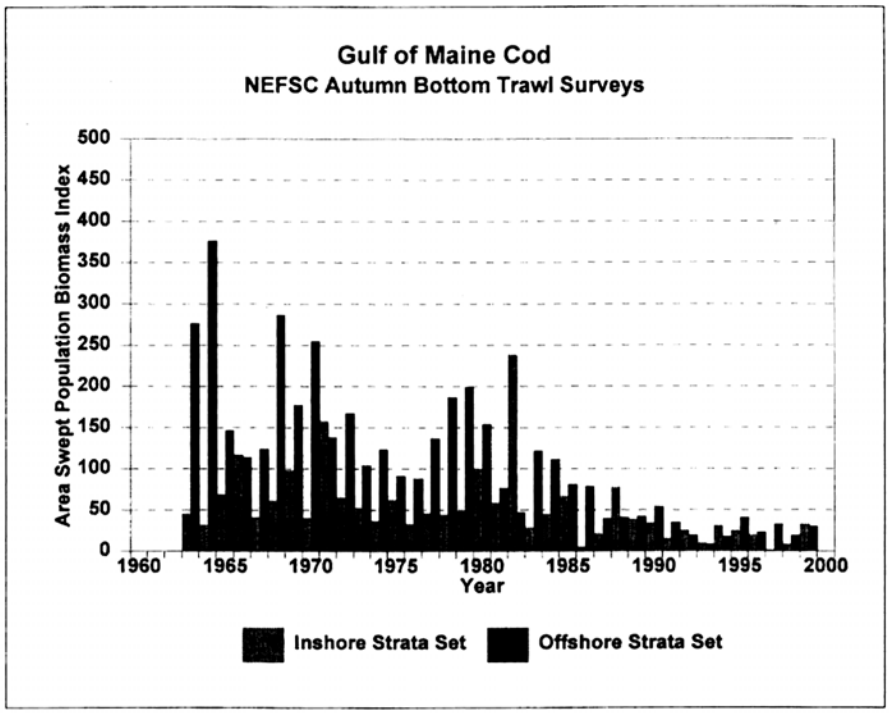


Figure F4b. Stratified mean weight per tow indices for Gulf of Maine cod by Inshore (strata 26 and 27), Offshore (strata 28-30 and 36-40), and Combined (Strata 26-30 and 36-40) regions weighted by the area of each region providing comparative indices of relative stock biomass between regions.

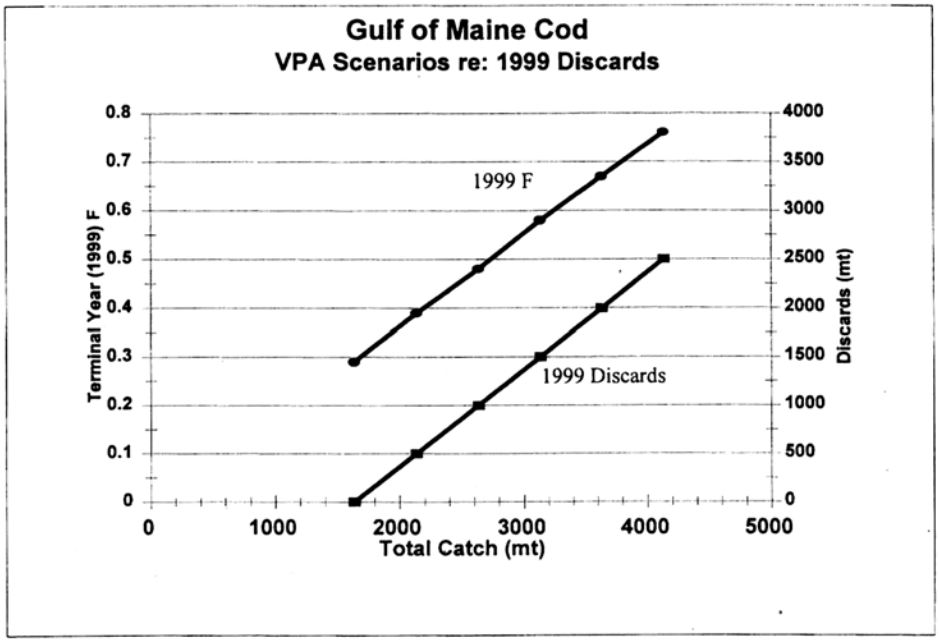


Figure F5 Effect of increased 1999 discarding on estimates of fully recruited terminal F for Gulf of Maine cod.