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Assessment of 11 Northeast Groundfish Stocks through 1999

A Report to the New England Fishery Management Council's Multi-Species Monitoring Committee

by

Northern Demersal Working Group,
Northeast Regional Stock Assessment Workshop

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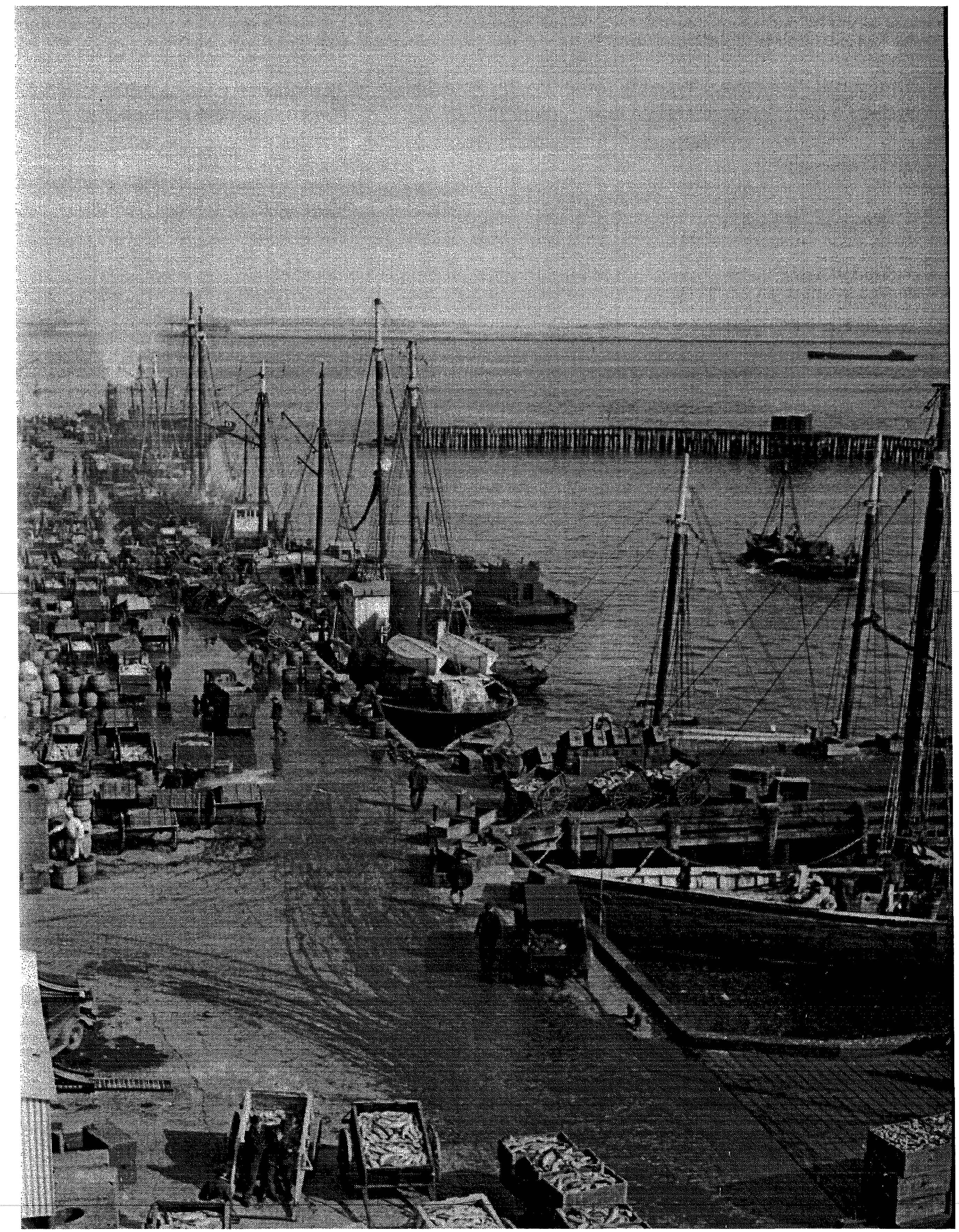


Section 1. Introduction

The Northern Demersal Working Group met on a continuing basis throughout July, 1999 to prepare and review assessments for 11 groundfish stocks. A final review and follow up meeting was held during 27-28 July, 1999. Participants included:

A. Applegate, NEFMC
J. Brodziak, NEFSC
R. Brown, NEFSC
S. Cadrin, NEFSC
S. Clark, NEFSC
S. Correia, MA, DMF
P. Haring, NEFMC
R. Mayo (Chair), NEFSC
J. Neilson, DFO, St. Andrews, N.B.
R. O'Boyle, DFO, Dartmouth, N.S.
L. O'Brien, NEFSC
W. Overholtz, NEFSC
P. Rago, NEFSC
T.P. Smith, NEFSC
K. Sosebee, NEFSC
W. Stobo, DFO, Dartmouth, N.S.
M. Terceiro, NEFSC
S. Wigley, NEFSC

Each of the stocks had been assessed during 1998 or 1999, and all assessments were peer-reviewed during the 27th, 28th, or 29th Stock Assessment Review Committee meetings. For 10 of the 11 stocks, terminal year 1997 fishing mortality and January 1, 1998 survivors had been estimated during the 1998 assessment period at SAW 27 or SAW 28. The Gulf of Maine witch flounder stock was assessed during 1999, and the assessment was reviewed at SAW 29. For this stock, estimates of terminal year 1998 fishing mortality and January 1, 1999 survivors were directly available from the recent SAW.

The Northern Demersal Working Group was requested to meet inter-sessionally between the 29th and 30th Stock Assessment Workshops during July, 1999 to prepare and review updated stock assessments for the remaining 10 stocks through the beginning of calendar year 1999.
In addition, the Working Group was requested to develop medium-term forecasts, taking into account starting stock conditions as of Jan1, 2000, with the forecast horizon extending through calendar year 2009. To bridge 1999, at this point during the year (July), the Working Group concluded that, barring any definitive evidence of a change in 1999 fishing effort *versus* 1998 fishing effort for these stocks, a status quo F scenario would be applied in the forecasts for 1999 (i.e., $F_{1999} = F_{1998}$).

Overview

Of the 11 stocks included in the Working Group review, 7 were assessed via VPA and 4 were updated via 1-year projection of F given the 1998 landings. This report represents a summary of the assessment and forecast results presented to the Working Group at its 27-28 July Final Review Meeting. The report consists of an initial overview of stock projection and forecast methodology, followed by a concise section for each of the 11 stocks in the review. A concluding section contains overall comments by the Working Group, an evaluation of the quality of the data and assessments, and recommendations for future improvement.

The following stocks are addressed in this report:

A. Georges Bank cod
B. Georges Bank haddock
C. Georges Bank yellowtail flounder
D. Southern New England yellowtail flounder
E. Cape Cod yellowtail flounder
F. Gulf of Maine cod
G. Gulf of Maine/Georges Bank witch flounder
H. Gulf of Maine/Georges Bank American plaice
I. Georges Bank winter flounder
J. Southern New England winter flounder
K. Gulf of Maine/Georges Bank white hake

A summary of current stock status, control rule targets, and medium-term projections results for eleven groundfish stocks is given in the following table.

		target F		year B>Bmsy	
stock	B99/Bmsy	on biomass	fully-recruited	50% prob.	90% prob.
SNE yellowtail	0.11	0.00	0.00	2007	>2009
white hake	0.25	0.00	0.00	2004	2005
GB winter fl.	0.30	0.00	0.00	2004	2006
GOM cod	0.39	0.15	0.22	2007	2009
GB cod	0.41	0.13	0.19	2006	2008
GB haddock	0.43	0.00	0.00	2002	>2009
CC yellowtail	0.58	0.04	0.07	2001	2002
Am. plaice	0.60	0.02	0.02	2003	2004
SNE winter fl.	0.90	0.24	0.43	2001	>2009
GB yellowtail	0.93	0.27	0.50	2002	>2009
witch flounder	1.03	0.09	0.11	1999	2001

Assessment Issues

Decreasing Port Sampling Coverage

For many stocks the quantity and the seasonal and market category coverage of the commercial port samples has decreased considerably. This has likely introduced more variability into the estimation of landings at age and, consequently, more uncertainty into the assessment. This issue should be addressed to prevent the sampling coverage from worsening, and to initiate procedures to ensure adequate coverage of the landings.

Conditioning of q in ASPIC

In some stocks, the catchability (q) in the ASPIC model was fixed to obtain consistency between VPA and ASPIC biomass estimates. This also achieves a more reasonable estimate of r, the intrinsic rate of increase of the stock. However, the adjustment of q may affect the estimates of Bmsy obtained from ASPIC.

Conversion of fully recruited F to biomass-weighted F

Since the SFA control rule has been developed and specified in terms of mean biomass and biomass-weighted fishing mortality, the estimates of fully recruited F associated with the age-structured VPA results must be converted to biomass-weighted F and *vice versa*. The translation between these two measures of F will vary depending on the age structure of the stock at the time of the translation. This may cause confusion, and may introduce apparent inconsistencies.

In addition, for some stocks, there is no catch at age 1 or age 2. If the calculation of biomass-weighted F in the SFA control rule reflects all ages, it has been necessary to translate age-specific Fs from the VPA to biomass-weighted Fs by accounting for all ages, including those for which F is 0.0. An adjustment to the control rule F and mean biomass may be required to restore consistency between the two measures of F and biomass.

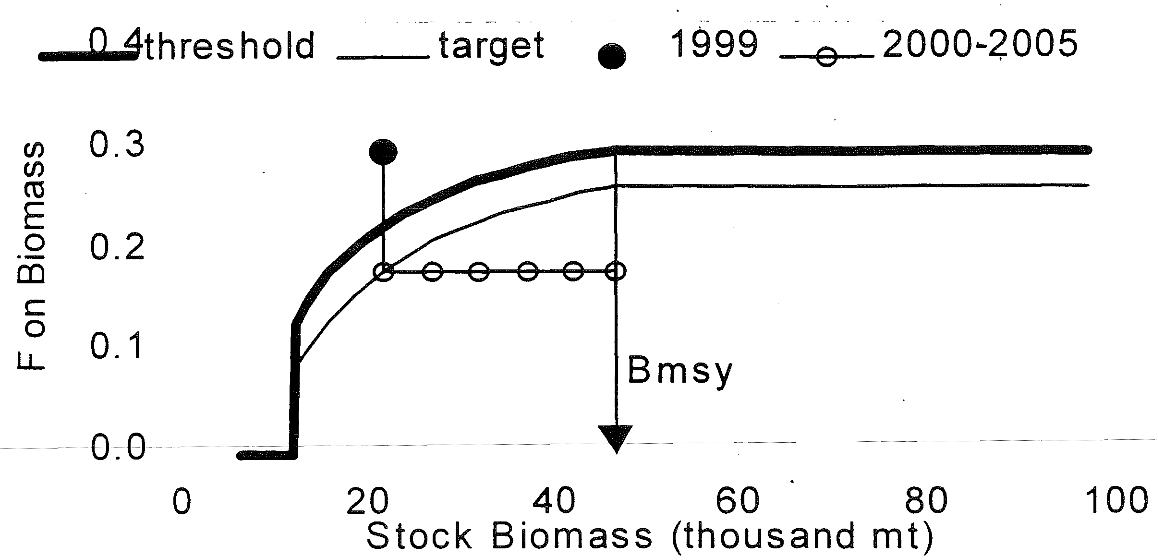
The Working Group considers this to be an issue to be addressed further.

For the purposes of this analysis, the Working Group has determined the appropriate biomass-weighted F based on the SFA control rule for each stock. To execute the 10-year projections in an age-structured framework, the biomass-weighted F was converted to a corresponding fully-recruited F. This value of F was then held constant throughout the 10-year forecast horizon. A more detailed explanation and illustration of the SFA control rule is given in the following section.

Harvest Control Rules

Many of the harvest control rules in Amendment #9 were recommended based on deterministic biomass projections (Applegate et al. 1998). Threshold and target fishing mortalities were derived from estimates of minimum biomass that could rebuild to B_{MSY} at a constant rebuilding F within a fixed time period (Cadrin 1999).

For the example depicted below, rebuilding targets and thresholds are based on a 5-year rebuilding period. If mean biomass in 1999 was estimated to be 22,000 mt, the target F in 2000 would be 0.18. The target F (0.18) would be maintained in subsequent years as the stock grows to B_{MSY} (which is expected to take 5 years given the historical productivity of the stock).



Therefore target F does not increase during the rebuilding period as stock biomass increases.

Although the control rule targets account for uncertainty in MSY reference points, they do not account for uncertainty in stock status determination. Uncertainty in current F and biomass should be considered to assess the risk of overfishing, because their probability distributions are negatively correlated (i.e., the uncertainty cloud around the point labeled '1999' on the graph above would slope up and to the left).

References

Applegate, A., S. Cadrin, J. Hoenig, C. Moore, S. Murawski, and E. Pikitch. 1998. Evaluation of existing overfishing definitions and recommendations for new overfishing definitions to comply with the Sustainable Fisheries Act. New England Fishery Management Council Report.

Cadrin, S.X. 1999. A precautionary approach to fishery control rules based on surplus production modeling. National Oceanographic and Atmospheric Administration Technical Memorandum NMFS-F/SPO-40: 17-22.

Section 2. Projection Methodology

Stock-Recruitment Data and Analyses for Eleven Northeast Groundfish Stocks.

1.0 Background

Time-series of Stock-Recruitment data from VPA's for the eleven groundfish stocks were summarized to determine the suitability of the data for forecasting purposes. A set of exploratory graphs were produced for each stock. These included plots of recruitment (year class strength) vs spawning stock biomass(SSB), recruit per spawner ratios (RSSB) vs spawning stock biomass, and recruitment, SSB, and RSSB vs time. A scatterplot smoother was also applied to these plots to give an indication of trend. Autocorrelation plots for rssb were also generated to evaluate whether there was serial correlation in productivity which might be expected if environmental effects persisted through time. A summary data table for each series and basic statistics for each variable were also produced.

Graphical results (see individual stock sections B-L) showed that the relationship between estimated recruitment and spawning stock varied considerably through the available time series. Some stocks appeared to produce higher recruitment at high spawning stock sizes, while others exhibited no obvious relationship between recruitment and spawning stock. There were time trends in recruitment and spawning stock for some stocks. Some stocks also appeared to have a trend in recruit per spawner ratios. Overall, the graphical results indicated that the available stock-recruitment data were very noisy and that the determination of functional relationships between spawning stock and recruitment is difficult.

2.0 Analyses of the Appropriateness of using Stock-Recruitment Relationships for Northeast Groundfish

Several analyses were completed to determine if basic assumptions from stock-recruitment theory were evident in the empirical data for the eleven Northeast groundfish stocks. Myers and Barrowman (1996) analyzed 364 stock-recruitment data sets to examine hypotheses relating recruitment to spawner abundance, concluding that there was strong evidence to support a relationship between spawner abundance and recruitment in general and within several families of fish. We used similar non-parametric rank and ratio estimates to examine hypotheses for the eleven stocks. We were interested in the same set of hypotheses as Myers and Barrowman (1996), (1) if the largest recruitment occurs at the highest SSB, (2) if the smallest recruitment occurs at the lowest SSB, and (3) if recruitment is greater when SSB is above the median SSB (Table 1). In addition we looked at a similar approach for RSSB ratios. We were interested in (1) the rank of the maximum RSSB at high SSB, (2) the rank of the minimum RSSB at low SSB, and (3) the ratio when SSB was above or below the median (Table 1).

Results from these analyses indicated that maximum recruitment had occurred at above average stock size ranking in 6 out of 11 stocks. Similarly, we found that minimum observed recruitment had occurred at below average stock size ranking in 6 out of 11 stocks (Table 1). The ratio of average recruitment when SSB was above its median to average recruitment when SSB was below its median was greater than 1.0 in 6 out of 11 stocks as well. Together, these measures suggested that extreme values of recruitment were not tightly linked to ssb levels for some stocks. They also suggested that average recruitment levels were not strongly affected by SSB for some stocks.

Results from the analyses on relative productivity (rssb) were more conclusive. In 11 out of 11 stocks, the maximum value of rssb occurred at a below-average stock ranking (Table 1). Similarly, in 8 out of 11 stocks, the minimum rssb value occurred at an above-average stock ranking. The ratio of average rssb when ssb was above its median to its average when ssb was below its median was less than 1 in 10 out of 11 stocks. Overall, these results suggested that maximum values of rssb were associated with below average stock sizes and that minimum values were associated with above average stock sizes. The apparent decline in rssb as ssb increased in 10 out of 11 stocks was consistent with the notion that compensation influenced the relative productivity of these stocks.

We also used contingency tables to compute the probabilities of obtaining various combinations of recruitment and spawner biomass. These were useful for computing the odds of obtaining high or low recruitment at high or low ssb. These 'odds ratios' were also useful for examining the benefits of higher spawning biomass for Northeast groundfish (Table 2). In fact, the odds ratios showed that recruitment likely improves when ssb is above its median in 7 out of 11 stocks. Note that these contingency table analyses were conducted on data available prior to July 15th and that changes to the VPA stock-recruitment series made after this date may affect results.

3.0 Stock Recruitment Modeling and Forecasting

A Beverton-Holt (B&H) stock-recruitment model with a multiplicative lognormal error structure was previously used in ten year projections for the five New England groundfish stocks (cod, haddock, yellowtail flounder) during SARC 24 (NEFSC 1997; NRC 1998). This form of the model (FORM 1 in equation (1) below)

$$R = \frac{aS}{b+S} \times e^{w} \qquad (1)$$

as well as another form of the B&H model (FORM 3 in equation (2) below)

$$R = \frac{0.8 \times z \times Rmax \times S}{0.2 \times Smax(1-z) + S(z-0.2)} \qquad (2)$$

were thoroughly investigated as potential sources for modeling stock-recruitment in the current exercise. We parameterized B&H models for the eleven stocks and used results from feasible parameter estimations in preliminary ten year forecasts to determine the applicability of this approach for modeling medium-term stock dynamics of groundfish (Table 3). These trial projections were performed in relation to control rules and required rebuilding schedules currently in place for New England groundfish.

Results from the stock-recruitment model fits were infeasible for Georges Bank winter flounder. Gulf of Maine witch flounder, and American plaice (Table 3. z values >1.0). Each of these stocks appeared to exhibit overcompensation and/or time trending of recruitment and rssb. As a result, the B&H models were not used for these stocks. Two yellowtail stocks (Cape Cod and Southern New England) showed high resilience (Table 3, z values near 1.0). Of these, Southern New England yellowtail also exhibited high variability about the mean B&H curve and also showed evidence of serial correlation in residuals from the model fit. In contrast, Cape Cod yellowtail had relatively low variability and also had residuals that did not appear to be lognormal. Regardless of the model fits, however, the average relationship between recruitment and spawning stock for these two stocks was effectively constant over the observed range of stock sizes. Three stocks had moderate levels of resilience (Table 3, z values between 0.4 and 0.75): Georges Bank yellowtail, Gulf of Maine cod, and white hake. Of these, white hake had a pattern of serial correlation in residuals from the model fit. Three other stocks exhibited low resiliency (z values between 0.15 and 0.35): Georges Bank haddock, Georges Bank cod, and Southern New England winter flounder. Of these, Georges Bank haddock exhibited strong departures from B&H model assumptions. In addition, the point estimate of z of 0.18 for Georges Bank haddock suggested mild depensation in this stock-recruitment curve.

Results suggested that forecasts with these models may have been too optimistic for some stocks (Gulf of Maine cod, Georges Bank haddock, white hake, Southern New England winter flounder), Results for these stocks appeared inconsistent with ASPIC estimates of K and or Bmsy, historic research survey biomass indices, VPA biomass estimates, and feasible increases in biomass from average recruitment. However, forecasts for other stocks such as Georges Bank cod and yellowtail flounder and Southern New England yellowtail flounder using the estimated Beverton-Holt model, were reasonable when compared to other information on stock productivity. For stocks where a stock-recruitment model was not feasible or overly optimistic, the empirical recruitment data were used to generate recruitment over the ten year horizons. It is important to note that this work is currently still in progress and further testing, validation, and software enhancements are necessary. Nonetheless, projection results to date can serve as the foundation for future research and development of approaches for medium and long-term forecasts.

4.0 Sources of Uncertainty

"Prediction is very difficult, especially about the future."
Niels Bohr

Projection results may be optimistic and should be interpreted with the following caveats:

- Stock-recruitment data are limited. With the short-time series available, long-term relationships are difficult to discern, especially given the inherent variability in recruitment. Further, there is a general lack of observations of recruitment levels at high spawning stock sizes and this leads to imprecise determination of maximum expected recruitment levels. It is important to note that, with the exception of Georges Bank haddock, the length of the 10-year projection period is roughly half or more of the available time series of stock-recruitment data.
- Measurement error in estimates of spawning stock and recruitment may have obscured patterns in stock-recruitment data. Current stock assessment models may have retrospective patterns in estimates of spawning stock and recruitment that cannot be incorporated in these analyses.
- Several stocks appear to have recent trends in productivity. Modeling nonstationary stock-recruitment relationships is very difficult without prior information on the magnitude and duration of trends.
- The possibility of compensatory changes in weight at age and maturation probability at age are not included in the 10-year projections. This implies that projection results may be optimistic because at higher stock sizes, individual growth rates may decline, and assumed future values of population mean weights at age may be biased high.
- Genetic diversity of some of these stocks may have been reduced through intensive exploitation. As a result, some stocks may be less fit to compete in portions of their historic range. Similarly, near shore components of some stocks may have been adversely affected by habitat loss and pollution. Recolonization of some near shore and estuarine areas may not be possible without improved habitat. Potential losses in genetic diversity and habitat are impossible to quantify, however, without decadal time series of baseline information.

Section 3. Stock Assessments and Medium-Term Forecasts

The following sections A-K contain a summary of the assessment results through 1999 and medium-term forecasts through 2009 for 11 Northeast groundfish stocks.

A. Georges Bank Atlantic Cod by L. O'Brien

1.0 Background

This stock was last assessed in 1998 and reviewed by the 27th Northeast Regional SAW. Fully recruited F (ages 4-8, u) was estimated to be 0.26 , the lowest in the time series (1978-1997) and about 45% higher than $F_{0.1}$ = 0.18. Spawning stock biomass was 36,000 mt in 1997, continuing to increase from the record low estimate of 25,000 mt in 1994. Recruiting year classes continued to decline with the four most recent year classes (1994-1997) being the lowest on record with recruit/SSB survival ratios below the long term average. The NEFSC spring and autumn bottom trawl survey indices continued to decline and remain near record low values. Recruitment indices for the 1994-1996 year classes were among the lowest in the time series.

2.0 1999 Assessment

The Fishery

Total commercial landings of Georges Bank cod (Table A1, Figure A1) in 1998 (8,800 mt) declined 15% from 1997. USA landings declined about 8% from 7,500 mt to 7,000 mt and Canadian landings declined about 35% from 2,900 mt to 1,900 mt (Table A1). No discards estimates were derived for 1998. Recreational landings were estimated at 515 mt, a decline of about 33 % from 1997.

The total number of commercial length samples in 1998 were about equal to the 1997 samples. The number of quarterly samples were adequate for the scrod and market category and were poor for the large market category. The large samples were pooled on a semi-annual basis. Spatial coverage was poor for eastern Georges Bank (SA 561, 562). As in the last assessment, length samples from western Georges Bank and US and Canadian combined age samples from eastern Georges Bank were applied to characterize the landings from eastern Georges Bank. Landings were dominated by age 3 fish in both the US and Canadian fisheries.

Input data and Analyses

The current assessment is an update of the 1998 assessment (O'Brien and Cadrin 1999) and assumes the same VPA formulation. A slight variation from the previous assessment is that the number of surveys available as tuning indices in the terminal year increases from two to three with the addition of the US spring survey. Catch at age has been updated with total 1998 landings (US and Canadian) and NEFSC 1998 spring and autumn survey indices and NEFSC and Canadian 1999 spring survey indices.

A conditional non-parametric bootstrap procedure (Efron 1982) was used to evaluate the precision of fishing mortality and spawning stock biomass estimates. A retrospective analysis was performed for terminal year fishing mortality, spawning stock biomass, and age 1 recruitment.

3.0 Assessment Results

NEFSC spring and autumn survey indices increased in both abundance and biomass in 1998. The 1999 NEFSC spring indices declined to similar values observed in 1997 (Table A2, Figures A2 and A3). The Canadian spring survey index of abundance declined in 1998 , then increased in 1999 to a value similar to 1997 (Figure A3). The recruitment index of NEFSC autumn age 1 in 1998 remains well below average.

Fully recruited fishing mortality (age 4-8) is estimated as 0.28 in 1998, an 8% increase from the 1997 F (0.26) estimated in the previous assessment (O'Brien and Cadrin 1999). The current assessment now estimates the 1997 fishing mortality as 0.53 (Figure A4). Spawning stock biomass in 1998 was estimated as 28,700 mt an 8% increase from 1997 and a 27% increase from the record low SSB in 1994 (Table A3, Figure A5). Recruitment in 1998 is estimated to be similar to the 1992 and 1996 year classes (Table A3, Figure A5). The recruit/SSB survival ratios for the 1995, 1996, and 1998 year classes were above average and the 1997 year class had the lowest survival in the time series. Mean biomass increased from a record low 31,000 mt in 1995 to 38,000 mt in 1997 and declined to 36,000 mt in 1998 (Table A3, Figure A5). Biomass weighted fishing mortality declined from a time series high of 0.63 in 1993 to a time series low of 0.24 in 1998 (Table A3, Figure A4).

VPA Diagnostics

Stock size estimates for ages 1-8 were well estimated with CVs ranging from 0.37 to 0.44. Ages 2, 3, and 4 all have positive residuals in 1999 indicating that all survey estimates may be too low, and ages 6, 7, and 8 all have negative residual indicating that the survey estimates are too high. The distribution of F estimates from the bootstrap analysis ranged from 0.2 to 0.43 with an 80% probability that F in 1998 was between 0.26 and 0.32. Estimates of SSB ranged from 20,000 mt to 36,000 mt with an 80% probability that SSB in 1998 was between 24,000 mt and 32,000 mt.

A retrospective pattern exists in this model formulation back to 1994. In the terminal year, fishing mortality has been underestimated and spawning stock biomass has been overestimated each year since 1994 and recruitment has been underestimated since 1995.

4.0 Forecasts

An analysis of the stock-recruit data indicated a relationship of increased recruitment with increased spawning stock biomass. Parameters estimated by a Beverton-Holt stock recruitment model were statistically feasible and this model was used to generate recruitment for forecasts of stock size and landings for 1999-2009. Constraints derived from the 0%, 75%, and 100% quartiles of the time series of R/SSB survival ratios were imposed on the recruitment when the SSB reached a level of 50,000 mt. Input data are presented in Table A4. Catch mean weights, stock mean weights, and the partial recruitment were based on the average of the last 5 years (1994-1998).

Short term forecasts of stock size and landings were performed for 1999-2000 where the F in 1999 was assumed to be equal to the F in 1998 given the lack of complete 1999 landings data (Table A5). SSB is predicted to increase 13 % from 28,700 mt in 1998 to 32,500 mt in 1999. Mean biomass in 1999 is estimated to increase 21% from 36,300 mt in 1998 to 43, 900 mt in 1999.

The SFA control rule for Georges Bank cod is based on B_{MSY} (108,000 mt) and states that when the stock biomass is between 1/4 and ½ B_{MSY} (27,000-54,000 mt), the threshold mortality rate is defined by a five year rebuilding time period, and if the stock is between 1/2 B_{MSY} and B_{MSY} the rebuilding time period is10 years. In 1999, mean biomass is predicted to be about 44,000 mt, less than ½ B_{MSY} . Applying the 1999 mean biomass to the target control rule (Figure A6) indicates that the stock is to be fished at biomass weighted F no higher than 0.125.

Long term forecasts from 2000-2009 were conducted with the fully recruited F equivalent (0.185) of the biomass weighted F (0.125) required to achieve compliance with the SFA control rule. Landings, SSB, and mean biomass trajectories are presented in Table A5. There is a 50% probability that B_{MSY} will be achieved by 2006 (Table A5, Figure A7).

5. 0 Sources of Uncertainty

There was poor commercial sampling in1998 both temporally and spatially. The large market category was not well sampled by quarter, and samples from eastern GB were minimal.

There is a retrospective pattern in the VPA. Fishing mortality has been underestimated since 1994 and recruitment has been underestimated since 1995.

Short term projections are likely optimistic if fishing mortality is underestimated in 1998.

There is inadequate data to characterize both the recreational and discarded catch, particularly if these components increase. The SARC previously rejected using poorly sampled recreational catch since it would only be a scaling factor if the age structure is the same.

6.0 References

O'Brien, L. and S.X. Cadrin. 1999. Assessment of the Georges Bank Atlantic Cod Stock for 1998. NEFSC Ref. Doc 99-03.

Efron, B. 1982. The jackknife, the bootstrap and other resampling plans. Phila. Soc. Ind. and Appl. Math. 34: 92 p.

Table A1. Commercial landings (metric tons, live) of Atlantic cod from Georges Bank and South (Division 5Z and Subarea 6), 1960 - 1998.

Year	USA	Canada	USSR	Spain	Poland	Other	Total
			Country				
1960	10834	19	-	-	-	-	10853
1961	14453	223	55	-	-	-	14731
1962	15637	2404	5302	-	143	-	23486
1963	14139	7832	5217	-	-	1	27189
1964	12325	7108	5428	18	48	238	25165
1965	11410	10598	14415	59	1851	-	38333
1966	11990	15601	16830	8375	269	69	53134
1967	13157	8232	511	14730	-	122	36752
1968	15279	9127	1459	14622	2611	38	43136
1969	16782	5997	646	13597	798	119	37939
1970	14899	2583	364	6874	784	148	25652
1971	16178	2979	1270	7460	256	36	28179
1972	13406	2545	1878	6704	271	255	25059
1973	16202	3220	2977	5980	430	114	28923
1974	18377	1374	476	6370	566	168	27331
1975	16017	1847	2403	4044	481	216	25008
1976	14906	2328	933	1633	90	36	19926
1977	21138	6173	54	2	-	-	27367
1978	26579	8778	-	-	-	-	35357
1979	32645	5978	-	-	-	-	38623
1980	40053	8063	-	-	-	-	48116
1981	33849	8499	-	-	-	-	42348
1982	39333	17824	-	-	-	-	57157
1983	36756	12130	-	-	-	-	48886
1984	32915	5763	-	-	-	-	38678
1985	26828	10443	-	-	-	-	37271
1986	17490	8411	-	-	-	-	25901
1987	19035	11845	-	-	-	-	30880
1988	26310	12932	-	-	-	-	39242
1989	25097	8001	-	-	-	-	33098
1990	28193	14310	-	-	-	-	42503
1991	24175	13455	-	-	-	-	37630
1992	16855	11712	-	-	-	-	28567
1993	14594	8519	-	-	-	-	23113
1994	9893	5276	-	-	-	-	15169
1995	6759	1100	-	-	-	-	7859
1996	7020	1885	-	-	-	-	8905
1997	7537	2898	-	-	-	-	10435
1998	6959	1873					8832

Table A2. Standardized stratified mean catch per tow in numbers and weight (kg) for Atlantic cod in NEFSC offshore spring and autumn research vessel bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 1999. [a,b,c]

	Spring		Autumn	
Year	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	4.37	17.8
1964	-	-	2.98	11.6
1965	-	-	4.25	11.7
1966	-	-	4.81	8.1
1967	-	-	10.38	13.6
1968	4.72	12.6	3.30	8.6
1969	4.64	17.8	2.20	8.0
1970	4.34	15.6	5.07	12.5
1971	3.39	14.2	3.19	9.9
1972	8.97	19.0	13.09	23.0
1973	18.68 [d]	39.7 [d]	12.28	30.8
1974	14.75	36.4	3.49	8.2
1975	6.89	26.0	6.41	14.1
1976	7.06	18.6	10.44	17.7
1977	6.30	15.4	5.45	12.5
1978	12.31	31.2	8.59	23.3
1979	5.16	16.9	5.95	16.5
1980	6.12	16.7	2.91	6.7
1981	10.44	26.1	9.04	19.0
1982	8.20 [e]	15.4 [e]	3.71	6.9
1983	7.70	24.0	3.64	6.5
1984	4.08	15.4	4.75	10.3
1985	6.94	21.5	2.43	3.5
1986	5.04	16.7	3.12	4.7
1987	3.26	10.3	2.33	4.4
1988	5.86	13.5	3.11	5.8
1989	4.80	10.8	4.78	4.6
1990	4.74	11.6	3.62 [f]	7.1 [f]
1991	4.39	9.0	0.96	1.4
1992	2.67	7.5	1.84	3.1
1993	2.48	7.3	2.15	2.2
1994	0.94	1.2	1.82	3.3
1995	3.29	8.4	3.62	5.6
1996	2.70	7.5	1.10	2.7
1997	2.32	5.2	0.87	1.9
1998	4.36	11.7	1.87	2.8
1999	2.15	4.7	--	--

[a] During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFC 1991).
[b] Spring surveys during 1980-1982, 1989-1991 and 1994 and autumn surveys during 1977-1981, 1989-1991, and 1993 were accomplished with the *R/V Delaware II*; in all other years, the surveys were accomplished using the *R/V Albatross IV*. Adjustments have been made to the *R/V Delaware II* catch per tow data to standardize these to *R/V Albatross IV* equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFC 1991).
[c] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data for these gear differences.
[d] Excludes unusually high catch of 1894 cod (2558 kg) at Station 230 (Strata tow 20-4).
[e] Excludes unusually high catch of 1032 cod (4096 kg) at Station 323 (Strata tow 16-7).
[f] Excludes unusually high catch of 111 cod (504 kg) at Station 205 (Strata tow 23-4).

Table A3. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F), mean biomass (mt), spawning stock biomass (mt), and percent mature of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1978-1998.

Stock Numbers (Jan 1) in thousands

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	27713	23514	20105	41393	17471	9615	27393	8674	42758	16379	23460	15723	9250	18016	7005	9366	7802	4247	7576	8639	2280	10469
2	4268	22688	19220	16380	33865	14004	7774	22354	6980	34867	13386	19198	12873	7567	14703	5672	7664	6386	3477	6202	7070	1867
3	25526	3139	16776	12319	10511	19458	7588	5183	12488	4515	21784	9533	13829	6068	4816	8259	3709	5915	4874	2659	4610	5120
4	7947	13888	1755	8461	6266	5145	8635	3115	2033	6086	2425	10577	5161	6760	2033	1979	2920	1656	3885	3173	1599	2700
5	2878	4422	6964	985	4698	2609	1990	4051	1313	943	3064	1069	4900	2522	2566	726	611	739	729	2064	1801	926
6	1124	1605	2524	3613	594	2037	1181	869	1611	640	520	1154	576	1963	746	760	196	144	343	379	972	1181
7	1434	802	900	1093	1686	232	965	500	339	752	296	205	455	264	623	245	195	74	78	169	192	581
8	67	862	587	334	517	772	104	376	212	199	371	97	93	151	102	230	57	36	37	50	63	122
9	146	12	477	402	162	231	419	45	124	109	106	126	40	44	60	53	59	5	16	27	27	39
10+	54	148	28	190	187	148	293	206	76	68	98	45	89	43	18	28	9	2	1	12	18	27
1 +	71158	71081	69336	85170	75958	54251	56344	45374	67934	64557	65510	57726	47267	43399	32672	27316	23223	19203	21015	23376	18631	23032

Fishing Mortality

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0	0	0	0	0.02	0.01	0	0.02	0	0	0	0	0	0	0.01	0	0	0	0	0	0
2	0.11	0.1	0.24	0.24	0.35	0.41	0.21	0.38	0.24	0.27	0.14	0.13	0.55	0.25	0.38	0.22	0.06	0.07	0.07	0.1	0.12
3	0.41	0.38	0.48	0.48	0.51	0.61	0.69	0.74	0.52	0.42	0.52	0.41	0.52	0.89	0.69	0.84	0.61	0.22	0.23	0.31	0.34
4	0.39	0.49	0.38	0.39	0.68	0.75	0.56	0.66	0.57	0.49	0.62	0.57	0.52	0.77	0.83	0.97	1.17	0.62	0.43	0.37	0.35
5	0.38	0.36	0.46	0.31	0.64	0.59	0.63	0.72	0.52	0.4	0.78	0.42	0.71	1.02	1.02	1.11	1.25	0.57	0.45	0.55	0.22
6	0.14	0.38	0.64	0.56	0.74	0.55	0.66	0.74	0.56	0.57	0.73	0.73	0.58	0.95	0.91	1.16	0.78	0.41	0.51	0.48	0.31
7	0.31	0.11	0.79	0.55	0.58	0.6	0.74	0.66	0.33	0.51	0.92	0.58	0.9	0.75	0.79	1.26	1.5	0.5	0.24	0.8	0.25
8	1.48	0.39	0.18	0.52	0.61	0.41	0.63	0.91	0.47	0.43	0.88	0.67	0.56	0.72	0.46	1.16	2.25	0.63	0.09	0.43	0.28
9	0.36	0.44	0.49	0.44	0.66	0.65	0.6	0.72	0.54	0.49	0.74	0.58	0.63	0.87	0.93	1.1	1.23	0.6	0.44	0.45	0.28
10+	0.36	0.44	0.49	0.44	0.66	0.65	0.6	0.72	0.54	0.49	0.74	0.58	0.63	0.87	0.93	1.1	1.23	0.6	0.44	0.45	0.28
mn4-8	0.54	0.35	0.49	0.47	0.65	0.58	0.64	0.74	0.49	0.48	0.79	0.59	0.65	0.84	0.80	1.13	1.39	0.55	0.34	0.53	0.28
Fwb	0.31	0.29	0.39	0.32	0.47	0.52	0.41	0.53	0.29	0.33	0.42	0.35	0.53	0.55	0.56	0.63	0.49	0.26	0.25	0.27	0.24

Table A3 continued. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F), mean biomass (mt), spawning stock biomass (mt), and percent mature of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1978-1998.

Mean biomass (mt)

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	17758	18931	15197	33078	11990	8411	26102	7071	35932	10768	16709	11529	6964	18162	7249	7400	6406	3487	6056	7468	1196
2	4814	29258	22651	19777	36452	15601	10450	24028	8346	41193	17253	26465	14114	9905	17229	7088	9851	8232	4596	8464	8961
3	47056	5116	29981	21114	20010	31666	12313	7020	21795	8389	36592	16166	24315	9402	7860	11568	5519	10117	9650	4838	8218
4	20860	42241	4890	21843	16003	10992	21920	8106	5193	18438	5813	27830	12980	14806	4877	3881	5804	4328	9753	8557	4309
5	9451	16546	28839	4029	17042	8355	6880	13463	5247	4127	10564	4303	15708	6954	6980	2009	1554	2832	2629	5950	6958
6	5522	8746	11415	18262	2505	9174	5217	3612	8108	3448	2247	5029	2534	6879	2770	2648	928	796	1628	1655	4509
7	8287	6326	4789	6592	10954	1269	5569	2720	2343	4827	1565	1166	2332	1266	2964	968	751	568	530	863	1262
8	276	6708	4441	2351	3515	5941	712	2327	1541	1477	2265	692	698	1040	740	1162	199	281	268	323	427
9	1318	108	2905	4201	1358	1746	3261	337	1112	897	765	1019	346	261	436	289	306	35	148	238	270
10+	549	1382	315	2602	2097	1453	3099	1817	755	737	974	532	881	408	205	205	81	25	6	113	206
Total	115890	135362	125423	133849	121927	94607	95523	70501	90372	94302	94745	94729	80872	69083	51310	37219	31398	30702	35264	38469	36317

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

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	913	1104	850	1960	1200	903	3124	773	8514	2225	3481	2481	638	1979	806	733	215	115	193	256	25
2	1410	7539	6913	5782	16138	6345	4303	11651	5031	25335	8903	13729	6634	4243	9102	3646	3643	3101	1709	3063	3506
3	33844	3729	22417	15929	15642	26059	10500	6878	18778	7106	32849	14544	22040	9073	7482	11649	5499	8966	7986	4249	7472
4	20219	38256	4297	21379	15792	12648	21655	8075	4842	17028	6135	27198	12818	16523	5305	4617	6665	4162	9314	8468	4159
5	8798	16585	30442	3958	17473	9639	7110	14906	5434	3937	12381	4198	18072	8437	8401	2548	1923	2914	2837	6788	6865
6	4882	8130	12541	20323	2957	10520	5655	4243	8583	3705	2764	5942	2957	8704	3357	3317	1011	775	1837	1840	4401
7	8215	5550	5918	7296	12172	1460	6226	3166	2346	5363	2024	1327	2850	1546	3510	1306	1049	584	571	1047	1249
8	367	6810	5034	2696	4165	6840	811	2985	1705	1692	2931	812	770	1222	784	1529	317	299	332	386	481
9	1331	112	3963	4097	1561	2112	3955	416	1250	1033	956	1192	408	373	563	418	441	42	171	245	259
10+	653	1681	388	3168	2710	1873	3940	2384	945	909	1284	673	1128	555	283	295	120	32	7	138	239
Total	80633	89496	92763	86588	89810	78398	67279	55478	57428	68331	73709	72095	68315	52657	39594	30058	20883	20991	24959	26480	28656

Percent Mature (females)

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	7	7	7	7	13	13	13	13	28	28	28	28	12	12	12	12	4	4	4	4	4
2	34	34	34	34	47	47	47	47	67	67	67	67	52	52	52	52	44	44	44	44	44
3	78	78	78	78	84	84	84	84	91	91	91	91	90	90	90	90	93	93	93	93	93
4	96	96	96	96	97	97	97	97	98	98	98	98	99	99	99	99	100	100	100	100	100
5-10+	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table A4. Input data used for long term stochastic projection of stock biomass for Georges Bank cod, 1999-2009.

Input for Projections:

Number of Years: 11; Initial Year: 1999; Final Year: 2009

Number of Ages : 10; Age at Recruitment: 1; Last Age: 10

Natural Mortality is assumed Constant over time at: .20

Proportion of F before spawning: .1667

Proportion of M before spawning: .1667

Last age is a PLUS group.

Age	Partial Recruitment	Proportion Mature	Average Weights Catch	Average Weights Stock
1	0.00	0.04	0.845	0.624
2	0.15	0.44	1.499	1.164
3	0.60	0.93	2.264	1.848
4	1.00	1.00	3.581	2.839
5	1.00	1.00	4.809	4.128
6	1.00	1.00	6.678	5.687
7	1.00	1.00	8.666	7.651
8	1.00	1.00	9.333	8.874
9	1.00	1.00	11.504	10.404
10+	1.00	1.00	14.203	14.203

Table A5. Projections of landings, spawning stock biomass, mean biomass,and recruitment with probabilities of exceeding a SSB threshold of 50,000 mt and a mean biomass threshold of 108,000 mt, 1999-2009.

YEAR	F	Landings	SSB	P (SSB > 50,000 mt)	Re cruits	Mean Biomass	P (Mean biomass > 108,000 mt)	F biomass weighted	P (F biomass wt'd > 0.125)
1999	0.28	8.287	32.461	0.00	6778.77	43.863	0.000	0.189	1.00
2000	0.185	6.199	35.769	0.00	7467.61	49.952	0.000	0.124	0.47
2001	0.185	7.161	43.339	0.12	9107.23	56.415	0.000	0.127	0.62
2002	0.185	8.769	50.136	0.51	11027.6	65.101	0.002	0.135	0.92
2003	0.185	9.679	56.486	0.81	13041.4	73.39	0.025	0.131	0.76
2004	0.185	10.774	63.332	0.94	15124.8	84.909	0.127	0.127	0.60
2005	0.185	12.386	73.314	0.99	17607.6	99.609	0.357	0.125	0.54
2006	0.185	14.272	85.538	1.00	20345.8	115.523	0.612	0.125	0.52
2007	0.185	16.765	99.491	1.00	23350.4	134.695	0.809	0.125	0.53
2008	0.185	19.751	116.973	1.00	27014.2	157.698	0.924	0.126	0.56
2009	0.185	23.042	136.347	1.00	31024.2	183.124	0.973	0.126	0.57

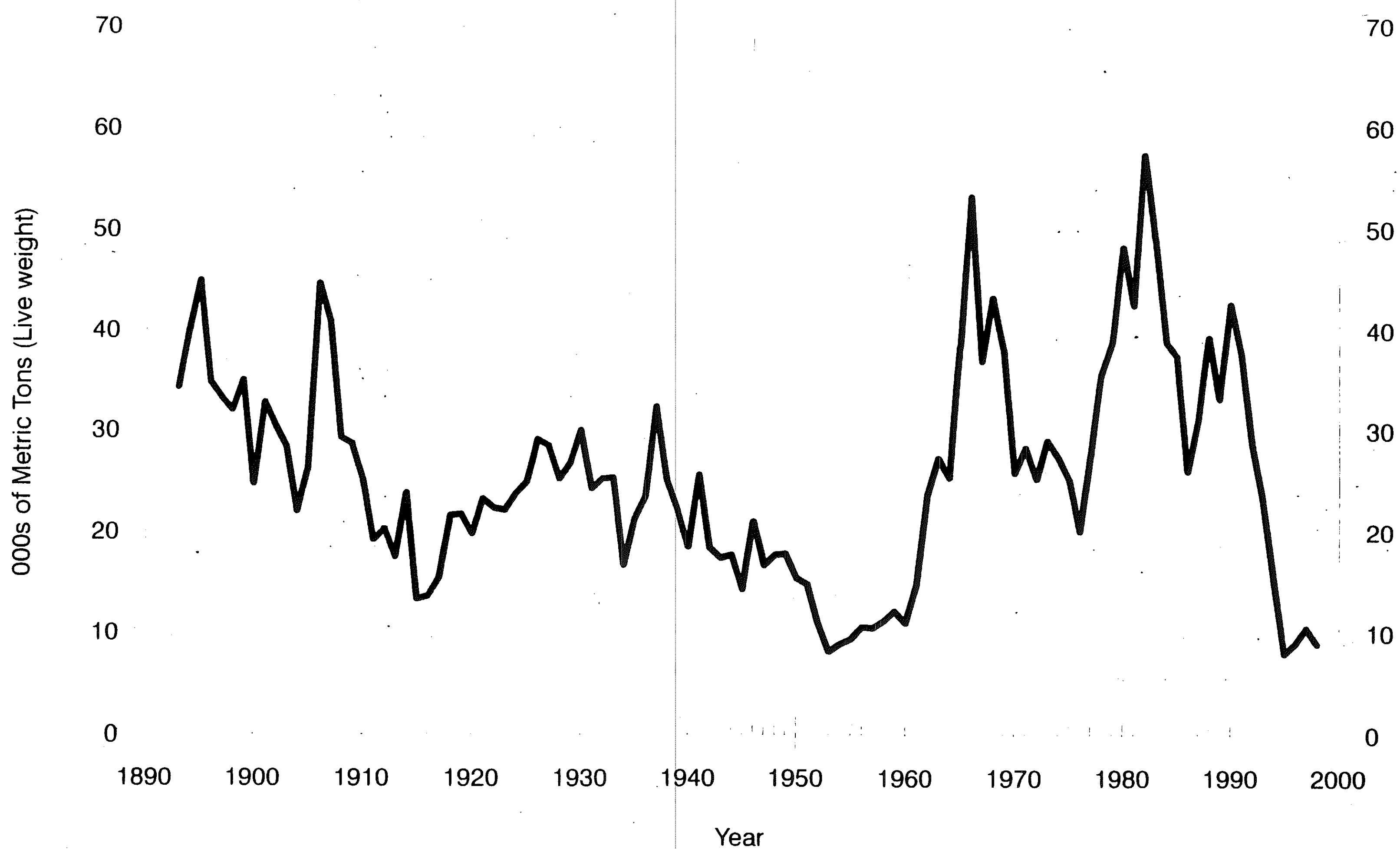


Figure A1. Total commercial landings of Georges Bank cod (Division 5Z and Subarea 6), 1893-1998.

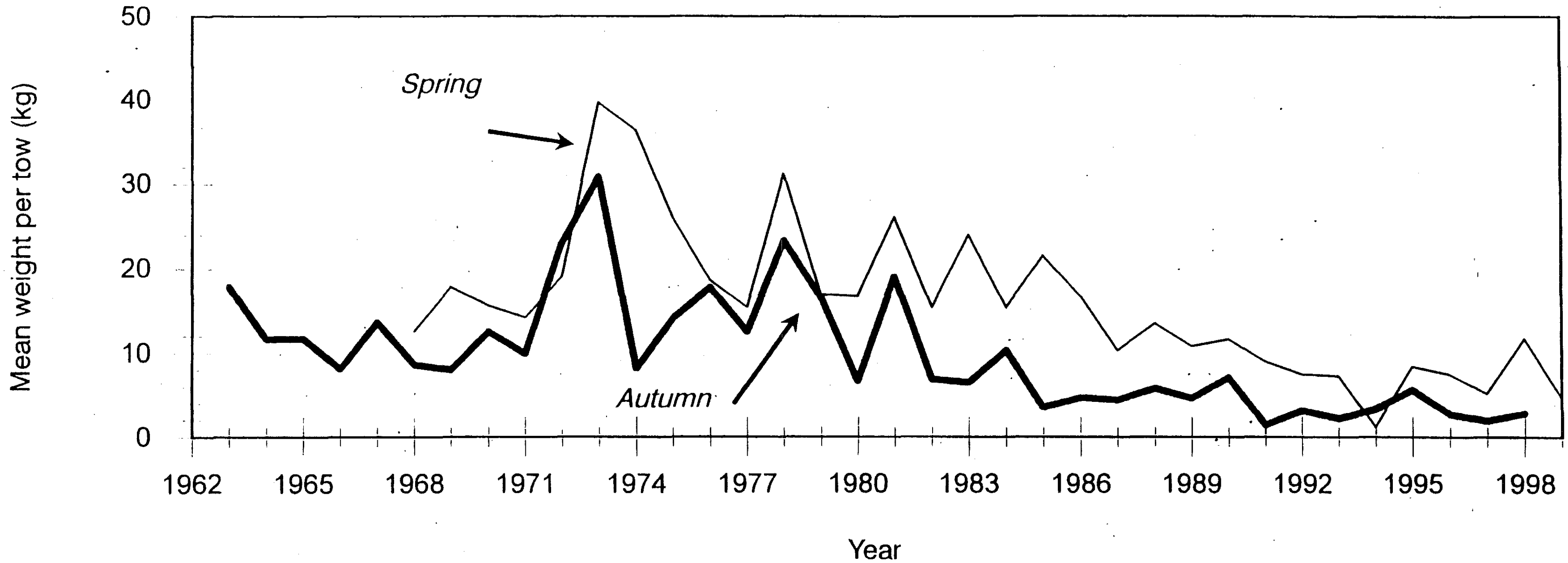


Figure A2. Standardized stratified mean catch per tow (kg) of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys on Georges Bank, 1963-1998.

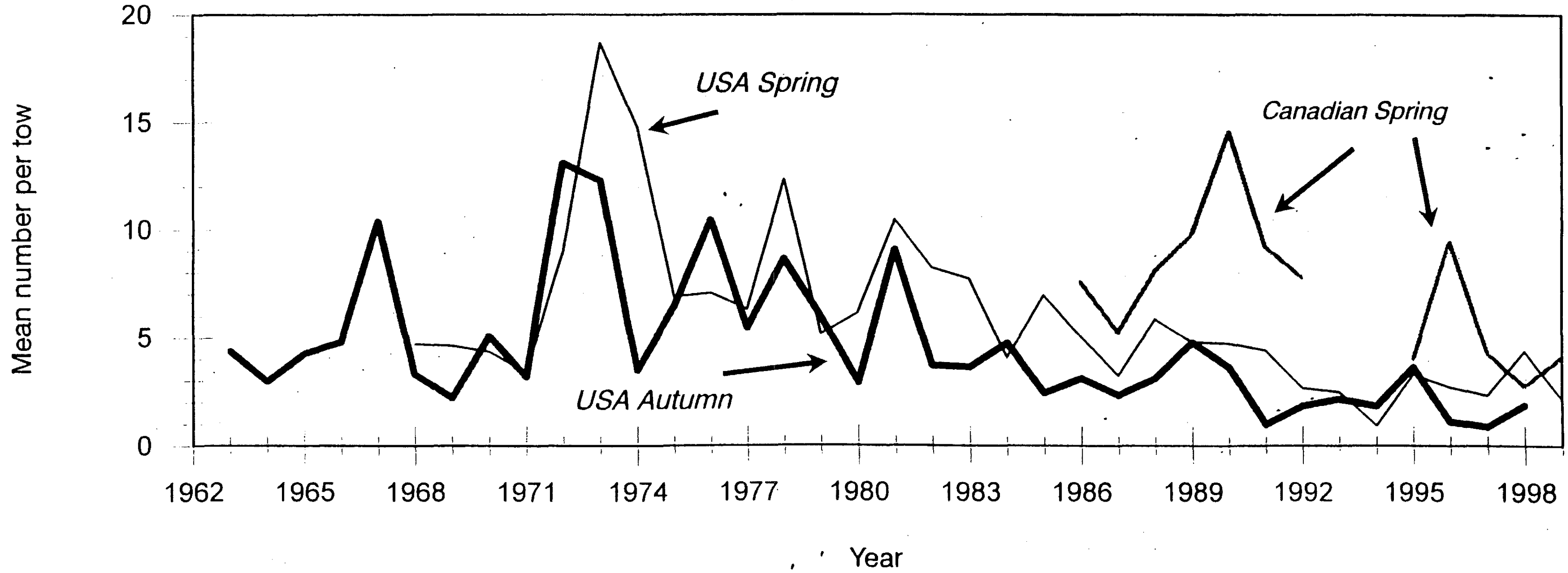


Figure A3. Standardized stratified mean number per tow of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys on Georges Bank, 1963 -1998.

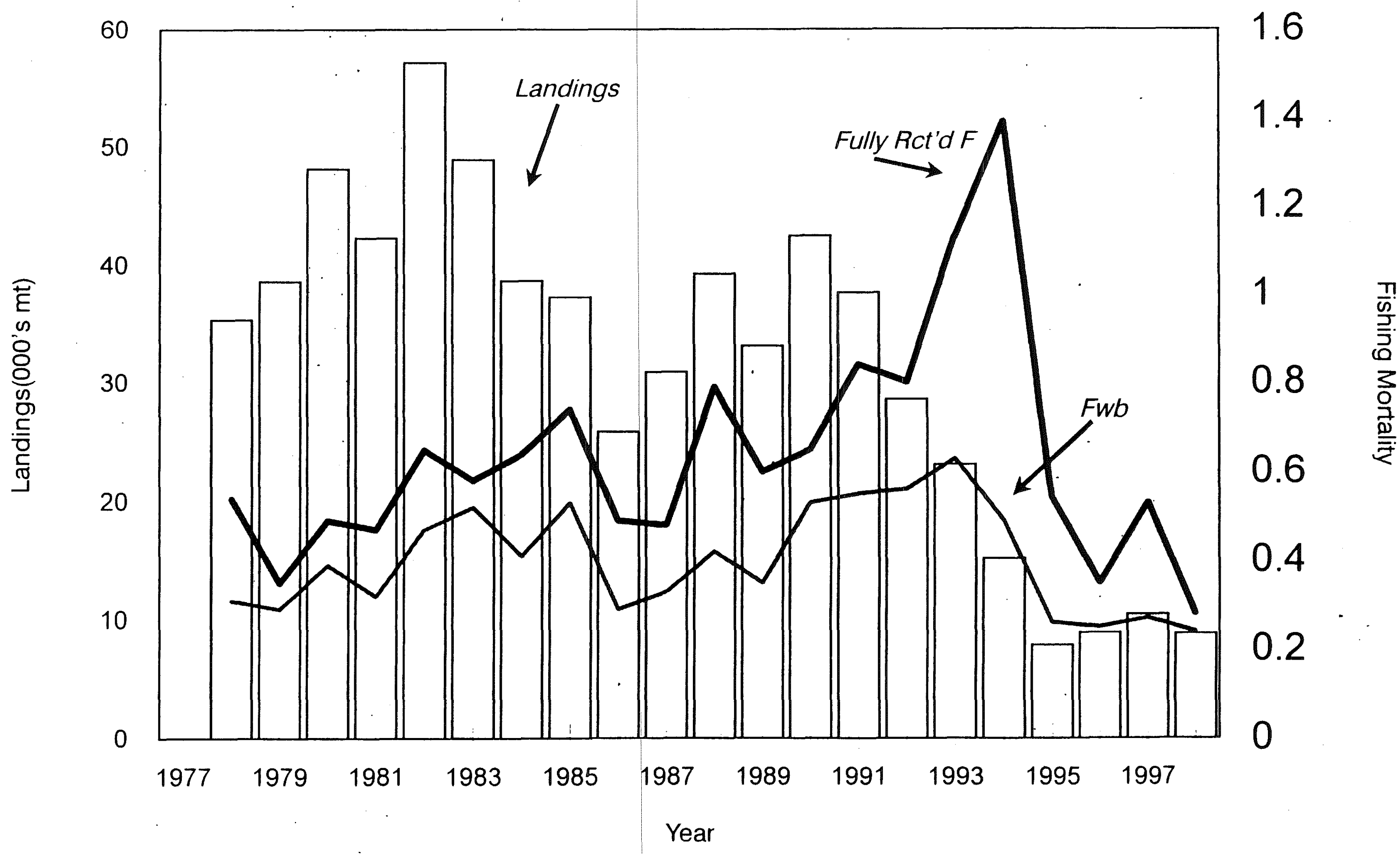


Figure A4. Trends in total commercial landings and fishing mortality for Georges Bank cod, 1978-1998.

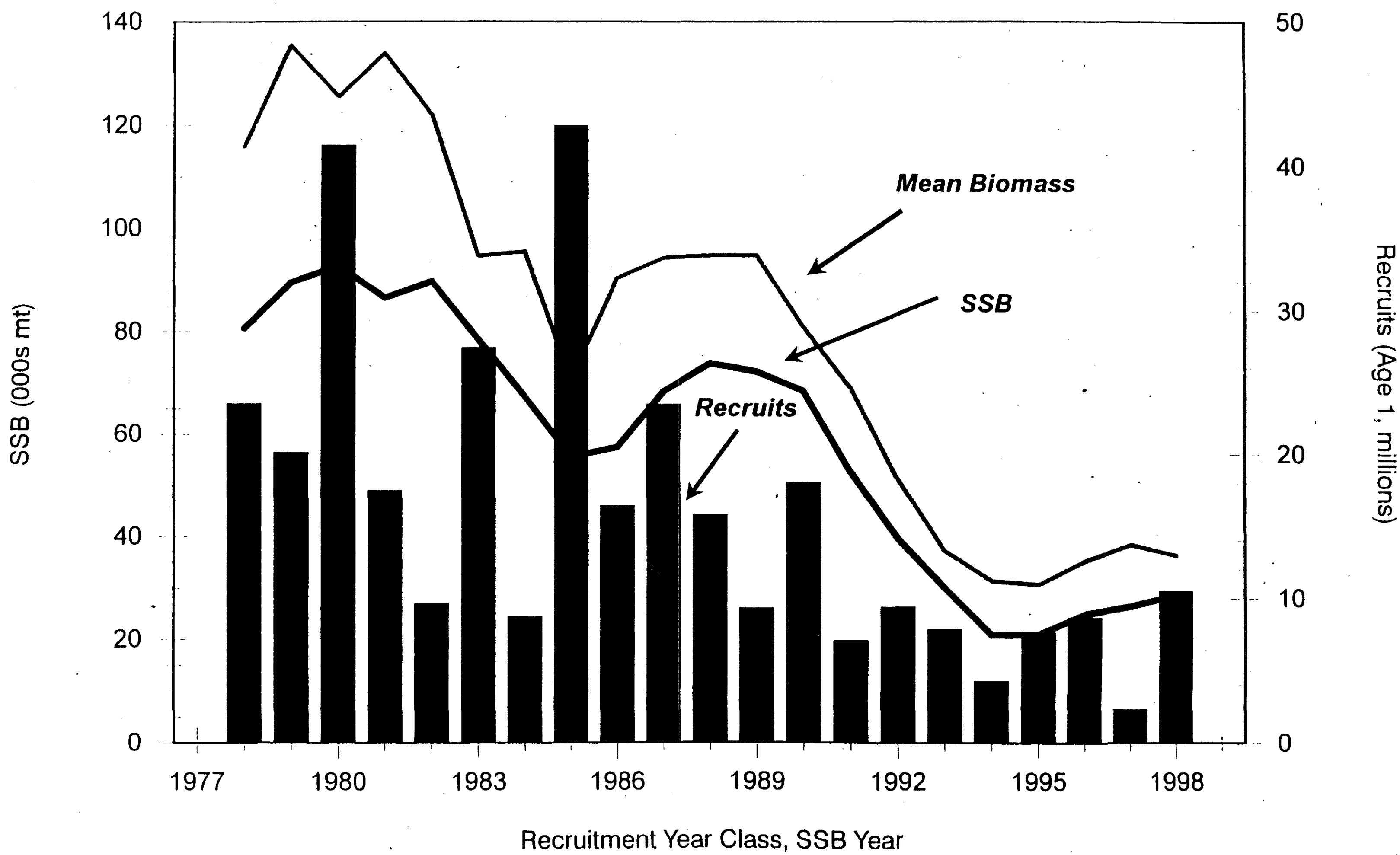


Figure A5. Trends in spawning stock biomass and recruitment for Georges Bank cod, 1978-1998.

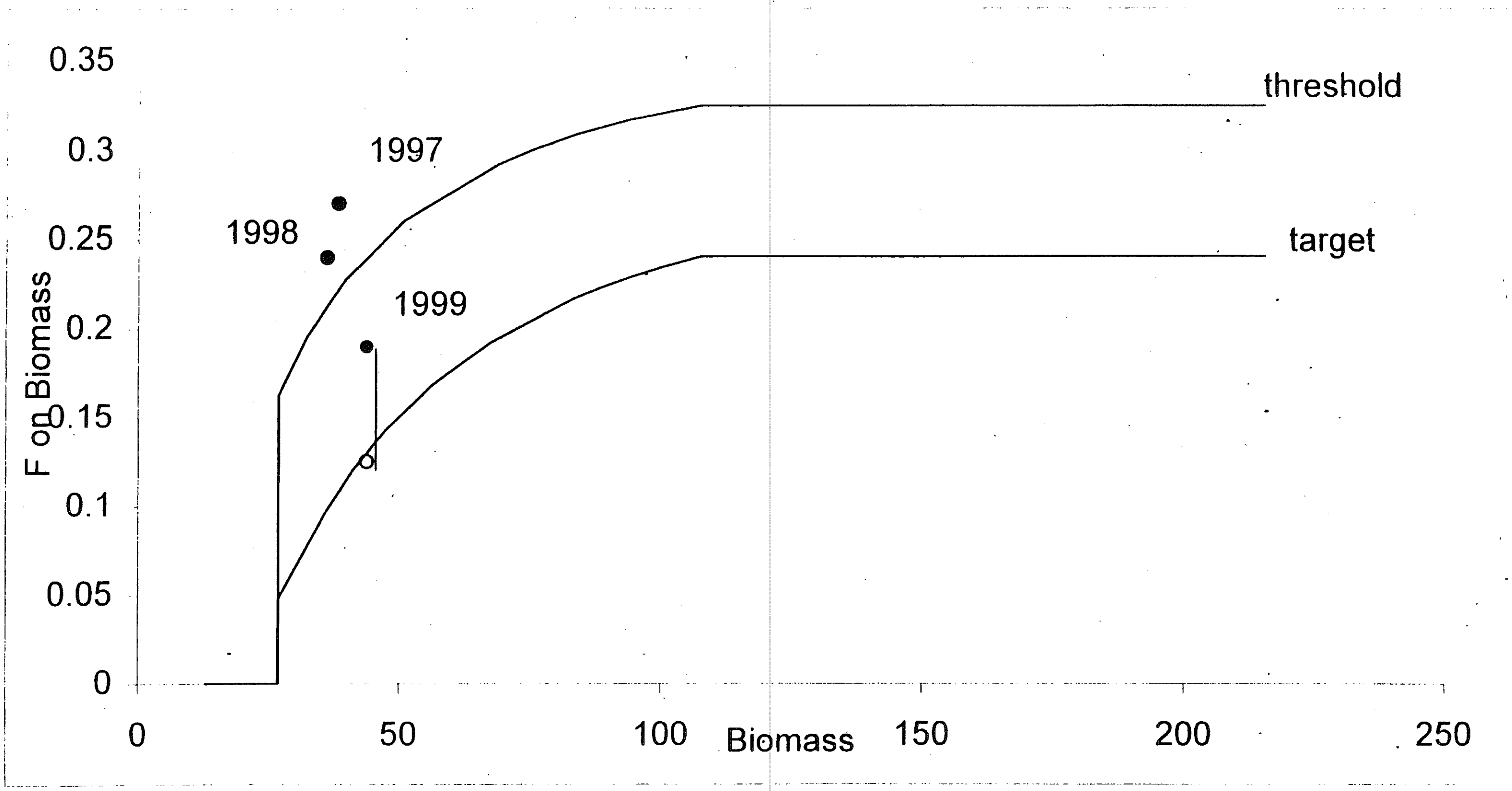


Figure A6. Control rule and recent and projected (1999) stock status for Georges Bank Atlantic cod.

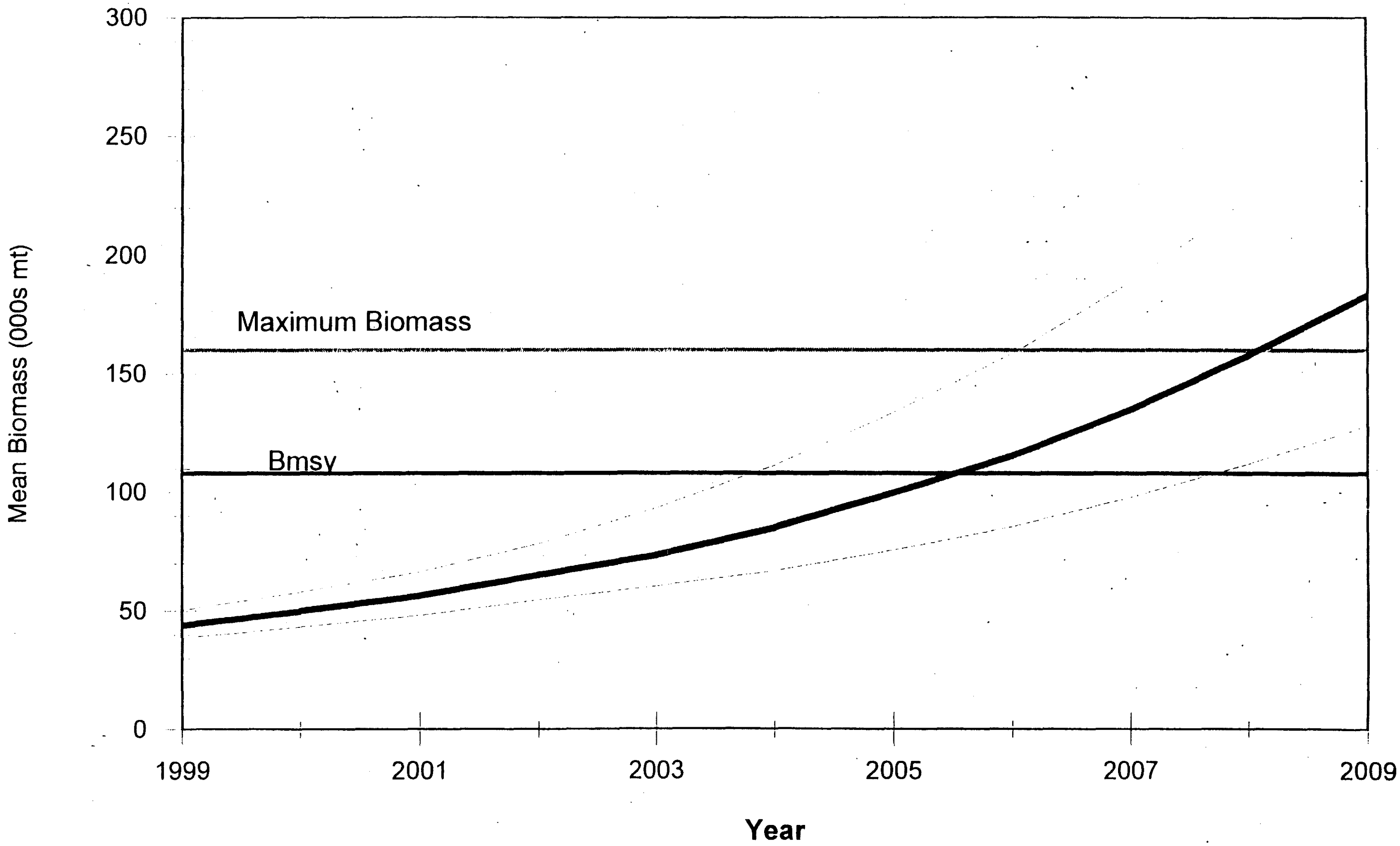


Figure A7. Long-term forecasts of mean stock biomass (ages 1+) with 80% confidence itervals for Georges Bank cod, 1999-2009, and Bmsy and ASPIC estimated maxiimum biomass.

B. Georges Bank Haddock by R.W. Brown

1.0 Background

The Georges Bank haddock stock was last assessed by the United States in 1998 and reviewed by the Transboundary Resource Assessment Committee and SAW/SARC 27. A Canadian assessment through 1998 was completed in the Spring of 1999 for the 5Zj&m portion of the stock. The 1998 U.S. assessment estimated fully recruited fishing mortality (ages 4-7) in 1997 to be 0.11 (9% exploitation rate), which was below the $F_{0.1}$ rebuilding target in place at the time. Fishing mortality was estimated to have remained between 0.10 and 0.15 between 1995 and 1997. Spawning stock biomass was estimated to have increased from 11,900 mt in 1993 to 40,500 mt in 1997. The age structure of the population was continuing to expand and the age 4+ biomass was estimated to be at it's highest level since 1983. Although the 1994 - 1996 year classes appeared moderate relative to recruitment observed over the past decade, recent recruitment was far below average levels observed when the stock was in a healthy condition. The 1996 year class, estimated at 13.8 million fish at age 1, was expected to result in continued increases in SSB through 1999.

2.0 1999 Assessment

1998 Fishery

U.S. trip limit regulations were significantly more liberal in 1998 compared to the 1997 calendar year. The trip limit from January-August 1998 was 1,000 pounds•day^{-1} up to a maximum of 10,000 pounds•trip^{-1}, compared to 1000 pounds•trip^{-1} during the same period in 1997. The trip limit from September-December 1998 was 3,000 pounds•day^{-1} up to a maximum of 30,000 pounds•day^{-1}, compared to 1,000 pounds•day^{-1} up to a maximum of 10,000 pounds•trip^{-1} during the same period in 1997. As a result of both increased haddock abundance and liberalization of trip limit regulations, U.S. commercial landings of Georges Bank haddock in 1998 were 1,841 mt, a 107% increase compared to 1997 U.S. landings (888 mt; Table B1; Figure B1). U.S. landings included 1,530 mt of landings from western Georges Bank (statistical areas 521, 522, 525, 526) and 311 mt of landings from eastern Georges Bank (statistical areas 561 & 562). U.S. catch continues to be displaced inshore as a result of Days at Sea regulations.

U.S. landings from western Georges Bank (statistical areas 521, 522, 525, 526), were adequately characterized by 23 port samples. The U.S. landings at age for western Georges Bank was estimated for two market categories (scrod and large) and sampling was pooled separately for quarters 1 and 2, and combined for quarters 3 and 4. Sampling of U.S. landings from eastern Georges Bank (n=1) were insufficient to characterize the size and age distribution of this portion of the U.S. catch.. U.S. landings from eastern Georges Bank represented 17% of the total U.S. landings, and 5.8% of the total 1998 catch included in the assessment. Length and age samples from the Canadian fishery was used to characterize the size and age composition of U.S. landings from eastern Georges Bank.

U.S. discards were estimated based on kept to discard ratios reported in the Vessel Trip Report database following procedures used in previous U.S. haddock assessments. Discarding in the U.S. fishery is estimated to have declined from 626 mt in 1997 to 118 mt in 1998. The proportion of the U.S. catch accounted for by discarding has declined from 51.1% in 1996 to 41.4% in 1997, and is estimated to be 6.0% of the U.S. catch in 1998. Trends in the proportion of U.S. catch accounted for by discarding are consistent with the continuing liberalization of U.S. haddock trip limit regulations.

The size and age distribution of U.S. discards was poorly sampled by the U.S. at-sea observer program. U.S. discards represented 2.2% of the total catch included in the assessment. Available length samples were used to characterize the length distribution of discards, and age information from U.S. commercial landings and U.S. surveys were used to partition the discard at length data into a discard at age estimate.

Canadian catch from the Georges Bank haddock stock consisted of 3,371 mt of landings (Table B1), approximately 86% of the allocated 1998 quota of 3,900 mt and 63% of the total haddock landings from the Georges Bank stock. Canadian landings were monitored at dockside and at-sea monitoring by observers resulted in coverage of almost 400 sea days when approximately 10% of Canadian haddock landings were taken. Comparison of observer samples with port samples did not reveal any persistent patterns which would indicate that discarding or high grading was occurring. The size and age composition of the 1998 Canadian fishery was characterized by port and at sea samples from all principal gears and all seasons.

The combined catch at age was dominated by age 4 (1994 year class) haddock, although there were significant contributions to the catch by ages 3 (1995 year class), 5 (1993 year class), and 6 (1992 year class). Almost two thirds of the total landings by weight from the stock came from fish that were ages 5 or older.

Fishery Independent Information

Abundance (stratified mean number • tow^{-1}) and biomass (stratified mean weight • tow^{-1}) survey indices in the U.S. Spring survey in 1998 and 1999 remained above levels observed from 1986-1995, but below levels observed in 1996 and 1997 (Table B2; Figure B2). The 1999 U.S. Spring survey catch of age 1 haddock (1998 year class) was the highest level observed since 1979 (1978 year class). The abundance and biomass survey indices in the U.S. Autumn survey in 1998 remained above levels observed since 1986 (Table B2; Figure B2). The 1998 U.S. Autumn survey catch of age 0 haddock (1998 year class) was the highest level observed since 1985 (1985 year class). Aggregate abundance survey indices in the Canadian Spring survey were the highest levels observed since the initiation of the survey in 1986 (Figure B2). The majority of this abundance was comprised of large catches of age 1 haddock (1998 year class) yielding a stratified mean number at age estimate that is 3.7 times higher that the next highest age 1 index in the Canadian survey time series.

Input Data and Analysis

The present assessment represents a one-year update to the previous U.S. assessment (Brown 2000, NEFSC 1998). The VPA formulation used for the current assessment was identical to the one used in the 1998 U.S. assessment, except for the addition of current year (1999) Spring survey data. Catch at age data for 1998 and U.S. and Canadian survey abundance indices (stratified mean number • tow^{-1} at age) were updated through 1999. Very minor revisions were made to 1997 catch at age to incorporate revisions to the estimate of 1997 Canadian catch at age.

Precision of the 1999 stock sizes and 1998 fishing mortality and SSB estimates was derived from 1000 bootstrap simulations of the 1999 VPA formulation. A retrospective analysis of terminal year estimates of stock sizes, fully recruited fishing mortality and SSB was carried out back to 1992.

3.0 Assessment Results

The current assessment continues to consistently estimate the strength of incoming year classes, indicating that the 1992 (15.2 million at age 1), 1993 (12.2 million), and 1996 (14.9 million) were stronger than other year classes since 1988 (Table B3; Figure B3). The 1997 year class (8.3 million at age 1) continues to be estimated as being lower than adjacent year classes. Based on the consistent strength of age 0+ and 1 survey indices, the 1998 year class is estimated to be 61.9 million fish at age 1. If this estimate is reliable, the 1998 year class would be the third largest year class since 1964, although smaller than the 1975 (103.3 million at age 1) and 1978 (84.0 million) year classes (Table B3). Although all three research surveys that have assessed the 1998 year class indicate a strong year class, the size of this year class remains uncertain until addition fishery dependent and independent information is collected and analyzed. The age distribution of the stock continues to show evidence of broadening, although the numerical abundance of age 4+ fish has stabilized over the last three years.

The 1994-98 estimates of spawning stock biomass (SSB) have been revised slightly downward by the current assessment, and 1998 SSB is estimated to be 38,100 mt (Table B3; Figure B3). Despite this revision, both the 1998 and 1999 assessments indicate that SSB is continuing to increase. Fully recruited fishing mortality (ages 4-7) in 1998 is estimated to be 0.15, a slight increase from the fishing mortality estimated for 1997 (Table B3; Figure B4).

VPA Diagnostics

The sums of squares and mean squared residuals from the VPA were within the range of accepted VPAs from the last three U.S. assessments of Georges Bank haddock. The coefficients of variation on estimated age 1-8 stock sizes (range 0.25 - 0.49) were slightly to significantly lower than were observed in the previous three U.S. assessments. The reduction of the CV on age 1 in the current assessment (0.49 vs. 0.60-0.62) is an artifact of the revised assessment formulation which includes the addition of the U.S. Spring survey in the terminal year. Other VPA diagnostics including the range of CV's on survey q estimates, the number of large standardized residuals and the maximum partial variance estimates are consistent with previous U.S. haddock assessments. There were no outstanding residual patterns detected during an analysis of standardized residuals. There was a significant shift in the estimate of q for the Canadian and U.S. Spring indices, raising concerns regarding model performance in estimating the size of the 1998 year class.

Accounting for precision in the current assessment, there is a 90% probability that fully recruited F in 1998 was between 0.125 and 0.167, and that SSB in 1998 was between 34,700 and 42,200 mt. There was a zero percent probability that SSB in 1998 had exceeded either the target (68,000 mt) or limit threshold (53,000 mt) biomass level.

The retrospective analysis indicates that before 1994, the VPA calibration had a tendency to significantly overestimate fully recruited F (4-7, u) and slightly underestimate SSB. After 1994, the pattern shifted to where F is accurately estimated and SSB is slightly overestimated in the terminal year of the assessment.

Evaluation of the Harvest Control Rule

The Amendment 9 harvest control rule for Georges Bank haddock is based on MSY-based reference point proxies (Figure B5). When SSB is greater than 105,000 mt, the overfishing limit is $F_{0.1}$ (currently estimated to be 0.26), and the target F is 75% of the F_{MSY} proxy (0.20). The limit F decreases linearly from 0.26 at 105,000 mt of SSB to zero at 53,000 mt SSB, and the target F decreases linearly from 0.20 at 105,000 mt of SSB to zero at 68,000 mt of SSB.

To evaluate the stock status relative to the harvest control rule in 1999, a 2-year projection was completed assuming F_{1999} would be equal to F_{1998} (0.15). Spawning stock biomass, the biomass reference point proxy in the harvest control rule, was projected to be 44,700 mt in 1999. Projected SSB levels are below the ½ SSB_{MSY} threshold level of 68,000 mt, and application of the harvest control rule indicates that fishing mortality should be reduced to zero.

4.0 Forecasts

Forecasts for Georges Bank haddock are uncertain both due to the uncertainty of the size of the 1998 year class and historical patterns in recruitment in relation to SSB. Terminal year stock size estimates from the current assessment were assumed and fishing mortality in 1999 was assumed to be equal to fishing mortality in 1998 ($F_{1998} = F_{1999} = 0.15$). Fishing mortality for the years 2000 - 2009 was set to the level required by the harvest control rule ($F_{2000\text{-}2008} = 0.00$). Projections were based on a partial recruitment vector estimated as the geometric mean of the 1995-1998 F's from the final VPA calibration, arithmetic mean of the 1995-1998 stock and catch weights, and pooled median maturity at age estimates for 1995-1997.

Projection Methodology

Projections for Georges Bank haddock were completed using AGEPRO software (Brodziak and Rago 1996). Fully recruited fishing mortality in 1999 was assumed to be equal to the 1998 estimate (0.15), and fully recruited fishing mortality for the years 2000-2009 were set at 0.00 as indicated by the harvest control rule. Projections were based on a partial recruitment vector estimated as the geometric mean of the 1995-1998 F's from the final VPA calibration, arithmetic mean of the 1995-1998 stock and catch weights; and pooled median maturity at age estimates for 1995-1997.

The stock recruitment history for Georges Bank haddock indicates two stanzas of recruitment: a period from 1931-1966 where recruitment was consistently higher, and a period from 1966-1998 when average recruitment was significantly lower. The presence of two recruitment stanzas in the stock recruitment data set for Georges Bank highlights the importance of recruitment assumptions as the stock rebuilds to a level where spawning stock biomass approaches the interface between these recruitment stanzas.

Efforts to develop a stock-recruit relationship for the full stock recruit data set (1931-present) have not been successful because of issues with model significance, convergence and residual problems (Overholtz et al. 1999). In addition, parameters from a non-linear Ricker model produce extremely large estimates of management parameters (Overholtz et al. 1999). Overholtz et al. (1986) used non-parametric methods (probability transition matrices) to provide long-term estimates of productivity for this stock. Overholtz et al. (1999) used a Beverton-Holt model to project recruitment, but recruitment was constrained to values within the observed time series. Initial attempts to complete stock projections using a stock-recruit relationship or R/SSB approaches were largely unsuccessful because of poor diagnostics in the estimation of stock-recruitment relationships, or unrealistic increases in stock numbers and biomass observed during initial projection attempts.

Two sets of projections are reported that use differing approaches to resampling empirical recruitment. A projection was completed by resampling 1966-1999 recruitment values for the entire 11-year projection. Spawning stock biomass increased quickly, exceeding the SSB threshold of 105,000 mt in 2002 (Figure B6). The probability that SSB_{MSY} exceeds the threshold SSB (105,000 mt) is 29.7% in 2001, 64.1% in 2002, and 74.8% in 2003 (Table B4). SSB gradually stabilized at a level at approximately 133,000 mt by 2009. This stabilization may indicate that this level of recruitment over the long term is insufficient to support fishery exploitation and allow for the maintenance of stock sizes at these levels. However, at stock levels approaching SSB_{MSY} levels, significant improvement in recruitment above the levels assumed during this project may be realized.

A second projection was completed using a 2-stage resampling approach of empirical recruitment values from the 1931-1965 and 1966-1999 time periods. The more recent recruitment data (1966-1999) were resampled during the during the first five years of the projection, and the entire time series of recruitment data (1931-1999) was resampled during the remaining 6 years of the projection. Use of the entire time series to model recruitment for the "rebuilt" stock was consistent with the surplus production modeling methods used to develop the control rule. This strategy was employed to simulate a population shifting from the recent recruitment regime, which has been dominated by poor recruitment, to a regime where strong recruitment events occur with greater frequency. In this projection, spawning stock biomass increased above 105,000 mt by 2002, but began to increase sharply in 2007 as recruitment resampled from the earlier regime began to mature (Table B4; Figure B6). Results from this projection exceed the maximum stock sizes observed for this stock in the 68 year assessment time series. Many of the population compensatory features that affect stocks at high levels of abundance (reduced growth, later maturation, and reduced recruitment) were not accounted for in this modeling effort.

It is important to note that if recruitment improves to the pre-1966 regime, there will be substantial opportunities for fishery harvest, while maintaining stock sizes at levels at or exceeding B_{MSY}. To achieve recruitments at these levels, the stock must be rebuilt so that it is fully utilizing the two major spawning areas on Georges Bank: the Northeast Peak and the Great South Channel. Currently, the stock appears to be rebuilding in both areas; however, the majority of biomass still remains in the eastern portion of the stock area. Continued rebuilding of haddock stocks in the western portion of the stock area, which is primarily influenced by U.S. management initiatives, is essential to achieve improved recruitment observed from the 1931-1966 regime on a consistent basis.

Each of these projections exhibited an initial sharp increase in SSB between 1999 and 2002, highlighting the importance of incoming recruitment estimated by the VPA (particularly the 1998 year class). These projections demonstrate that SSB will increase to the SSB threshold in 2002, largely as a result of stock size (initial stock size estimates from the VPA) inputs into the projection rather than recruitment assumed within the projection. Indications from research vessel surveys are that the 1998 year class is strong, but there is still considerable uncertainty about it's relative size. If the 1998 year class is either significantly overestimated or underestimated, this will have a significant effect on the accuracy of these stock forecasts.

5.0 Sources of Uncertainty

1 Sampling of U.S. landings and discards was insufficient to accurately characterize the size and age distribution of the catch.

2 There is considerable uncertainty regarding the size of the 1998 year class, estimated as age 1 recruits in 1999. Shifts in the estimates of survey q's of the Canadian and U.S. Spring age 1 indices between the 1998 and 1999 stock assessments represent symptoms of a significant change in the weighting of these indices in response to survey indices for this year class.

3 U.S. survey biomass indices do not exhibit the same increases as has been observed in the VPA estimates of biomass and SSB.

4 The VPA assessment continues to exhibit a slight to moderate retrospective pattern in the terminal year estimates of SSB.

6.0 Conclusions

The Georges Bank haddock stock continues to rebuild toward historic levels. Continued low exploitation rates have promoted broadening of the age structure and the age 4+ biomass is at it's highest levels since the early 1980s. Spawning stock biomass has increased almost four fold since 1992 and is expect to exceed 40,000 mt by 1999.

Observed increases in spawning stock biomass of Georges Bank haddock have resulted from conservation of a series of relatively weak year classes. This is a necessary first step in the stock rebuilding process. Stock rebuilding to levels approaching the SSB threshold of 105,000 mt will require recruitment significantly above levels observed during the past two decades. This assessment provides initial indications that the 1998 year class may be significantly larger than year classes observed in the 1980s and 1990s. However, there is considerable uncertainty about the size of the 1998 year class based on diagnostics from the VPA analysis. Projection results over the next five years are highly dependent on the estimate of this year class. If the current estimate of the 1998 year class is reasonably accurate, recruitment of this year class should result in significant stock rebuilding toward the SSB threshold.

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Table B1. Commercial landings (metric tons, live) of haddock from Georges Bank and South (NAFO Division 5Z and Statistical Area 6), 1960-1998.[1]

Year	USA	Canada	USSR	Spain	Other	Total
1960	40800	77	0	0	0	40877
1961	46384	266	0	0	0	46650
1962	49409	3461	1134	0	0	54004
1963	44150	8379	2317	0	0	54846
1964	46512	11625	5483	2	464	64086
1965	52823	14889	81882	10	758	150362
1966	52918	18292	48409	1111	544	121274
1967	34728	13040	2316	1355	30	51469
1968	25469	9323	1397	3014	1720	40923
1969	16456	3990	65	1201	540	22252
1970	8415	1978	103	782	22	11300
1971	7306	1630	374	1310	242	10862
1972	3869	609	137	1098	20	5733
1973	2777	1563	602	386	3	5331
1974	2396	462	109	764	559	4290
1975	3989	1358	8	61	4	5420
1976	2904	1361	4	46	9	4324
1977	7934	2909	0	0	0	10843
1978	12160	10179	0	0	0	22339
1979	14279	5182	0	0	0	19461
1980	17470	10017	0	0	0	27487
1981	19176	5658	0	0	0	24834
1982	12625	4872	0	0	0	17497
1983	8682	3208	0	0	0	11890
1984	8807	1463	0	0	0	10270
1985	4273	3484	0	0	0	7757
1986	3339	3415	0	0	0	6754
1987	2156	4703	0	0	0	6859
1988	2492	4046[2]	0	0	0	6538
1989	1430	3059	0	0	0	4489
1990	2001	3340	0	0	0	5341
1991	1395	5446	0	0	0	6841
1992	2005	4061	0	0	0	6066
1993	687	3727	0	0	0	4414
1994	218	2411	0	0	0	2629
1995	218	2064	0	0	0	2282
1996	313	3643	0	0	0	3956
1997	888	2622	0	0	0	3510
1998	1841	3371	0	0	0	5212

[1]All landings 1960-1979 are from Clark et al. (1982); USA landings 1980-1981 are from Overholtz et al. (1983); USA landings 1982-1993 are from NMFS, NEFC Detailed Weighout Files and Canvass data; Canadian landings 1980-1994 from Gavaris and Van Eeckhaute (1996); Canadian landings 1995-1996 from S. Gavaris (Personal Communication).
[2]1895 tons were excluded because of suspected misreporting (Gavaris and Van Eeckhaute 1995).

Table B2. Stratified mean number and mean weight (kg) • tow^{-1} of haddock caught in NEFSC Spring and Autumn bottom trawl surveys from 1963-1999.

	Spring Survey		Autumn Survey	
Year	Number/Tow	Weight (kg)/tow	Number/tow	Weight (kg)/tow
1963	-----	-----	145.01	79.77
1964	-----	-----	193.24	96.75
1965	-----	-----	101.69	72.78
1966	-----	-----	33.26	29.87
1967	-----	-----	17.70	25.47
1968	13.84	20.55	7.51	15.40
1969	7.33	16.93	3.38	8.44
1970	6.00	17.12	7.70	13.50
1971	2.79	5.00	4.20	5.59
1972	6.38	7.37	11.35	8.47
1973	37.62	15.37	14.89	9.78
1974	19.01	17.70	4.05	3.99
1975	6.24	8.21	30.95	15.10
1976	83.19	15.72	71.07	35.76
1977	36.86	26.58	23.25	27.52
1978	19.41	31.27	25.29	18.06
1979	45.50	19.77	52.24	31.98
1980	60.06	53.92	30.54	21.98
1981	31.21	38.02	13.45	14.01
1982	8.60	13.11	4.96	7.34
1983	5.60	13.21	7.99	5.75
1984	6.24	7.45	5.38	4.48
1985	8.85	11.14	14.19	3.86
1986	5.85	5.86	6.81	5.10
1987	4.95	5.60	3.62	2.56
1988	3.38	3.43	5.35	5.57
1989	5.35	4.70	4.34	4.70
1990	7.68	7.57	2.92	2.62
1991	3.97	4.38	2.92	0.94
1992	1.18	1.41	6.06	3.17
1993	2.79	2.48	8.09	4.33
1994	4.99	3.63	3.58	2.93
1995	5.61	5.72	17.11	10.66
1996	23.40	25.73	4.47	4.11
1997	12.95	18.50	6.16	6.51
1998	7.28	6.12	11.07	5.75
1999	16.66	7.74	To be conducted in October 1999	

Table B3. Beginning year stock size, spawning stock biomass, mean biomass, and fishing mortality of Georges Bank haddock estimated from VPA calibration.

STOCK NUMBERS (Jan 1) in thousands - D:\What 1.6

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	190706	471885	33154	4137	12954	422	988	4661	369	8517	19418	10547	7661	103303
2	32266	153504	377207	18457	3284	9565	338	807	3774	301	6832	13582	8593	6098
3	32743	22756	111260	194986	8920	2536	5122	267	518	1846	245	3716	7211	6100
4	45821	20096	14510	50830	68425	4687	1435	2657	204	222	1104	198	2448	4217
5	29031	27424	12131	7034	24273	37321	2099	770	1660	131	109	555	160	1665
6	9186	16351	14561	5959	3254	10519	17419	1127	462	1097	78	41	391	127
7	5595	5526	8144	5868	2535	1570	5446	8874	729	156	790	37	32	282
8	2795	3309	2640	3255	2694	1177	682	3035	5177	339	57	577	28	22
9	4217	4251	3258	2201	2031	2163	1712	1875	3245	6311	1679	2702	622	623
1+	352360	725101	576866	292727	128369	69960	35241	24071	16137	18919	30311	31953	27145	122438

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	13809	6072	83981	10135	7224	2479	3106	17258	1759	14733	2099	16708	1085	2640
2	84447	11305	4971	68757	8291	5914	2028	2543	14129	1440	12057	1718	13676	888
3	4565	51418	8567	4046	28244	5211	3788	1467	1998	9391	1130	8066	1360	10054
4	4497	3568	29072	5452	2999	13172	2789	2365	932	1138	5146	809	4447	1036
5	2657	3066	2645	17316	3582	1703	7407	1659	1279	588	730	2754	541	2847
6	1168	1709	1997	1691	8699	2085	1041	4038	999	630	349	487	1412	313
7	104	633	931	1264	847	4795	1192	606	1965	612	359	220	264	832
8	210	82	392	478	541	394	2913	808	284	1133	365	214	130	175
9	594	390	187	251	319	406	275	1627	550	254	461	351	208	166
1+	112050	78243	132744	109390	60746	36158	24538	32371	23896	29919	22697	31327	23123	18952

	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	2389	9083	15161	12175	8941	8236	14897	8328	61925
2	2160	1951	7430	12407	9967	7312	6738	12170	6817
3	717	1363	1374	5821	9914	8079	5938	5359	9784
4	6924	505	826	808	4032	7578	6099	4603	4012
5	692	3724	294	406	507	2888	5348	4310	3315
6	1546	474	1668	147	273	361	1945	3884	2903
7	168	895	288	769	57	195	234	1400	2704
8	521	71	440	201	493	40	140	175	1012
9	242	246	208	197	156	58	349	338	363
1+	15359	18312	27689	32930	34341	34745	41689	40567	92837

Table B3 (Continued). Beginning year stock size, spawning stock biomass, mean biomass, and fishing mortality of Georges Bank haddock estimated from VPA calibration.

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

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	00	00	00	00	00	00	00	00	00	00	00	00	00	00
2	00	00	00	00	00	1675	61	164	756	67	1594	3142	2253	1510
3	24233	15655	65996	91773	4934	1433	3119	185	411	1652	273	4216	7623	6068
4	56101	23010	14892	48128	60273	4294	1636	3442	266	304	1789	359	4459	6766
5	38629	36355	15691	8788.	26351	41983	2731	1303	3215	236	189	1248	342	3694
6	16464	25247	20964	8946	5063	15410	26018	2067	873	2671	183	116	1039	316
7	10877	10439	13799	10289	4575	2780	10823	17573	1590	354	2308	126	113	863
8	6533	7059	5446	6850	5610	2397	1526	7608	12676	962	170	1956	105	87
9	11435	10811	8271	5784	5324	5124	5278	6177	10450	20678	5770	10659	2455	2771
1+	164272	128575	145060	180558	112131	75096	51190	38520	30236	26923	12275	21821	18388	22076

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	00	00	00	00	00	00	00	376	79	1113	137	1102	97	117
2	17995	2457	1134	12824	1686	1074	293	435	4743	491	4331	684	5029	338
3	4151	45758	6799	3345	20418	4054	3145	1428	1786	8529	1096	6673	1392	9883
4	7098	5675	44465	7304	3874	17418	3990	3211	1317	1592	7113	1111	6039	1504
5	5546	6779	5353	30526	6241	3137	12971	2931	2273	1162	1339	4731	909	4759
6	2927	4333	5274	3784	18207	4568	2278	8193	2161	1445	807	982	2847	637
7	351	1847	2736	3438	2262	12569	3239	1405	4895	1525	922	539	671	1988
8	725	286	1233	1494	1781	1315	8352	2283	820	3254	1053	597	376	474
9	2664	1797	799	827	1223	1445	1019	5140	1816	847	1708	1195	706	602
1+	41457	68933	67794	63542	55692	45579	35286	25402	19890	19957	18506	17613	18067	20303

	1991	1992	1993	1994	1995	1996	1997	1998
1	93	315	517	246	46	48	77	65
2	945	827	1663	2988	2112	1619	1456	2488
3	697	1586	1217	5226	11119	8516	7144	5693
4	9627	665	1227	1321	6766	11488	9417	7642
5	1241	6072	478	878	1104	5677	9963	8212
6	3190	982	3294	279	683	824	4360	8656
7	366	2099	680	1901	156	557	611	3587
8	1313	184	1122	567	1358	122	438	492
9	903	873	700	796	572	195	1172	1262
1+	18376	13602	10898	14201	23916	29046	34639	38096

Table B3 (Continued). Beginning year stock size, spawning stock biomass, mean biomass, and fishing mortality of Georges Bank haddock estimated from VPA calibration.

MEAN BIOMASS (using catch mean weights at age)

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	97717	211390	14554	2142	7375	223	465	2983	224	4739	9796	6866	4247	46779
2	23694	108938	190543	9574	2026	5762	235	828	2777	280	5270	10666	7130	5242
3	30570	20524	79454	107563	6249	2031	4131	286	458	2511	348	5529	9097	7308
4	52683	22565	13938	45273	60547	4252	1805	4091	287	324	1700	414	4489	6720
5	37107	33322	14500	8336	23357	41005	2735	1320	3249	248	167	1324	315	3728
6	15484	23667	19034	8292	4737	16183	25212	2183	791	2731	181	136	980	356
7	10228	9378	12048	9296	4088	2471	10392	17699	1487	300	2318	132	107	901
8	6577	6509	4809	6534	5219	2165	1497	7654	12198	942	169	1948	96	85
9	10122	9407	6938	4896	4586	4345	4563	5489	9174	18665	5097	9910	2252	2513
1+	284182	445699	355818	201907	118183	78438	51035	42532	30643	30739	25047	36924	28713	73632

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	6633	2917	40341	5050	2553	494	929	5162	526	6008	818	6359	521	1531
2	71233	9280	4493	42803	5770	4629	1767	2079	11483	1202	8241	1502	10477	776
3	5826	58784	8823	4231	24501	5618	4139	1557	2124	9598	1374	8145	1762	12420
4	8107	6291	45831	7702	4191	18827	3981	3233	1479	1682	7652	1119	6422	1516
5	5864	6958	5353	27162	6362	3187	12273	2863	2254	1173	1351	4138	921	4511
6	2803	4087	5034	3442	17828	4408	2130	7686	2147	1364	735	893	2819	595
7	384	1695	2568	3068	2195	12235	3209	1258	4624	1414	846	508	701	1865
8	683	242	1162	1257	1652	1198	7489	2021	810	3085	1041	560	370	403
9	2411	1633	711	717	1071	1274	897	4442	1599	755	1496	1044	634	532
1+	103944	91887	114315	95432	66124	51871	36814	30300	27047	26280	23554	24267	24627	24148

	1991	1992	1993	1994	1995	1996	1997	1998
1	1256	4427	9053	4932	3474	3403	5611	3857
2	2079	1933	7707	12148	8693	7248	5986	10584
3	793	1758	1842	8005	12945	10543	8881	6910
4	9375	690	1284	1427	6942	11760	9765	7523
5	1259	5595	449	881	1093	5546	10138	8307
6	3149	941	3051	259	653	745	4225	8758
7	322	1901	642	1802	157	568	630	3620
8	1197	170	985	607	1295	117	402	449
9	790	742	599	714	528	179	1084	1164
1+	20221	18157	25610	30774	35781	40108	46721	51170

Table B3 (Continued). Beginning year stock size, spawning stock biomass, mean biomass, and fishing mortality of Georges Bank haddock estimated from VPA calibration.

FISHING MORTALITY - D:\What 1.6

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	0.02	0.02	0.39	0.03	0.10	0.02	0.00	0.01	0.00	0.02	0.16	0.00	0.03	0.00
2	0.15	0.12	0.46	0.53	0.06	0.42	0.04	0.24	0.52	0.01	0.41	0.43	0.14	0.09
3	0.29	0.25	0.58	0.85	0.44	0.37	0.46	0.07	0.65	0.31	0.01	0.22	0.34	0.10
4	0.31	0.30	0.52	0.54	0.41	0.60	0.42	0.27	0.24	0.52	0.49	0.01	0.19	0.26
5	0.37	0.43	0.51	0.57	0.64	0.56	0.42	0.31	0.21	0.31	0.77	0.15	0.03	0.15
6	0.31	0.50	0.71	0.65	0.53	0.46	0.47	0.24	0.89	0.13	0.55	0.06	0.13	0.00
7	0.33	0.54	0.72	0.58	0.57	0.63	0.38	0.34	0.57	0.81	0.11	0.06	0.15	0.09
8	0.34	0.42	0.61	0.56	0.47	0.55	0.45	0.32	0.38	0.24	0.35	0.11	0.17	0.22
9	0.34	0.42	0.61	0.56	0.47	0.55	0.45	0.32	0.38	0.24	0.35	0.11	0.17	0.22

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.30	0.08	0.01	0.69	0.26	0.25	0.12	0.04	0.21	0.04	0.20	0.03	0.11	0.01
3	0.05	0.37	0.25	0.10	0.56	0.43	0.27	0.25	0.36	0.40	0.13	0.40	0.07	0.17
4	0.18	0.10	0.32	0.22	0.37	0.38	0.32	0.41	0.26	0.24	0.43	0.20	0.25	0.20
5	0.24	0.23	0.25	0.49	0.34	0.29	0.41	0.31	0.51	0.32	0.20	0.47	0.35	0.41
6	0.41	0.41	0.26	0.49	0.40	0.36	0.34	0.52	0.29	0.36	0.26	0.41	0.33	0.42
7	0.04	0.28	0.47	0.65	0.57	0.30	0.19	0.56	0.35	0.32	0.32	0.32	0.21	0.27
8	0.23	0.21	0.32	0.44	0.39	0.35	0.36	0.45	0.36	0.30	0.39	0.40	0.27	0.34
9	0.23	0.21	0.32	0.44	0.39	0.35	0.36	0.45	0.36	0.30	0.39	0.40	0.27	0.34

	1991	1992	1993	1994	1995	1996	1997	1998
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.26	0.15	0.04	0.02	0.01	0.01	0.03	0.02
3	0.15	0.30	0.33	0.17	0.07	0.08	0.05	0.09
4	0.42	0.34	0.51	0.27	0.13	0.15	0.15	0.13
5	0.18	0.60	0.50	0.20	0.14	0.20	0.12	0.20
6	0.35	0.30	0.57	0.74	0.14	0.23	0.13	0.16
7	0.65	0.51	0.16	0.24	0.17	0.13	0.09	0.12
8	0.40	0.54	0.51	0.27	0.14	0.16	0.13	0.14
9	0.40	0.54	0.51	0.27	0.14	0.16	0.13	0.14

Table B4. Medium term projection results for Georges Bank haddock. Model 1 projected recruitment by resampling empirical age 1 recruitment estimated by the VPA from 1966-1999. Model 2 projected recruitment by resampling empirical age 1 recruitment estimated by the VPA from 1966-1999 for the first five years of the projection and from 1931-1999 for the final 6 years of the projection.

	Model 1: Recent (1966-1999) Recruitment Assumed		Model 2: 1999-2003: 1966-1999 Recruitment 2004-2009: 1931-1999 Recruitment	
	SSB (mt)	Probability of Exceeding SSB Threshold	SSB (mt)	Probability of Exceeding SSB Threshold
1999	44,700	0.0%	44,700	0
2000	57,600	0.0%	57,600	0
2001	96,500	29.7%	96,500	29.9%
2002	111,500	64.1%	111,700	64.9%
2003	118,800	74.8%	119,400	75.3%
2004	122,600	77.8%	123,100	76.4%
2005	126,300	79.6%	126,700	79.2%
2006	127,200	78.0%	136,300	84.0%
2007	133,300	80.1%	171,800	92.0%
2008	132,400	74.7%	199,700	94.6%
2009	133,300	70.7%	227,200	95.8%

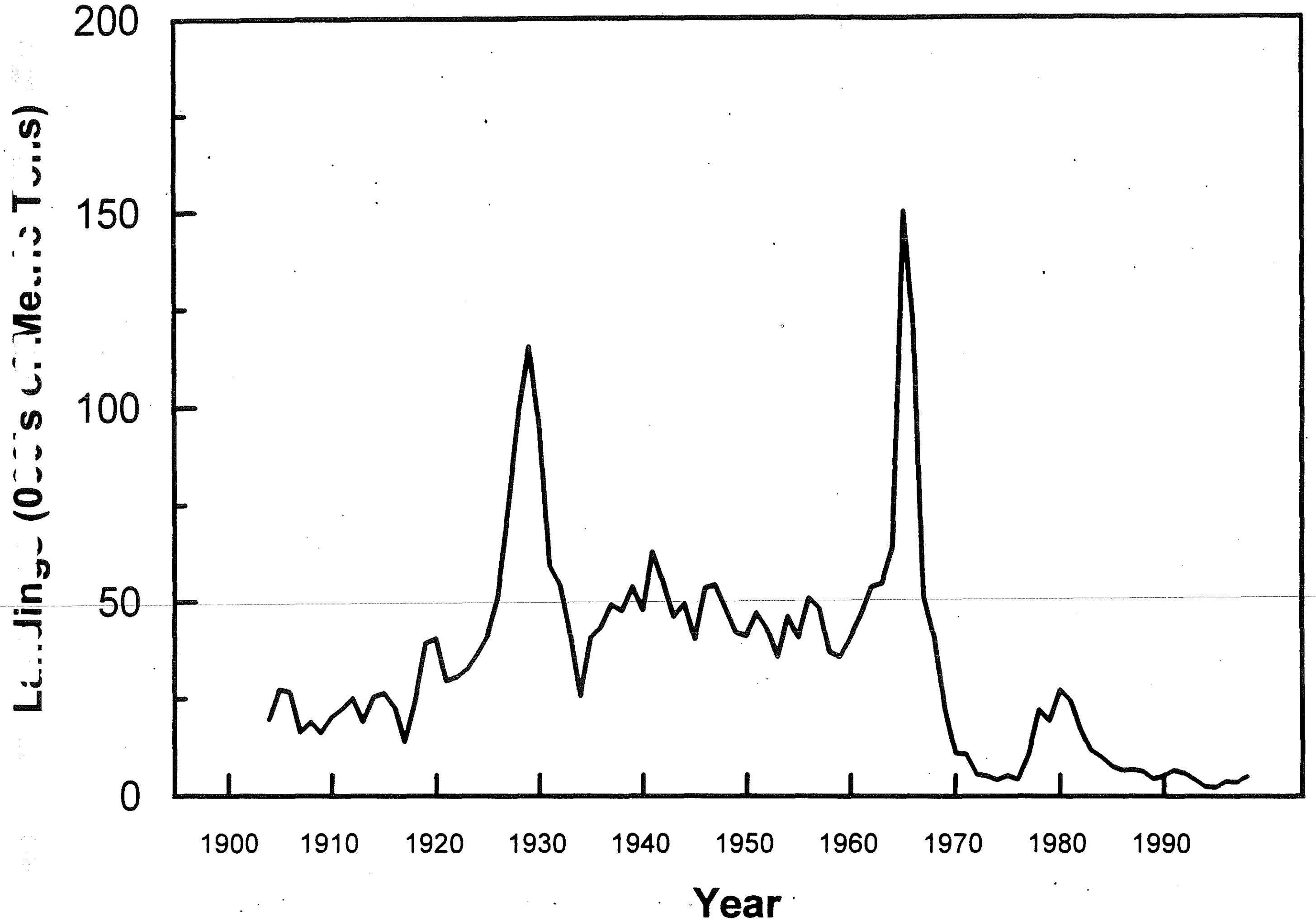

Figure B1. Total commercial landings of haddock from Georges Bank and South, 1904-1998.

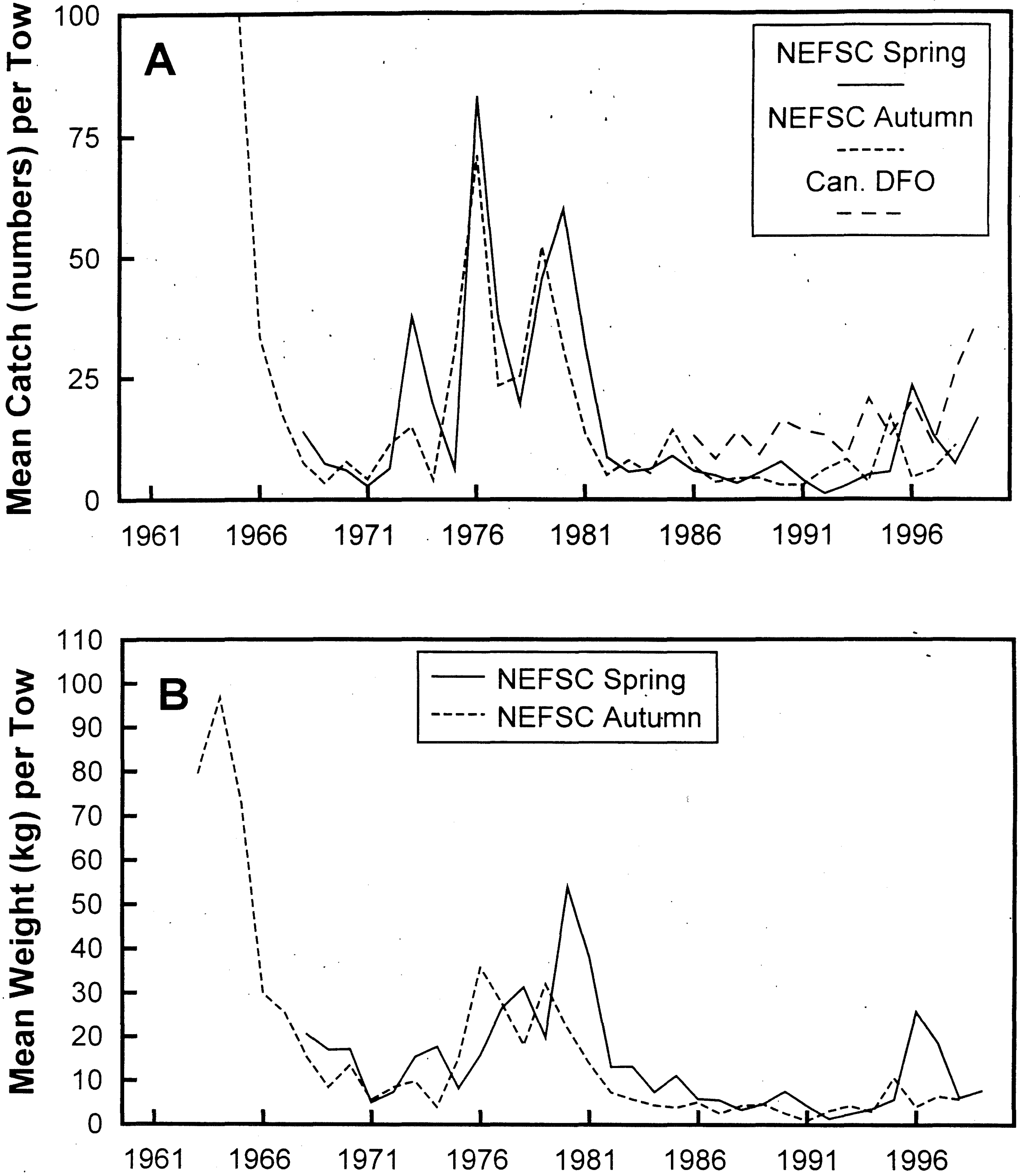

Figure B2. NEFSC and Canadian DFO bottom trawl survey abundance (number per tow; Panel A) and biomass (kg per tow; Panel B) for Georges Bank haddock, 1963-1999. Surveys have not been adjusted for catchabilities.

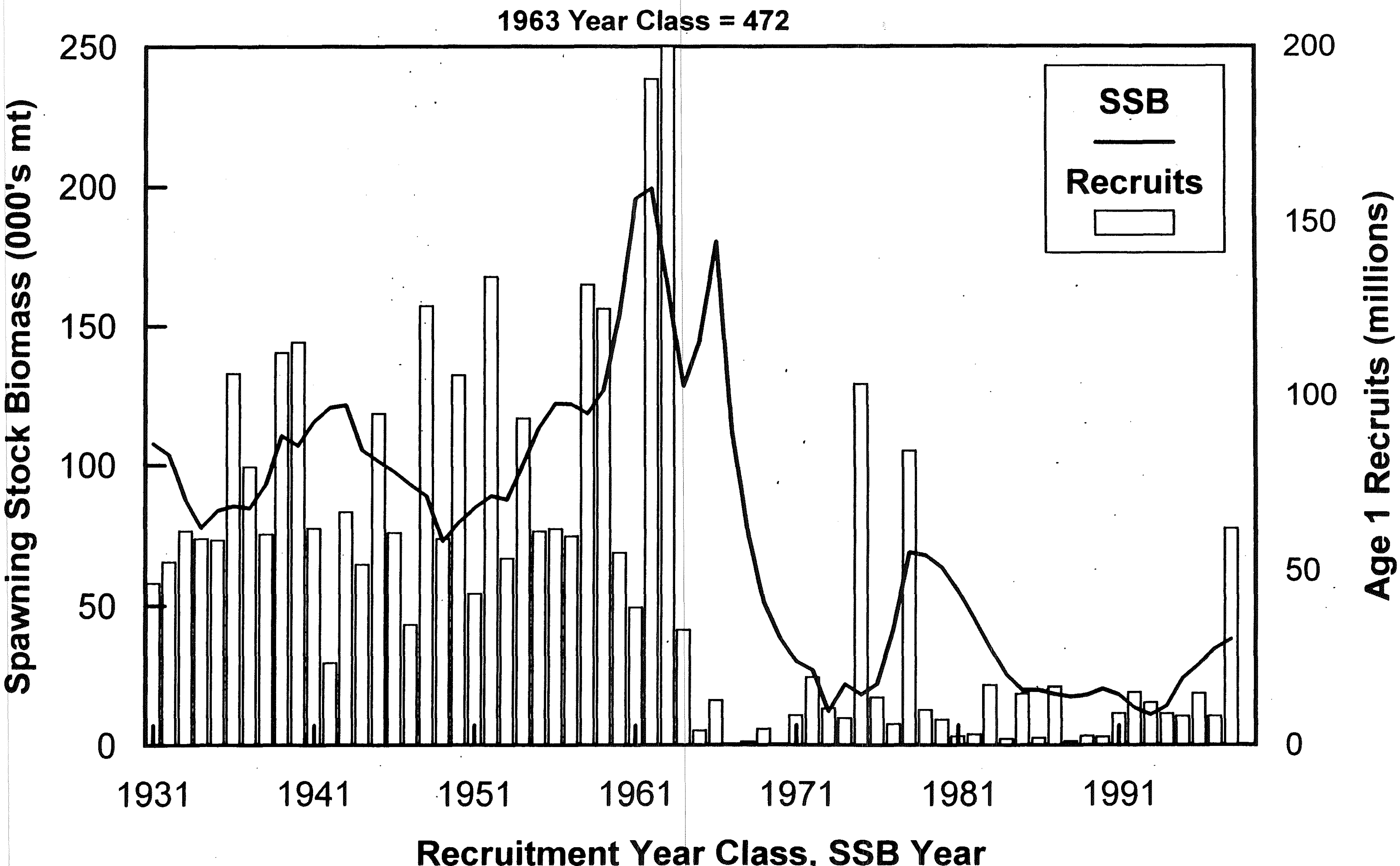

Figure B3. Trends in spawning stock biomass (line) and age 1 recruitment (bars) for Georges Bank (5Z & 6) haddock, 1931-1998.

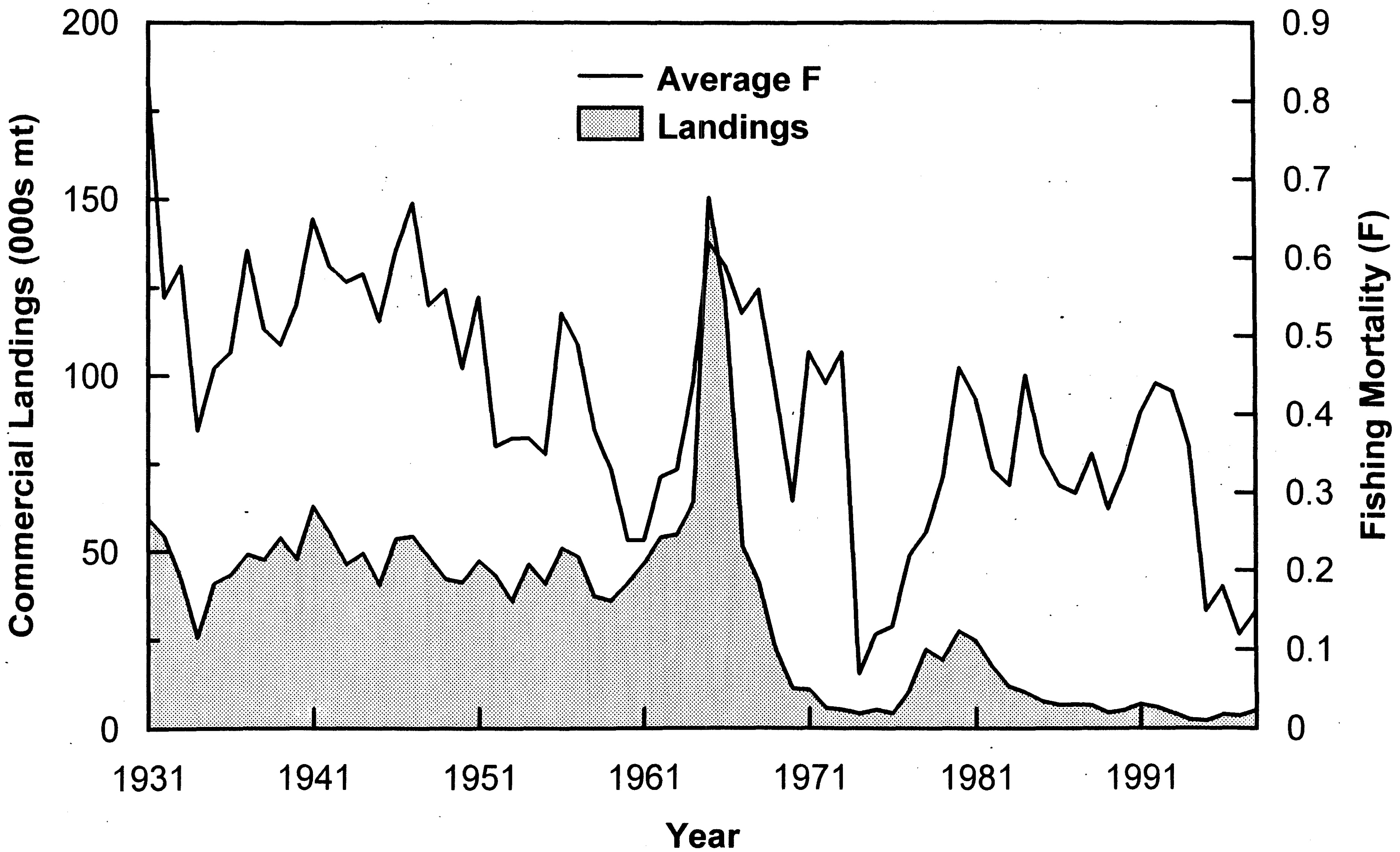

Figure B4. Trends in commercial landings (metric tons, live weight) and fully-recruited fishing mortality (mean F, ages 4-7, unweighted) for Georges Bank haddock, 1931-1998.

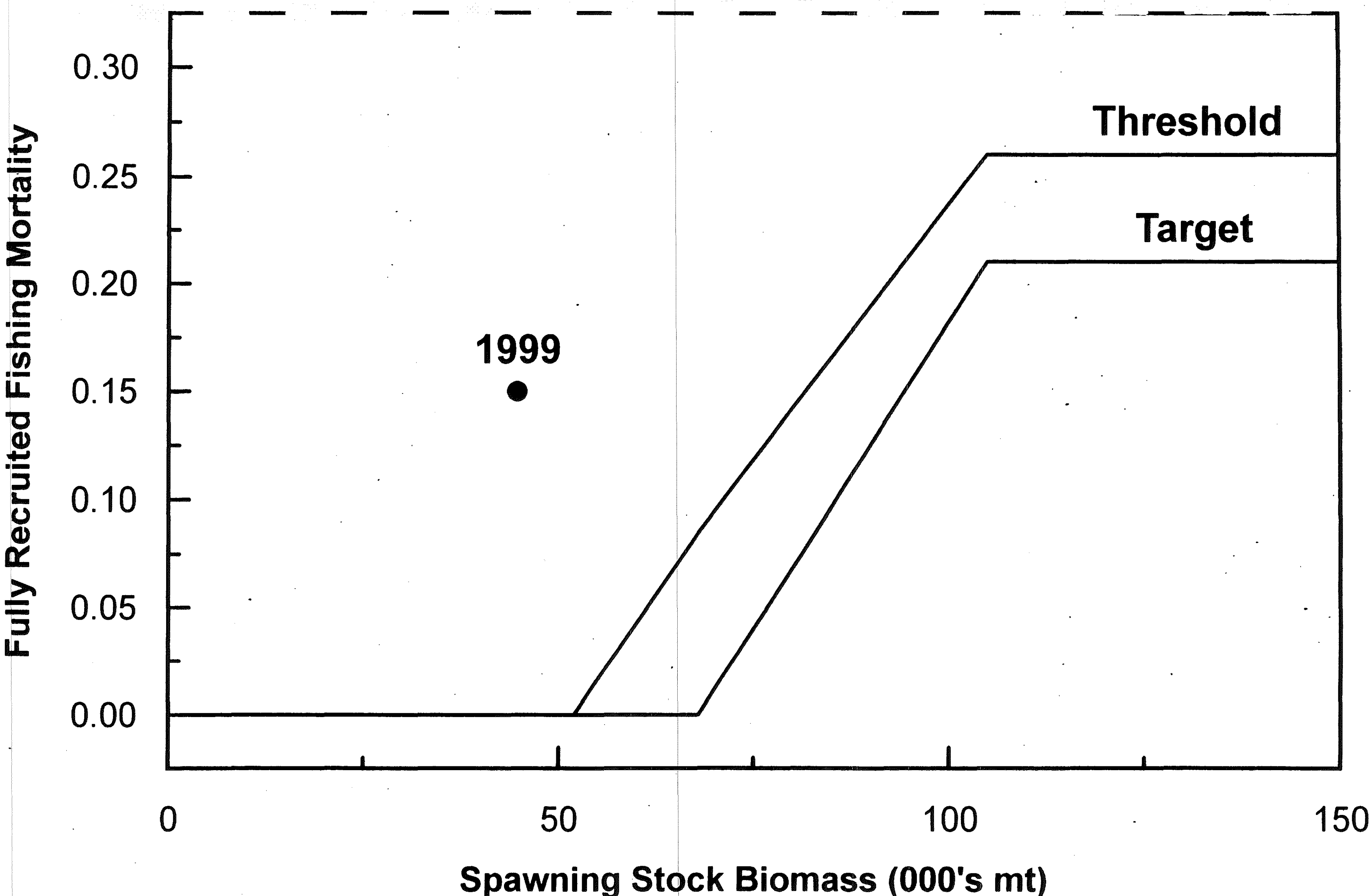

Figure B5. Harvest control rule for Georges Bank haddock based on proxies of MSY-based reference points and minimum biomass thresholds.

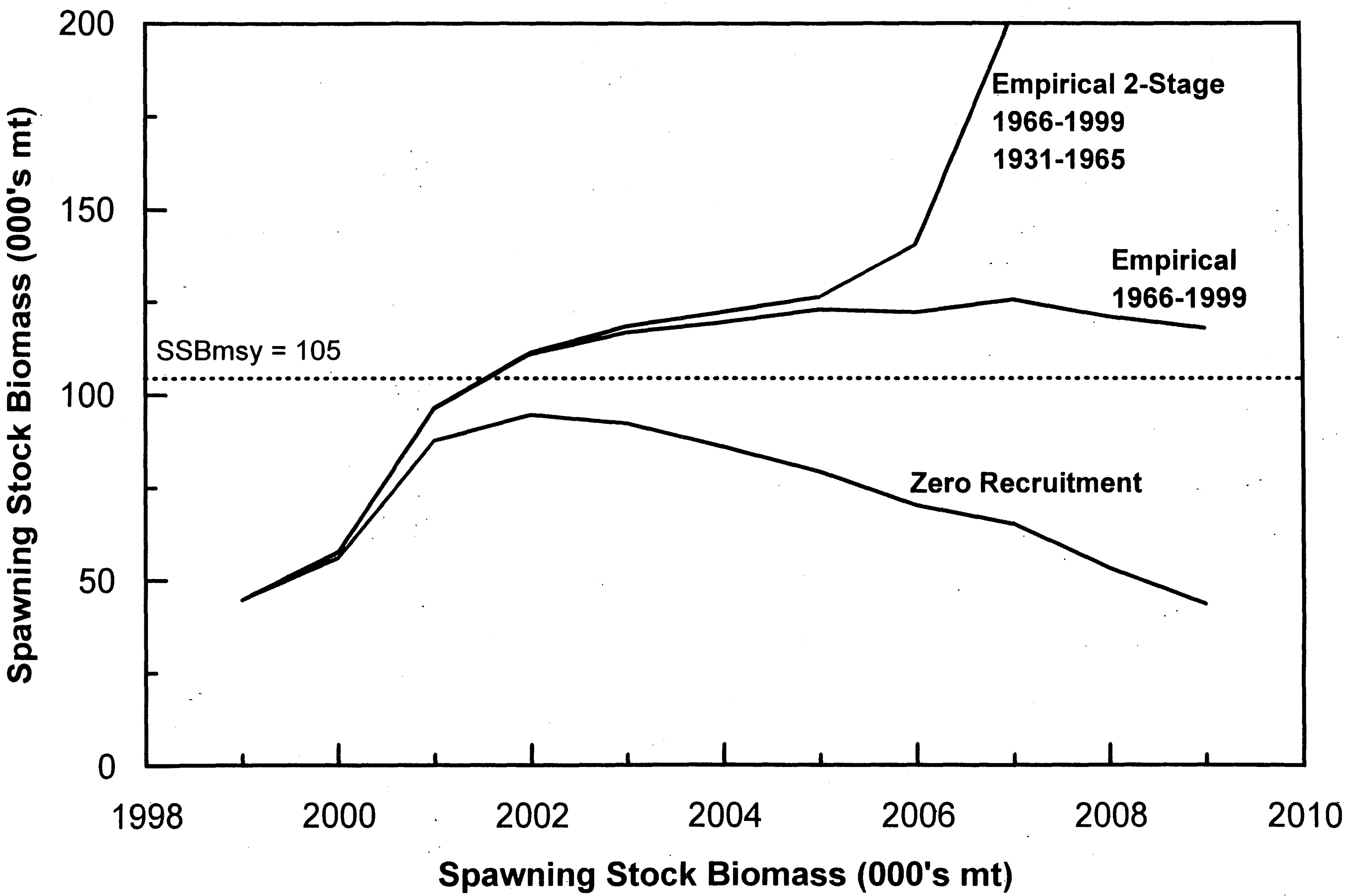

Figure B6. Results of medium term projections of Georges Bank haddock, assuming a fully recruited $F_{1999} = 0.15$ and $F_{2000\text{-}2008} = 0.00$. Recruitment was modeled using two stage resampling of R/SSB ratios, two stage resampling of empirical recruitment estimates, and resampling of recent (1966-1999) recruitment

C. Georges Bank Yellowtail Flounder by S.X. Cadrin

1.0 Background

In 1997, the Georges Bank yellowtail flounder stock was at a low biomass level (55% of B_{MSY}) and F was low (fully recruited F was 0.13, Neilson and Cadrin 1998). In 1998, the stock was at 75% of B_{MSY} with low F (fully recruited F was 0.21, Neilson et al. 1999). This report updates catch and survey indices, updates estimates of stock size and fishing mortality estimates, and evaluates medium-term projections.

2.0 1999 Assessment

2.1 1998 Landings

U.S. landings were prorated as described in Cadrin et al. (1999; Table C1; Figure C1). Landings from Georges Bank yellowtail (including Canadian landings) increased 70% from 1997.

Sampling intensity of landings in 1998 was poor. There were no commercial samples of yellowtail flounder in the fourth quarter from Georges Bank, which comprised nearly half of the landings. Landings at length were estimated by half year and market category. Canadian landings at age were estimated from Canadian port sample lengths and NEFSC fall survey ages (Neilson et al. 1999; Table C2a); U.S. landings at age and mean weights at age are reported in Table C2b.

2.2 1998 Discards

Discarded catch was estimated from logbook information on discard to kept ratios by half-year and gear (NEFSC 1998). Discard ratios are similar to those estimated in recent years for Georges Bank yellowtail, which were also based on logbook information. Discards at age were estimated from sea sampled lengths and pooled commercial-survey age-length keys. Discards at age and recent mean weights at age are reported in Table C3.

2.3 1998-1999 Survey Indices

Survey abundance and biomass indices are reported in Table C4. Estimates are from valid tows in Georges Bank (offshore strata 13-21; scallop strata 54, 55, 58-72, 74), standardized according to net, vessel, and door changes (NEFSC 1998). All survey indices of total abundance and total biomass increased for Georges Bank yellowtail in 1998 and 1999 (Figure C2).

3.0 Assessment Results

3.1 Age-Based Analysis

An updated VPA calibration for Georges Bank yellowtail is summarized in Table C5. This analysis is slightly different than that reported by Neilson et al. (1999) in that 1) US total landings in 1998 were revised with recently processed logbook information, 2) 1998 landings at age included some observer lengths to characterize unclassified landings, 3) total discards were estimated from 1998 logbooks and characterized to age with observer lengths and survey ages, rather than assuming 1997 discard at age ratios, and 4) the catch at age was expanded from ages 1-5 to ages 1-6+, 5) NEFSC spring indices were included in the calibration. Results indicate that F remained low (F_{4-5} = 0.17) and biomass continued to rebuild in 1998 (17,000 mt of spawning biomass and 28,000 mt of mean total biomass; Figures 3 and 4). Estimates of F and biomass were similar to those reported by Neilson et al. (1999), but abundance at ages 2 and 3 were substantially greater in the present analysis (the increase appears to be a result of the high spring survey indices). Retrospective analysis indicates a tendency toward underestimating F in the most recent years, but the pattern does not persist further back in time. Bootstrap analysis indicates that abundance was estimated with with moderate to high precision (CV=14-34%).

3.2 Biomass-Based Analysis

Due to continued poor sampling and resulting problems estimating catch at age, surplus production analyses (ASPIC) were updated to provide alternative perspectives on stock status. Results for the Georges Bank stock are similar to those from VPA; biomass increased to 74% of B_{MSY} in 1998 at low F (Figure C4). The estimate of B_{MSY} (46,850 mt) was similar to the 1999 TRAC estimate (45,050 mt, Neilson et al. 1999).

4.0 Forecasts

Age-based, stochastic projections were performed using bootstrap distributions of January 1, 1999 stock abundance at age, assuming F in 1999 was equal to 115% F in 1998 to account for additional scallop discards, and F in 2000-2009 were from the Amendment #9 control rule targets. Age-1 abundance in 1999 was estimated from multiple survey indices in the terminal year. Recruitment in subsequent years was estimated from Beverton-Holt stock-recruitment relationships estimated from VPA estimates (Overholtz and Brodziak 1999). Mean weight at age, exploitation pattern, and proportion discard at age was assumed to be equal to the 1994-1998 average.

Age-based Projection of the Georges Bank yellowtail stock suggests that at status quo F in 1999, the stock is projected to approach B_{MSY} (Table C6; Figure C5). At the long-term F target, the stock is projected to fluctuate at levels greater than B_{MSY} (approximately 50,000 mt total biomass after 2003) and yield nearly MSY (approximately 13,000 mt total yield after 2006).

Biomass-based, stochastic projections were performed using bootstrap distributions of January 1, 1999 stock biomass, assuming F in 1999 was equal to 115% F in 1998 to account for additional scallop discards), and F in 2000-2009 were from the Amendment #9 control rule targets. Results for the Georges Bank stock are similar to those from age-based projection (Figure C5).

5.0 Sources of Uncertainty

- Estimates of catch at age may not be reliable due to poor sampling intensity. Therefore VPA and age-based projections may be misleading. Odd exploitation patterns and retrospective patterns may indicate inadequate sampling and mis-allocation of catch at age.
- Retrospective patterns indicate that VPA estimates of biomass and F may be overly optimistic. Updated VPAs may indicate that 1998 biomass levels are lower, and 1998 F was greater than reported here.
- Although a historical perspective from production models is valuable, current and projected biomass levels may not be reliable, because recruitment is implicitly assumed to be a function of stock biomass.
- Stock-recruit observations used to derive the relationships assumed in long-term projections are limited to a short time series of relatively low stock sizes. Therefore, long-term forecasts at relatively high stock sizes may be substantially biased.
- Conversion of F on biomass targets to fully-recruited F for age-based projections are imprecise approximations that are conditional on the assumed exploitation pattern, weight at age and future recruitment. Inaccuracies in these assumptions may bias projection results.
- The assumption of status quo proportional discards at age may be inaccurate, because recruitment of the strong 1997 year class may substantially change discard patterns.
- Estimates of prorated landings and discard ratios are based on preliminary logbook data and are subject to change.

6.0 References

Cadrin, S.X., W.J. Overholtz, J.D. Neilson, S. Gavaris, and S. Wigley. 1998. Stock assessment of Georges Bank yellowtail flounder for 1997. NEFSC Ref. Doc. 98-06.

Neilson, J.D. and S.X. Cadrin. 1998. Assessment of Georges Bank (5Zjmnh) yellowtail flounder. Canada Department of Fisheries and Oceans Research Document 98/67.

Overholtz, W. and J. Brodziak. 1999. Background stock-recruit data for eleven groundfish stocks. NEFSC NDS Working Paper No. 10.

Table C1. Catch of Georges Bank yellowtail flounder (thousand mt).

Year	landings	discards	Canada	Foreign	Total
1963	11.0	5.6	0.0	0.1	16.7
1964	14.9	4.9	0.0	0.0	19.8
1965	14.2	4.4	0.0	0.8	19.4
1966	11.3	2.1	0.0	0.3	13.7
1967	8.4	5.5	0.0	1.4	15.3
1968	12.8	3.6	0.0	1.8	18.2
1969	15.9	2.6	0.0	2.4	20.9
1970	15.5	5.5	0.0	0.3	21.3
1971	11.9	3.1	0.0	0.5	15.5
1972	14.2	1.2	0.0	2.2	17.6
1973	15.9	0.4	0.0	0.3	16.5
1974	14.6	1.0	0.0	1.0	16.6
1975	13.2	2.7	0.0	0.1	16.0
1976	11.3	3.0	0.0	0.0	14.4
1977	9.4	0.6	0.0	0.0	10.0
1978	4.5	1.7	0.0	0.0	6.2
1979	5.5	0.7	0.0	0.0	6.2
1980	6.5	0.4	0.0	0.0	6.9
1981	6.2	0.1	0.0	0.0	6.3
1982	10.6	1.4	0.0	0.0	12.0
1983	11.4	0.1	0.0	0.0	11.4
1984	5.8	0.0	0.0	0.0	5.8
1985	2.5	0.0	0.0	0.0	2.5
1986	3.0	0.0	0.0	0.0	3.1
1987	2.7	0.2	0.0	0.0	3.0
1988	1.9	0.3	0.0	0.0	2.1
1989	1.1	0.1	0.0	0.0	1.2
1990	2.8	0.8	0.0	0.0	3.6
1991	1.8	0.2	0.0	0.0	2.0
1992	2.9	1.9	0.0	0.0	4.7
1993	2.1	1.1	0.7	0.0	3.9
1994	1.6	0.1	2.1	0.0	3.9
1995	0.3	0.0	0.5	0.0	0.8
1996	0.8	0.0	0.5	0.0	1.3
1997	1.0	0.1	0.8	0.0	1.8
1998	1.8	0.1	1.2	0.0	3.1
average	7.5	1.5	0.2	0.3	9.5

Table C2a. Canadian landings at age (thousands) of Georges Bank yellowtail Flounder (from Neilson et al. 1999).

	Age								
Year	1	2	3	4	5	6	7	8+	Total
1993	5	85	727	901	27	0	5	0	1750
1994	70	415	2890	1701	654	59	29	0	5818
1995	0	100	576	427	66	10	0	0	1179
1996	1	107	655	229	22	4	0	0	1018
1997	9	242	607	614	164	10	15	7	1668
1998	19	447	1086	642	254	29	6	0	2482
mean	17	190	1091	774	187	17	10	1	2287

Table C2b. U.S. landings at age (above) and mean weight at age (below) of Georges Bank yellowtail flounder.

Landings at age (thousands)				Age					
Year	1	2	3	4	5	6	7	8+	Total
1973	0	3837	13076	9274	3743	1259	278	81	31548
1974	180	6297	7818	7397	3544	852	452	173	26713
1975	427	16851	6943	3391	2084	671	313	164	30844
1976	43	19320	5085	1347	532	434	287	147	27195
1977	31	6616	9805	1721	394	221	129	124	19041
1978	0	2140	3970	1660	459	102	37	35	8403
1979	17	6804	3396	1242	550	141	79	52	12281
1980	0	2371	8696	1419	321	85	4	10	12906
1981	6	479	5267	4555	796	122	4	0	11229
1982	217	13132	7061	3245	1031	62	19	3	24770
1983	239	7667	16016	2316	625	109	10	8	26990
1984	244	1913	4266	4734	1592	257	47	17	13070
1985	371	3335	816	652	410	60	5	0	5649
1986	90	5733	978	347	161	52	16	8	7385
1987	15	1819	2730	761	132	39	32	41	5569
1988	0	1650	1181	624	165	15	20	3	3658
1989	0	1337	664	262	68	11	8	0	2350
1990	0	735	4582	738	105	17	3	0	6180
1991	0	27	867	2256	289	56	4	0	3499
1992	0	3183	1891	1176	502	20	7	0	6779
1993	0	375	1538	1392	287	65	4	1	3662
1994	0	129	2614	853	253	40	8	1	3897
1995	0	12	272	281	70	3	11	3	651
1996	0	161	751	482	144	5	5	1	1550
1997	0	205	616	875	175	16	30	12	1929
1998	0	422	1625	1156	366	53	14	0	3636
mean	72	4098	4328	2083	723	183	70	34	11592

Landed weight at age (kg)				Age				
Year	1	2	age-3	age-4	age-5	6	7	8+
1973	0.198	0.375	0.464	0.527	0.603	0.689	1.067	1.136
1974	0.200	0.378	0.500	0.609	0.680	0.725	0.906	1.249
1975	0.211	0.340	0.492	0.554	0.618	0.687	0.688	0.649
1976	0.185	0.339	0.545	0.636	0.741	0.814	0.852	0.866
1977	0.197	0.364	0.527	0.634	0.782	0.865	1.036	1.013
1978	0.182	0.337	0.513	0.684	0.793	0.899	0.930	0.948
1979	0.139	0.356	0.462	0.649	0.728	0.835	1.003	0.882
1980	0.138	0.354	0.495	0.656	0.813	1.054	1.256	1.214
1981	0.091	0.389	0.493	0.603	0.707	0.798	0.832	1.044
1982	0.213	0.313	0.487	0.650	0.748	1.052	1.024	1.311
1983	0.215	0.296	0.440	0.604	0.736	0.952	1.018	0.987
1984	0.208	0.240	0.378	0.500	0.642	0.738	0.944	1.047
1985	0.236	0.363	0.497	0.647	0.733	0.819	0.732	1.044
1986	0.234	0.343	0.540	0.664	0.823	0.864	0.956	1.140
1987	0.212	0.338	0.523	0.666	0.680	0.938	0.793	0.788
1988	----	0.351	0.557	0.688	0.855	1.054	0.873	1.385
1989	----	0.355	0.543	0.725	0.883	1.026	1.254	1.044
1990	----	0.337	0.419	0.588	0.699	0.807	1.230	1.044
1991	----	0.270	0.383	0.484	0.728	0.820	1.306	1.044
1992	----	0.341	0.381	0.528	0.648	1.203	1.125	1.044
1993	----	0.316	0.390	0.510	0.562	0.858	1.263	1.044
1994	----	0.300	0.355	0.473	0.629	0.787	0.896	1.166
1995	----	0.309	0.379	0.465	0.583	0.778	0.785	0.531
1996	----	0.321	0.417	0.569	0.726	0.926	1.031	1.209
1997	----	0.353	0.416	0.525	0.668	0.867	0.920	1.217
1998	----	0.360	0.468	0.540	0.664	0.819	0.879	
mean	0.191	0.336	0.464	0.591	0.710	0.872	0.985	1.042

Table C3. U.S. discards at age (above) and recent mean weights at age (below) of Georges Bank yellowtail flounder.

Discards at age (thousands)				Age					
Year	1	2	3	4	5	6	7	8+	Total
1973	347	1053	167	2	0	0	0	0	1569
1974	1963	2674	86	1	0	0	0	0	4724
1975	3945	8433	114	1	0	0	0	0	12493
1976	572	11692	61	0	0	0	0	0	12325
1977	299	1964	112	0	0	0	0	0	2375
1978	9659	965	64	0	0	0	0	0	10688
1979	216	2701	49	0	0	0	0	0	2966
1980	309	1201	125	0	0	0	0	0	1635
1981	49	250	84	1	0	0	0	0	384
1982	1846	4359	61	1	0	0	0	0	6267
1983	457	22	0	0	0	0	0	0	479
1984	184	4	0	0	0	0	0	0	188
1985	279	10	0	0	0	0	0	0	289
1986	68	38	0	0	0	0	0	0	106
1987	125	834	21	0	0	0	0	0	980
1988	483	717	10	0	0	0	0	0	1210
1989	185	179	4	0	0	0	0	0	368
1990	219	1196	1541	62	2	0	0	0	3020
1991	412	27	355	174	4	0	0	0	972
1992	2389	5176	636	93	8	0	0	0	8302
1993	5189	549	512	99	4	0	0	0	6353
1994	1	317	238	17	3	0	0	0	577
1995	14	45	47	7	0	0	0	0	114
1996	49	115	103	6	0	0	0	0	273
1997	7	148	35	13	1	0	0	0	205
1998	7	102	81	26	4	0	0	0	220
mean	1126	1722	173	19	1	0	0	0	3154

Discarded weight at age (kg)				Age				
Year	1	2	3	4	5	6	7	8+
1994	0.130	0.238	0.287	0.417	0.512	0.622	----	----
1995	0.155	0.233	0.283	0.357	0.496	0.593	----	----
1996	0.137	0.266	0.312	0.418	----	----	----	----
1997	0.162	0.250	0.315	0.442	0.544	0.671	0.792	0.895
1998	0.190	0.280	0.380	0.450	0.590	0.700	0.760	----
mean	0.155	0.254	0.315	0.417	0.536	0.647	0.776	0.713

Table C4a. Survey indices of Georges Bank yellowtail abundance and biomass.

NEFSC Fall Survey					Age						
Year	0	1	2	3	4	5	6	7	8+	Total	kg/tow
1963	0.000	14.722	7.896	11.226	1.858	0.495	0.281	0.034	0.233	36.746	12.791
1964	0.000	1.721	9.723	7.370	5.998	2.690	0.383	0.095	0.028	28.007	13.625
1965	0.014	1.138	5.579	5.466	3.860	1.803	0.162	0.284	0.038	18.345	9.104
1966	1.177	8.772	4.776	2.070	0.837	0.092	0.051	0.000	0.000	17.775	3.989
1967	0.106	9.137	9.313	2.699	1.007	0.309	0.076	0.061	0.000	22.708	7.577
1968	0.000	11.782	11.946	5.758	0.766	0.944	0.059	0.000	0.000	31.254	10.535
1969	0.135	8.106	10.381	5.855	1.662	0.553	0.149	0.182	0.000	27.023	9.278
1970	1.048	4.610	5.133	3.144	1.952	0.451	0.063	0.017	0.000	16.417	4.978
1971	0.025	3.627	6.949	4.904	2.248	0.551	0.234	0.024	0.024	18.586	6.362
1972	0.785	2.424	6.525	4.824	2.095	0.672	0.279	0.000	0.000	17.604	6.328
1973	0.094	2.494	5.497	5.104	2.944	1.216	0.416	0.171	0.031	17.967	6.600
1974	1.030	4.623	2.854	1.524	1.060	0.460	0.249	0.131	0.000	11.931	3.734
1975	0.361	4.625	2.511	0.877	0.572	0.334	0.033	0.000	0.031	9.344	2.365
1976	0.000	0.336	1.929	0.475	0.117	0.122	0.033	0.000	0.067	3.079	1.533
1977	0.000	0.928	2.161	1.649	0.618	0.113	0.056	0.036	0.016	5.577	2.828
1978	0.037	4.729	1.272	0.773	0.406	0.139	0.011	0.000	0.024	7.391	2.383
1979	0.018	1.312	1.999	0.316	0.122	0.138	0.038	0.064	0.007	4.014	1.520
1980	0.078	0.761	5.086	6.050	0.678	0.217	0.162	0.006	0.033	13.071	6.722
1981	0.000	1.584	2.333	1.630	0.500	0.121	0.083	0.013	0.000	6.264	2.621
1982	0.000	2.424	2.185	1.590	0.423	0.089	0.000	0.000	0.000	6.711	2.271
1983	0.000	0.109	2.284	1.914	0.473	0.068	0.012	0.000	0.038	4.898	2.131
1984	0.012	0.661	0.400	0.306	2.428	0.090	0.029	0.000	0.018	3.944	0.593
1985	0.010	1.350	0.560	0.160	0.040	0.080	0.000	0.000	0.000	2.200	0.709
1986	0.000	0.280	1.110	0.350	0.070	0.000	0.000	0.000	0.000	1.810	0.820
1987	0.000	0.113	0.390	0.396	0.053	0.079	0.000	0.000	0.000	1.031	0.509
1988	0.011	0.019	0.213	0.102	0.031	0.000	0.000	0.000	0.000	0.376	0.171
1989	0.027	0.248	1.992	0.774	0.069	0.066	0.000	0.000	0.000	3.176	0.977
1990	0.147	0.000	0.326	1.517	0.280	0.014	0.000	0.000	0.000	2.284	0.725
1991	0.000	2.100	0.275	0.439	0.358	0.000	0.000	0.000	0.000	3.172	0.730
1992	0.000	0.151	0.396	0.712	0.162	0.144	0.027	0.000	0.000	1.592	0.576
1993	0.000	0.842	0.136	0.587	0.536	0.000	0.000	0.000	0.000	2.101	0.545
1994	0.010	1.200	0.220	0.980	0.710	0.260	0.030	0.030	0.000	3.440	0.897
1995	0.070	0.280	0.120	0.350	0.280	0.050	0.010	0.000	0.000	1.160	0.354
1996	0.000	0.140	0.350	1.870	0.450	0.070	0.000	0.000	0.000	2.880	1.303
1997	0.000	1.392	0.533	3.442	2.090	1.071	0.082	0.000	0.000	8.611	3.781
1998	0.050	1.900	4.817	4.202	1.190	0.298	0.055	0.019	0.000	12.531	4.347
mean	0.146	2.796	3.338	2.539	1.082	0.383	0.085	0.032	0.016	10.417	3.786

Table C4b. Survey indices of Georges Bank yellowtail abundance and biomass.

NEFSC Spring Survey				Age						
Year	1	2	3	4	5	6	7	8+	Total	kg/tow
1968	0.149	3.364	3.579	0.316	0.084	0.160	0.127	0.000	7.779	2.813
1969	1.015	9.406	11.119	3.096	1.423	0.454	0.188	0.057	26.758	11.170
1970	0.093	4.485	6.030	2.422	0.570	0.121	0.190	0.000	13.911	5.312
1971	0.791	3.335	4.620	3.754	0.759	0.227	0.050	0.029	13.564	4.607
1972	0.138	7.136	7.198	3.514	1.094	0.046	0.122	0.000	19.247	6.450
1973	1.931	3.266	2.368	1.063	0.410	0.173	0.023	0.020	9.254	2.938
1974	0.316	2.224	1.842	1.256	0.346	0.187	0.085	0.009	6.265	2.719
1975	0.420	2.939	0.860	0.298	0.208	0.068	0.000	0.013	4.806	1.676
1976	1.034	4.368	1.247	0.311	0.196	0.026	0.048	0.037	7.268	2.273
1977	0.000	0.671	1.125	0.384	0.074	0.013	0.000	0.000	2.267	0.999
1978	0.936	0.798	0.507	0.219	0.026	0.000	0.008	0.000	2.494	0.742
1979	0.279	1.933	0.385	0.328	0.059	0.046	0.041	0.000	3.072	1.227
1980	0.057	4.644	5.761	0.473	0.057	0.037	0.000	0.000	11.030	4.456
1981	0.012	1.027	1.779	0.721	0.205	0.061	0.000	0.026	3.830	1.960
1982	0.045	3.742	1.122	1.016	0.455	0.065	0.000	0.026	6.472	2.500
1983	0.000	1.865	2.728	0.531	0.123	0.092	0.061	0.092	5.492	2.642
1984	0.000	0.093	0.809	0.885	0.834	0.244	0.000	0.000	2.865	1.646
1985	0.110	2.198	0.262	0.282	0.148	0.000	0.000	0.000	3.000	0.988
1986	0.027	1.806	0.291	0.056	0.137	0.055	0.000	0.000	2.372	0.847
1987	0.000	0.128	0.112	0.133	0.053	0.055	0.000	0.000	0.480	0.329
1988	0.078	0.275	0.366	0.242	0.199	0.027	0.000	0.000	1.187	0.566
1989	0.047	0.424	0.740	0.290	0.061	0.022	0.022	0.000	1.605	0.729
1990	0.000	0.065	1.108	0.393	0.139	0.012	0.045	0.000	1.762	0.699
1991	0.435	0.000	0.254	0.675	0.274	0.020	0.000	0.000	1.659	0.631
1992	0.000	2.010	1.945	0.598	0.189	0.000	0.000	0.000	4.742	1.566
1993	0.046	0.290	0.500	0.317	0.027	0.000	0.000	0.000	1.180	0.482
1994	0.000	0.621	0.638	0.357	0.145	0.043	0.000	0.000	1.804	0.660
1995	0.040	1.180	4.810	1.490	0.640	0.010	0.000	0.000	8.170	2.579
1996	0.030	0.990	2.630	2.700	0.610	0.060	0.000	0.000	7.020	2.853
1997	0.019	1.169	3.733	4.081	0.703	0.134	0.000	0.000	9.837	4.359
1998	0.000	2.081	1.053	1.157	0.759	0.323	0.027	0.000	5.400	2.324
1999	0.061	5.790	13.200	3.319	1.980	0.520	0.401	0.030	25.300	11.913
mean	0.253	2.323	2.647	1.146	0.406	0.103	0.045	0.011	6.934	2.739

Table C4c. Survey indices of Georges Bank yellowtail abundance and biomass.

Canadian Survey

	Age							
Year	1	2	3	4	5	6+	Total	kg/tow
1987	0.12	0.68	2.00	1.09	0.06	0.00	3.95	1.26
1988	0.00	0.66	1.89	0.80	0.59	0.01	3.96	1.24
1989	0.11	0.78	0.80	0.32	0.10	0.02	2.13	0.47
1990	0.00	1.27	4.62	1.12	0.43	0.01	7.45	1.58
1991	0.02	0.59	1.72	2.91	0.99	0.00	6.24	1.76
1992	0.22	10.04	4.52	1.21	0.16	0.00	16.14	2.48
1993	0.33	2.16	5.04	3.47	0.62	0.00	11.63	2.64
1994	0.00	6.03	3.33	3.08	0.75	0.33	13.51	2.75
1995	0.21	1.31	4.07	2.22	1.14	0.11	9.07	2.03
1996	0.45	5.54	8.44	7.49	1.37	0.16	23.45	5.30
1997	0.10	9.48	15.16	19.09	3.11	0.54	47.49	13.29
1998	0.92	3.10	3.81	5.15	2.44	0.59	16.01	4.29
1999	0.20	11.66	14.96	14.40	12.99	2.87	57.07	17.67
mean	0.21	4.10	5.41	4.80	1.90	0.36	16.78	4.37

Scallop Survey

Year	age-1
1982	0.313
1983	0.140
1984	0.233
1985	0.549
1986	0.103
1987	0.047
1988	0.116
1989	0.195
1990	0.100
1991	2.117
1992	0.167
1993	1.129
1994	1.503
1995	0.609
1996	0.508
1997	1.062
1998	1.872
mean	0.633

Table C5a. Estimates of Georges Bank yellowtail flounder abundance at age.

STOCK NUMBERS (Jan 1) in thousands - C:\Program Files\WHAT\gbyt99.5

	1973	1974	1975	1976	1977	1978	1979
1	28290	50265	68516	22919	15760	50823	23375
2	23279	22848	39214	52140	18208	12605	32871
3	28937	14635	10589	9228	14628	7144	7510
4	16960	11709	4830	2284	2899	3003	2199
5	6729	5492	2893	885	651	816	957
6	2859	2240	1551	1417	768	304	465
1+	107055	107189	127593	88873	52914	74695	67376

	1980	1981	1982	1983	1984	1985	1986
1	22099	61066	21627	5818	8620	14594	6660
2	18927	17814	49947	15840	4134	6670	11361
3	18312	12264	13925	25067	6011	1650	2434
4	3032	7011	5199	4957	6031	1062	613
5	677	1198	1618	1319	1962	654	279
6	206	185	129	264	382	102	129
1+	63252	99538	92445	53266	27141	24732	21476

	1987	1988	1989	1990	1991	1992	1993
1	7023	19353	8537	11736	22157	16337	13426
2	5310	5624	15408	6822	9410	17768	11214
3	4079	1947	2462	11243	3838	7656	6983
4	1108	851	516	1412	3665	2037	3981
5	188	219	132	185	432	802	519
6	155	49	36	34	86	42	120
1+	17863	28042	27091	31432	39588	44640	36243

	1994	1995	1996	1997	1998	1999
1	15860	26676	19221	37845	79474	00
2	6292	12921	21828	15692	30971	65044
3	8268	4373	10437	17525	12309	24478
4	3205	1574	2770	7180	13210	7551
5	1095	298	641	1620	4519	9165
6	157	58	57	425	743	3651
1+	34878	45899	54955	80287	141226	109889

Table C5b. Estimates of Georges Bank yellowtail flounder fishing mortality at age.

FISHING MORTALITY - C:\Program Files\WHAT\gbyt99.5

	1973	1974	1975	1976	1977	1978	1979
1	0.01	0.05	0.07	0.03	0.02	0.24	0.01
2	0.26	0.57	1.25	1.07	0.74	0.32	0.39
3	0.70	0.91	1.33	0.96	1.38	0.98	0.71
4	0.93	1.20	1.50	1.05	1.07	0.94	0.98
5	0.95	1.25	1.59	1.09	1.10	0.97	1.01
6	0.95	1.25	1.59	1.09	1.10	0.97	1.01

	1980	1981	1982	1983	1984	1985	1986
1	0.02	0.00	0.11	0.14	0.06	0.05	0.03
2	0.23	0.05	0.49	0.77	0.72	0.81	0.82
3	0.76	0.66	0.83	1.22	1.53	0.79	0.59
4	0.73	1.27	1.17	0.73	2.02	1.14	0.98
5	0.74	1.33	1.22	0.74	2.27	1.18	1.01
6	0.74	1.33	1.22	0.74	2.27	1.18	1.01

	1987	1988	1989	1990	1991	1992	1993
1	0.02	0.03	0.02	0.02	0.02	0.18	0.56
2	0.80	0.63	0.12	0.38	0.01	0.73	0.10
3	1.37	1.13	0.36	0.92	0.43	0.45	0.58
4	1.42	1.66	0.82	0.98	1.32	1.17	1.09
5	1.50	1.79	0.84	1.01	1.39	1.21	1.13
6	1.50	1.79	0.84	1.01	1.39	1.21	1.13

	1994	1995	1996	1997	1998
1	0.00	0.00	0.00	0.00	0.00
2	0.16	0.01	0.02	0.04	0.04
3	1.46	0.26	0.17	0.08	0.29
4	2.18	0.70	0.34	0.26	0.17
5	2.50	0.71	0.34	0.26	0.17
6	2.50	0.71	0.34	0.26	0.17

Average F for 4,5

	1973	1974	1975	1976	1977	1978	1979
4,5	0.94	1.22	1.54	1.07	1.09	0.96	0.99

	1980	1981	1982	1983	1984	1985	1986
4,5	0.74	1.30	1.19	0.73	2.14	1.16	1.00

	1987	1988	1989	1990	1991	1992	1993
4,5	1.46	1.73	0.83	1.00	1.35	1.19	1.11

	1994	1995	1996	1997	1998
4,5	2.34	0.70	0.34	0.26	0.17

Biomass Weighted F

1973	1974	1975	1976	1977	1978	1979
0.61	0.74	0.91	0.92	0.93	0.52	0.44

1980	1981	1982	1983	1984	1985	1986
0.48	0.36	0.62	0.96	1.38	0.62	0.68

1987	1988	1989	1990	1991	1992	1993
0.94	0.54	0.18	0.62	0.31	0.61	0.49

1994	1995	1996	1997	1998
0.84	0.11	0.10	0.10	0.10

Table C5c. Estimates of Georges Bank yellowtail flounder mean biomass (mt).

MEAN BIOMASS (using catch mean weights at age)

	1973	1974	1975	1976	1977	1978	1979
1	2547	4451	5996	2047	1412	4120	2107
2	6462	5404	6404	8972	3985	3040	8088
3	8797	4405	2648	2963	3847	2140	2271
4	5360	3840	1288	828	1042	1224	838
5	2408	1973	832	368	284	381	404
6	1169	858	496	648	371	161	225
1+	26743	20930	17663	15826	10943	11066	13934

	1980	1981	1982	1983	1984	1985	1986
1	1988	5532	1858	493	760	1291	596
2	4883	5368	10718	3003	649	1526	2431
3	5791	4034	4211	5879	1079	520	910
4	1296	2218	1839	1952	1210	379	239
5	356	435	646	629	467	260	133
6	140	76	73	163	104	45	65
1+	14454	17662	19346	12119	4271	4021	4374

	1987	1988	1989	1990	1991	1992	1993
1	630	1731	765	1053	1988	1362	941
2	1036	1221	4520	1458	2194	3268	2658
3	1073	598	1024	2630	1021	2023	1781
4	365	265	234	475	902	576	1125
5	61	81	72	75	157	277	161
6	70	22	23	16	36	27	57
1+	3235	3919	6638	5706	6297	7533	6723

	1994	1995	1996	1997	1998
1	1434	2417	1740	3429	7202
2	1382	3025	6056	4305	8003
3	1416	1288	3561	6992	3876
4	576	481	1121	3402	5665
5	237	114	331	923	2472
6	43	30	38	297	620
1+	5089	7355	12847	19348	27837

Table C5d. Estimates of Georges Bank yellowtail flounder spawning stock biomass (mt).

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

	1973	1974	1975	1976	1977	1978	1979
1	00	00	00	00	00	00	00
2	2796	2530	2984	4200	1870	1413	3767
3	8895	4500	2678	3026	3883	2185	2320
4	5531	3982	1319	861	1084	1275	873
5	2509	2042	848	383	296	397	421
6	1218	888	505	673	386	168	234
1+	20949	13942	8334	9143	7519	5438	7616
	1980	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**
1	00	00	00	00	00	00	00
2	2260	2678	5454	1534	629	1480	2358
3	5918	4161	4347	6031	1103	543	947
4	1351	2295	1908	2035	1195	394	248
5	371	449	670	656	450	270	139
6	146	78	75	170	101	47	67
1+	10047	9660	12455	10426	3479	2733	3760
	1987	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
1	00	00	00	00	00	00	00
2	1004	1183	4298	1403	2072	1772	1412
3	1106	621	1058	2741	1058	2099	1593
4	375	269	244	495	932	598	1170
5	63	82	75	78	162	287	167
6	72	22	24	17	37	28	59
1+	2620	2177	5700	4733	4260	4784	4402
	1994	**1995**	**1996**	**1997**	**1998**		
1	00	00	00	00	00		
2	737	1598	3201	2279	4847		
3	1250	1141	3141	6136	3549		
4	549	491	1135	3435	5936		
5	223	118	342	950	2352		
6	40	31	40	306	612		
1+	2799	3380	7859	13106	17297		

Table C6. Summary of results from stochastic projection of Georges Bank yellowtail flounder.

INPUT ASSUMPTIONS

Age	1	2	3	4	5	6+
Stock Wt.	0.150	0.290	0.398	0.512	0.653	0.996
Landed Wt.	0.191	0.329	0.407	0.510	0.654	0.851
Discard Wt.	0.155	0.254	0.315	0.417	0.536	0.652
Maturity	0.00	0.52	0.86	0.98	1.00	1.00
PR	0.00	0.03	0.63	0.97	1.00	1.00
% Discard	0.54	0.26	0.04	0.01	0.00	0.00

F-BASED PROJECTIONS

TIME-VARYING F

YEAR	F
1999	0.200
2000	0.500
2001	0.500
2002	0.500
2003	0.500
2004	0.500
2005	0.500
2006	0.500
2007	0.500
2008	0.500
2009	0.500

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1999	20.307	22.443	23.632	25.556	28.032	30.728	33.325	35.131	39.581
2000	22.536	25.564	26.966	29.798	33.287	37.144	41.325	44.163	50.498
2001	20.197	23.125	24.712	27.811	31.721	36.522	41.878	45.882	53.950
2002	19.237	22.281	24.106	27.662	32.486	38.594	45.501	50.188	60.045
2003	19.203	22.617	24.704	28.781	34.416	41.479	49.433	54.759	66.150
2004	18.467	21.997	24.237	28.632	34.682	42.243	50.708	56.338	68.877
2005	18.495	22.252	24.688	29.364	35.788	43.726	52.495	58.591	71.497
2006	18.612	22.544	25.056	29.910	36.554	44.785	53.774	59.961	73.982
2007	18.734	22.793	25.360	30.392	37.116	45.434	54.618	60.967	74.751
2008	18.866	23.008	25.649	30.678	37.526	46.021	55.372	61.816	75.572
2009	19.025	23.142	25.862	30.987	37.950	46.569	55.977	62.627	76.942

PERCENTILES OF MEAN STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1999	28.803	33.114	34.908	38.811	43.422	48.521	54.161	58.553	67.195
2000	29.504	33.602	35.900	40.344	45.947	52.794	60.564	66.142	77.589
2001	27.802	32.204	34.812	39.894	46.765	55.397	65.056	71.569	85.341
2002	27.305	32.011	34.984	40.693	48.601	58.507	69.616	77.041	92.781
2003	27.102	32.152	35.368	41.622	50.224	60.922	72.865	80.740	98.372
2004	26.732	32.074	35.496	42.141	51.239	62.449	74.752	83.403	101.347
2005	26.804	32.424	36.024	42.913	52.319	63.931	76.678	85.286	104.858
2006	27.066	32.864	36.496	43.661	53.214	65.022	77.947	86.880	105.967
2007	27.220	33.151	36.913	44.078	53.846	65.891	78.994	88.129	107.609
2008	27.428	33.343	37.213	44.529	54.426	66.607	79.895	89.288	109.228
2009	27.507	33.641	37.466	44.792	54.870	67.204	80.729	89.951	110.692

ANNUAL PROBABILITY THAT MEAN BIOMASS EXCEEDS THRESHOLD: 46.850 THOUSAND MT

YEAR	Pr(MEAN B > Threshold Value)
1999	0.321
2000	0.462
2001	0.497
2002	0.554
2003	0.599
2004	0.620
2005	0.648
2006	0.667
2007	0.681
2008	0.693
2009	0.701

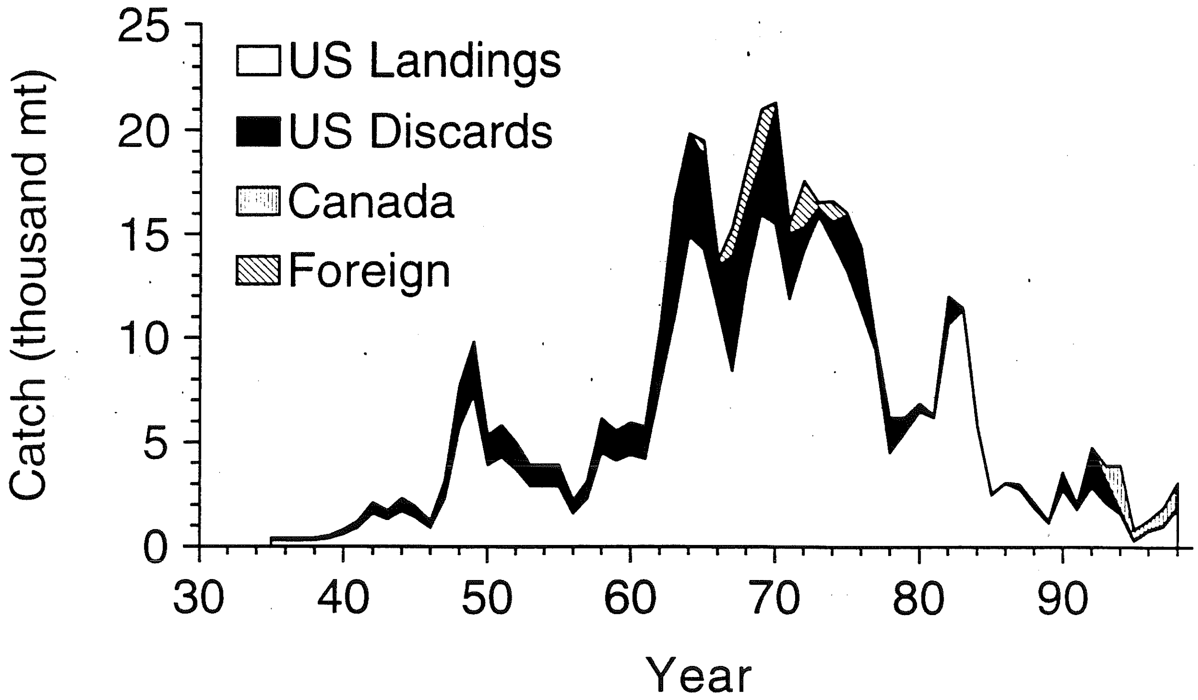

Figure C1. Total catch of Georges Bank yellowtail flounder.

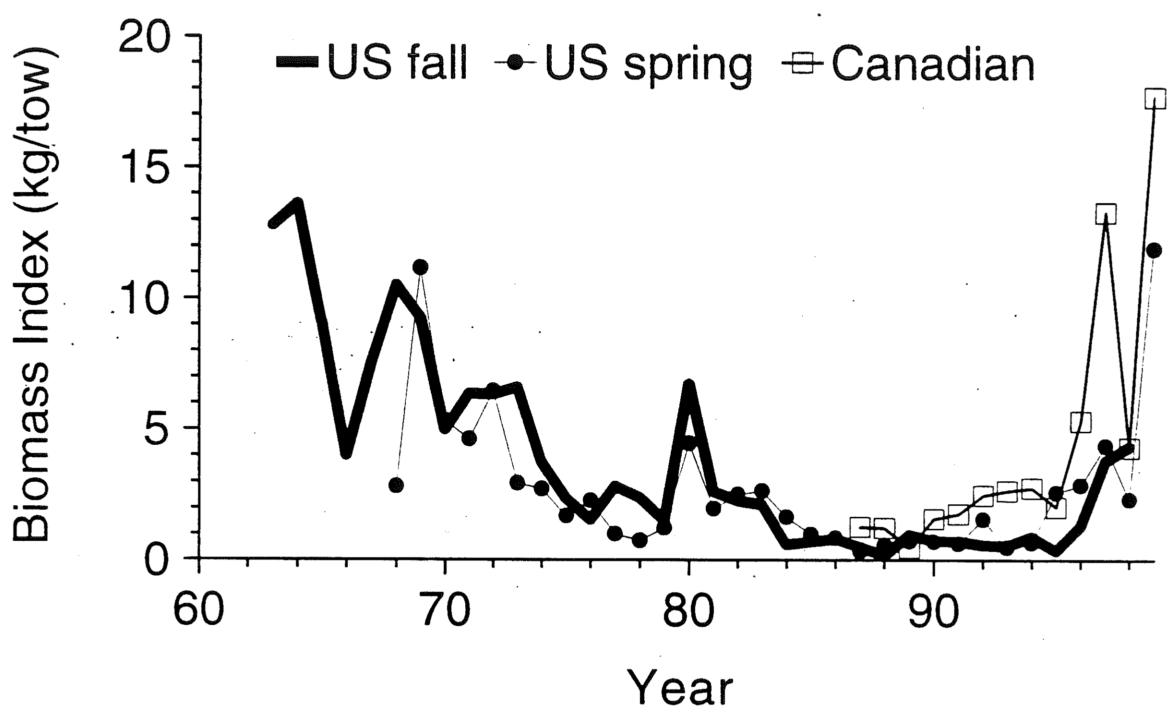

Figure C2. Survey indices of Georges Bank yellowtail flounder biomass.

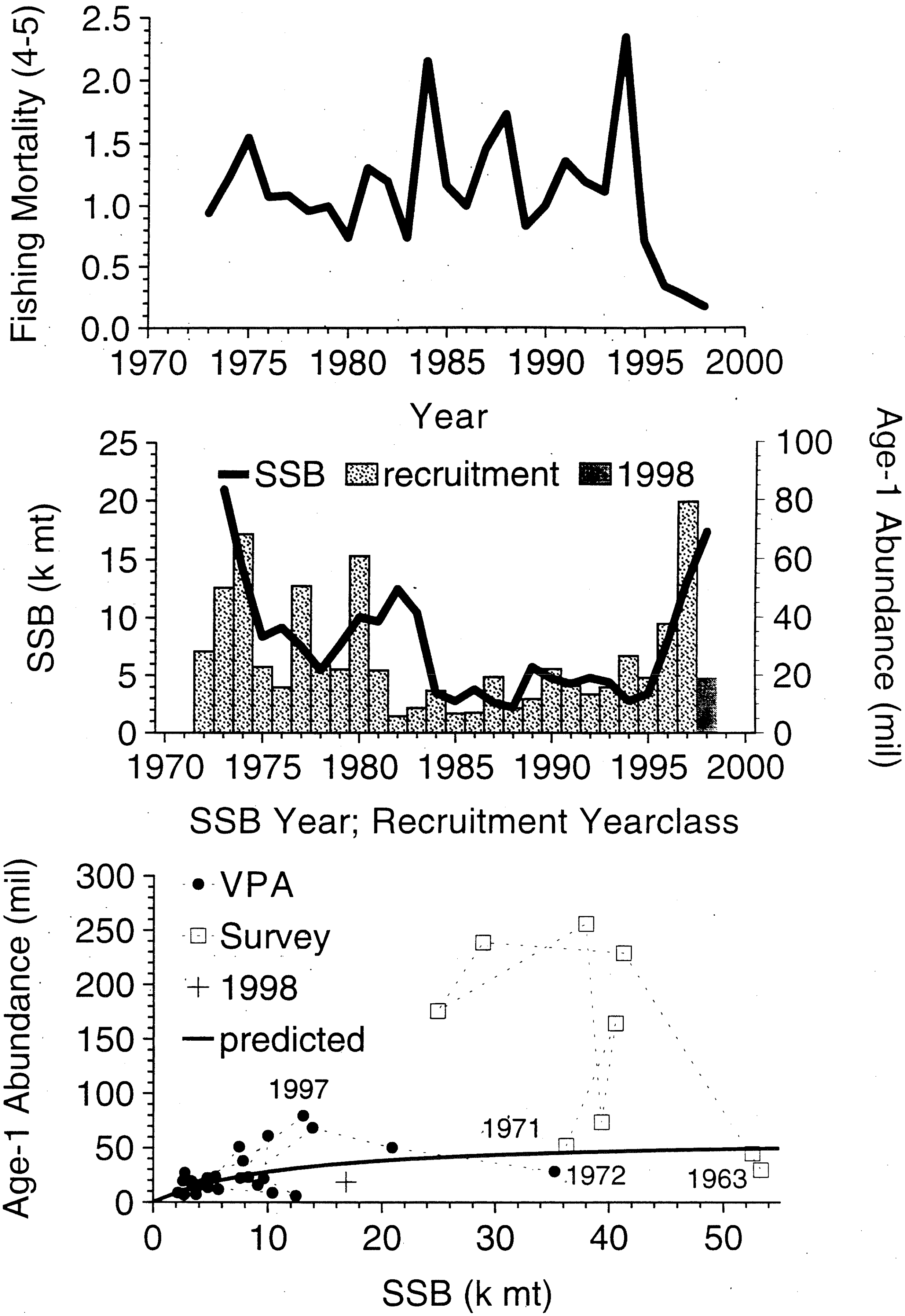

Figure C3. Summary of Georges Bank yellowtail VPA results.

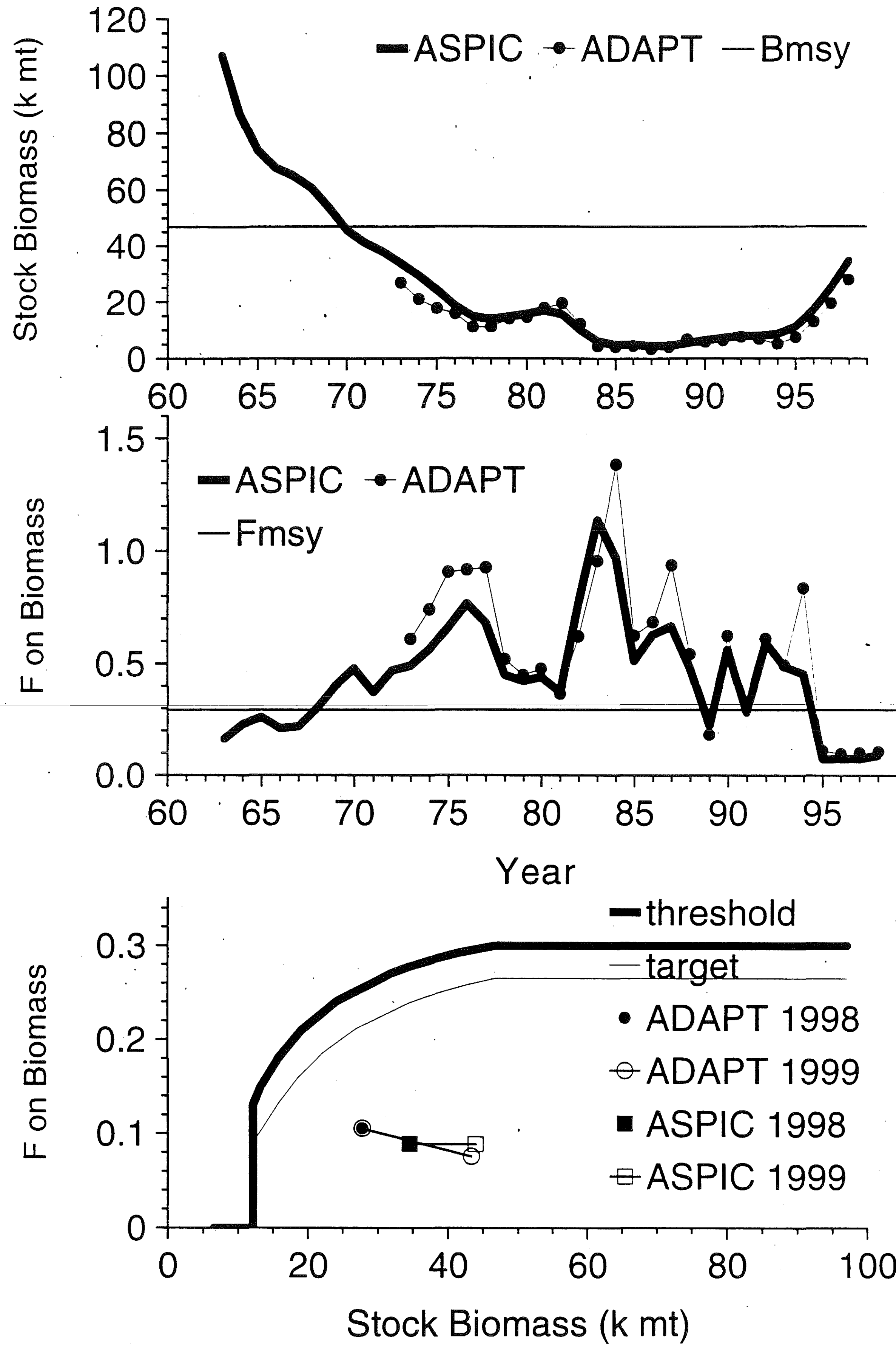

Figure C4. Status of the Georges Bank yellowtail flounder stock.

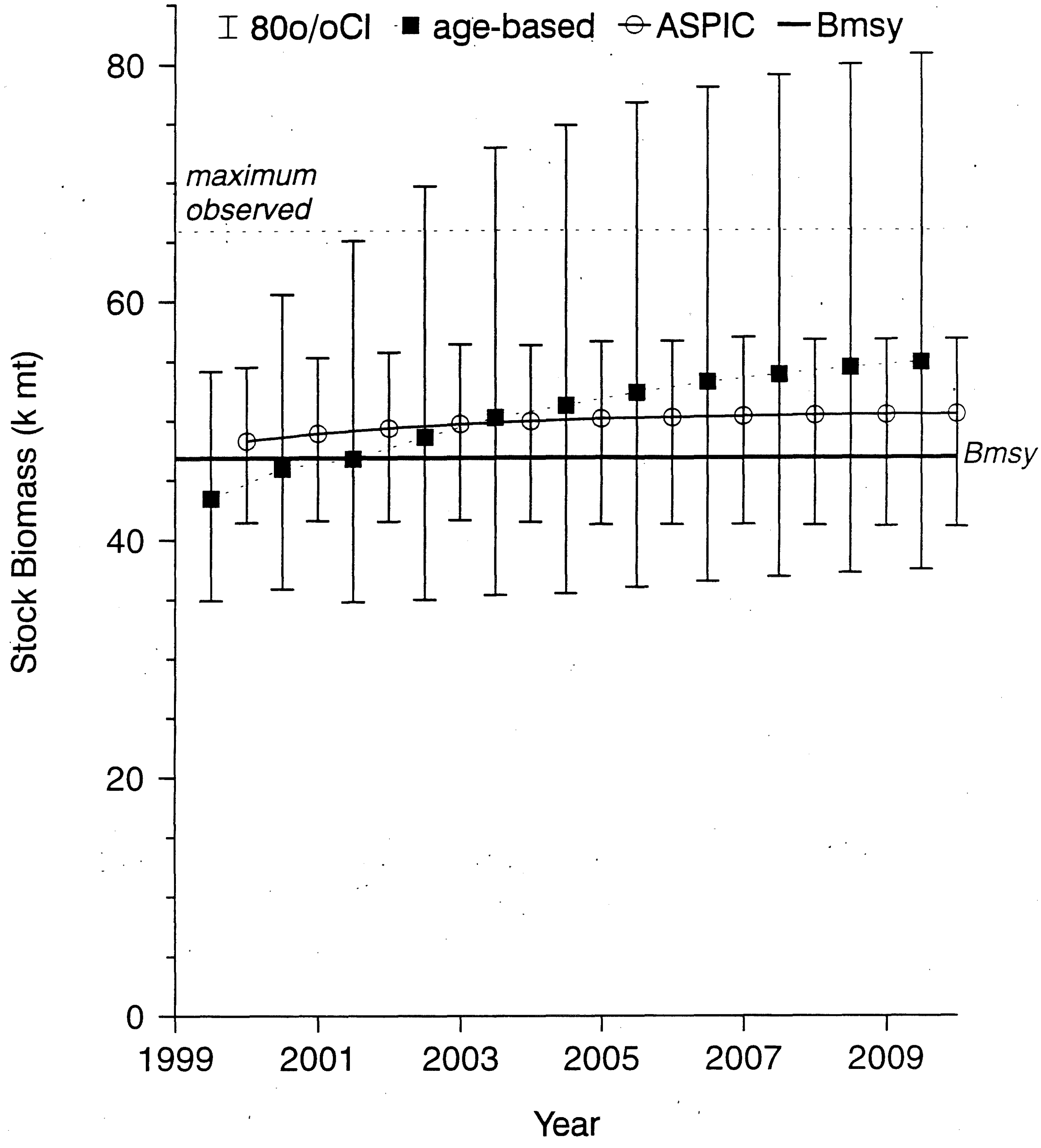

Figure C5. Projection of Georges Bank yellowtail flounder biomass at the Amendment #9 long-term fishing target in 2000-2009.

D. Southern New England Yellowtail Flounder by S.X. Cadrin

1.0 Background

The southern New England yellowtail stock was at low biomass (less than 25% B_{MSY}) at low F (fully recruited F was 0.2) in 1997 (NEFSC 1998). This report updates catch and survey indices, updates estimates of stock size and fishing mortality estimates, and evaluates medium-term projections.

2.0 1999 Assessment

2.1 1998 Landings

U.S. landings were prorated as described in Cadrin et al. (1999; Table D1; Figure D1). Landings from southern New England increased 48%.

Sampling intensity of landings in 1998 was poor. The large market category from southern New England was not sampled in the second half of the year, and there were no commercial samples of any market category in the fourth quarter, which comprised nearly half of the annual landings. Landings at length were estimated by half year and market category, where available, but first-half large samples were used to characterize second-half large landings. Landings at age and mean weights at age are reported in Table D2.

2.2 1998 Discards

Discarded catch was estimated from logbook information on discard to kept ratios by half-year and gear (NEFSC 1998; Table D4). Discard ratios are similar to those estimated in recent years for the southern New England yellowtail stocks, which were also based on logbook information. Discards at age were estimated from sea sampled lengths and pooled commercial-survey age-length keys. Discards at age and recent mean weights at age are reported in Table D3.

2.3 1998-1999 Survey Indices

Survey abundance and biomass indices are reported in Table D4. Estimates are from valid tows in southern New England (offshore strata 5, 6, 9, 10; scallop strata 33-48), standardized according to net, vessel, and door changes (NEFSC 1998). All survey indices of total abundance and total biomass increased for the southern New England yellowtail stocks in 1998 and 1999 (Figure D2).

3.0 Assessment Results

3.1 Age-Based Analysis

An updated VPA calibration of southern New England yellowtail is summarized in Table D5. This analysis updates the assessment reported in NEFSC (1998) by including 1998 landings and discards, 1998 winter, spring, scallop and fall indices, and 1999 winter and spring indices. Results indicate that F remained low ($F_{3\text{-}6}$ = 0.20), and biomass slightly increased but remained at low levels in 1998 (4,000 mt of spawning biomass and 5,000 mt of mean total biomass; Figures 3 and 4). The number of years in the retrospective analysis was limited by the short winter survey time series, but results indicate a strong pattern of underestimating F, and overestimating SSB and recruitment. Bootstrap analysis indicates that abundance was estimated with with moderate precision (CV=30-39%).

3.2 Biomass-Based Analysis

Due to continued poor sampling and resulting problems estimating catch at age, surplus production analyses (ASPIC) were updated to provide alternative perspectives on stock status. Results for the southern New England stock are similar to the VPA for most of the time series; F in 1998 was similarly low, but the estimate of 1998 biomass (21% of B_{MSY}) is substantially greater than the VPA estimate (Figure D4). The estimate of B_{MSY} (62,870 mt) was similar to 1998 SARC estimate (61,510 mt; NEFSC 1998).

4.0 Forecasts

Stochastic projections were performed using bootstrap distributions of January 1, 1999 stock abundance at age, assuming F in 1999 was equal to F in 1998, and F in 2000-2009 were from the Amendment 9 control rule targets. Age-1 abundance in 1999 was estimated from multiple survey indices in the terminal year. Recruitment in subsequent years was estimated from Beverton-Holt stock-recruitment relationships estimated from VPA estimates (Overholtz and Brodziak 1999). Mean weight at age, exploitation pattern, and proportion discarded at age was assumed to be equal to the 1994-1998 average.

Projection of the southern New England stock suggests that at status quo F in 1999, the stock will remain less than 25% B_{MSY} in 1999 (Figure D4b). At the rebuilding targets (F=0), the stock is projected to increase to B_{MSY} by 2007.

5.0 Sources of Uncertainty

- Estimates of catch at age may not be reliable due to poor sampling intensity. Therefore VPA and age-based projections may be misleading. Retrospective patterns may indicate inadequate sampling and mis-allocation of catch at age.

- Retrospective patterns indicate that VPA estimates of biomass and F may be overly optimistic. Updated VPAs may indicate that 1998 biomass levels are lower, and 1998 F was greater than reported here.
- Although historical perspective from production models are valuable, current biomass levels may not be reliable, because recruitment is implicitly assumed to be a function of stock biomass.
- Stock-recruit observations used to derive the relationships assumed in long-term projections are limited to a short time series of relatively low stock sizes. Therefore, long-term forecasts at relatively high stock sizes may be substantially biased.
- Inappropriate stock delineation may result in underestimated removals (e.g., from adjacent areas in the mid-Atlantic Bight).
- Medium-term projections may be biased because they implicitly assume constant environmental conditions. Cooling trends offer potential for faster rebuilding.
- Estimates of prorated landings and discard ratios are based on preliminary logbook data and are subject to change.

6.0 References

NEFSC (Northeast Fisheries Science Center). 1998. Southern New England yellowtail flounder. NEFSC Ref. Doc. 98-15: 328-350.

Overholtz, W. and J. Brodziak. 1999. Background stock-recruit data for eleven groundfish stocks. NEFSC NDS Working Paper No. 10.

Table D1. Landings of southern New England yellowtail flounder (thousand mt).

year	US Landings	US discards	Industrial landings	Foreign landings	total
1960	8.3	3.2	0.5		12.0
1961	12.3	4.7	0.7		17.7
1962	13.3	5.3	0.2		18.8
1963	22.5	5.4	0.3	0.2	27.9
1964	19.5	9.5	0.5		29.0
1965	21.3	6.5	1.0	1.4	27.8
1966	23.3	0.3	2.7	0.7	23.6
1967	18.1	7.7	4.5	2.8	25.8
1968	21.7	6.3	3.9	3.5	28.0
1969	33.2	2.4	4.2	17.6	35.6
1970	17.7	4.7	2.1	2.5	22.4
1971	8.9	3.3	0.4	0.3	12.2
1972	11.5	1.7	0.3	3.0	13.2
1973	7.4	1.0	0.3	0.2	8.4
1974	6.5	8.6		0.1	15.1
1975	3.2	1.9			5.1
1976	1.6	1.6			3.2
1977	2.8	1.9			4.7
1978	2.3	5.0			7.3
1979	5.3	4.4			9.7
1980	6.0	1.7			7.7
1981	4.7	1.2			5.9
1982	10.3	5.0			15.3
1983	17.0	3.5			20.5
1984	7.9	1.1			9.0
1985	2.7	1.2			3.9
1986	3.3	1.1			4.4
1987	1.6	0.9			2.5
1988	0.9	1.8			2.7
1989	2.5	5.5			8.0
1990	8.0	9.7			17.7
1991	3.9	2.3			6.2
1992	1.4	1.1			2.5
1993	0.5	0.1			0.6
1994	0.2	0.1			0.3
1995	0.2	0.1			0.2
1996	0.3	0.1			0.4
1997	0.2	0.0			0.3
1998	0.4	0.1			0.5
average	8.5	3.1	1.5	2.9	11.7

Table D2. Landings at age (above) and mean weight at age (below) of southern New England yellowtail flounder.

Landings at age (thousands)					Age				
Year	1	2	3	4	5	6	7	8+	Total
1973	28	2570	7169	4630	1716	1517	257	55	17942
1974	130	1766	3922	5053	2500	950	1021	196	15538
1975	170	2352	1496	973	1257	549	308	163	7268
1976	0	1396	898	245	337	391	167	188	3622
1977	66	2039	3931	392	205	253	123	160	7169
1978	21	3209	1488	1025	165	34	44	28	6014
1978	19	4972	8252	1033	428	96	24	0	14824
1980	119	4557	6324	3619	472	117	19	12	15239
1981	0	2732	6418	2449	884	128	14	0	12625
1982	56	17414	12788	1741	404	78	7	0	32488
1983	57	13823	33242	3347	376	129	35	7	51016
1984	45	2624	13902	6587	740	244	7	14	24163
1985	166	3984	1496	1312	774	135	27	4	7898
1986	39	5926	2882	561	324	119	21	1	9873
1987	72	1370	2014	803	139	47	8	1	4454
1988	0	1154	504	407	101	17	6	0	2189
1989	0	5213	1269	280	41	3	0	0	6806
1990	0	415	18476	1352	68	5	0	0	20316
1991	0	253	2230	6606	81	1	17	0	9188
1992	0	301	896	1687	246	10	3	0	3143
1993	0	211	361	417	124	4	0	0	1117
1994	0	15	187	136	120	48	1	0	507
1995	0	154	125	182	18	1	3	0	483
1996	0	224	439	122	15	10	5	1	817
1997	0	33	319	146	14	2	2	1	518
1998	0	300	364	139	25	2	0	0	830
mean	38	3039	5054	1740	445	188	82	32	10617

Landed weight at age (kg)					Age		
Year	1	2	3	4	5	6	7+
1973	0.21	0.298	0.381	0.42	0.43	0.506	0.611
1974	0.203	0.308	0.359	0.429	0.477	0.476	0.518
1975	0.218	0.29	0.385	0.439	0.436	0.469	0.515
1976 -		0.303	0.427	0.528	0.533	0.568	0.603
1977	0.215	0.284	0.385	0.521	0.529	0.484	0.612
1978	0.234	0.296	0.402	0.543	0.71	0.791	0.677
1979	0.189	0.301	0.366	0.476	0.59	0.684	0.679
1980	0.206	0.281	0.384	0.499	0.69	0.891	1.182
1981	0.14	0.262	0.343	0.484	0.619	0.664	0.476
1982	0.226	0.263	0.354	0.502	0.661	0.821	0.956
1983	0.175	0.262	0.341	0.499	0.671	0.829	0.838
1984	0.182	0.239	0.298	0.388	0.497	0.652	0.724
1985	0.183	0.264	0.37	0.428	0.541	0.62	0.867
1986	0.186	0.285	0.335	0.47	0.598	0.617	0.804
1987	0.247	0.268	0.361	0.412	0.542	0.595	0.905
1988 -		0.293	0.398	0.501	0.664	0.936	0.937
1989 -		0.337	0.389	0.546	0.736	0.959	1.278
1990 -		0.327	0.378	0.461	0.8	0.884	0.781
1991 -		0.336	0.379	0.426	0.715	1.53	0.599
1992 -		0.347	0.386	0.46	0.631	0.802	1.432
1993 -		0.358	0.43	0.471	0.645	1.04	1.04
1994 -		0.319	0.349	0.416	0.556	0.717	0.876
1995 -		0.317	0.41	0.46	0.668	0.883	0.863
1996 -		0.363	0.399	0.476	0.602	0.68	0.78
1997 -		0.347	0.435	0.494	0.677	0.847	0.926
1998 -		0.284	0.399	0.528	0.694	0.790	0.707
mean	0.254	0.364	0.476	0.603	0.775	0.953	0.815

Table D3. Discards at age of southern New England yellowtail flounder.

Discards at age (thousands)				Age					
Year	1	2	3	4	5	6	7	8+	Total
1973	160	2486	1130	43	0	0	0	0	3819
1974	728	26568	793	45	0	0	0	0	28134
1975	8670	1427	1	10	0	0	0	0	10108
1976	214	5203	14	0	0	0	0	0	5431
1977	5376	2732	42	0	0	0	0	0	8150
1978	8677	10102	7	0	0	0	0	0	18786
1979	185	14253	119	0	0	0	0	0	14557
1980	869	5441	18	0	0	0	0	0	6328
1981	38	4013	319	0	0	0	0	0	4370
1982	113	17716	905	3	0	0	0	0	18737
1983	2469	4607	5373	17	0	0	0	0	12466
1984	465	3107	941	74	0	0	0	0	4587
1985	2064	3031	20	0	0	0	0	0	5115
1986	423	3754	39	0	0	0	0	0	4216
1987	1518	2034	19	0	0	0	0	0	3572
1988	5899	896	4	0	0	0	0	0	6798
1989	24	14002	1834	131	6	0	0	0	15996
1990	192	1633	23709	673	11	0	0	0	26217
1991	445	1354	2820	2883	12	0	0	0	7514
1992	477	1152	1086	659	33	0	0	0	3408
1993	13	212	15	9	0	0	0	0	249
1994	9	134	35	29	12	2	0	0	221
1995	7	94	38	27	12	3	0	0	182
1996	21	81	56	29	13	2	0	0	202
1997	1	23	32	4	1	0	0	0	61
1998	0	88	114	40	9	3	1	0	255
mean	1502	4852	1519	180	4	0	0	0	8057

Table D4a. Survey indices of southern New England yellowtail abundance and biomass.

NEFSC Fall Survey					Age					
Year	1	2	3	4	5	6	7	8+	Total	kg/tow
1963	19.798	20.168	14.960	5.830	0.660	0.151	0.000	0.100	61.667	16.842
1964	22.529	31.952	5.861	8.701	3.983	1.108	0.000	0.000	74.133	19.03
1965	13.231	21.390	7.771	2.140	2.167	0.155	0.000	0.090	46.944	12.675
1966	43.305	13.066	2.375	1.247	0.231	0.000	0.000	0.000	60.224	9.431
1967	22.497	31.159	13.716	1.936	0.472	0.079	0.160	0.000	70.019	14.057
1968	11.285	13.352	22.860	1.443	0.115	0.000	0.000	0.000	49.055	10.062
1969	14.481	11.884	33.861	6.351	0.113	0.050	0.050	0.000	66.791	14.401
1970	5.157	6.736	19.936	12.961	3.067	0.520	0.089	0.000	48.466	10.965
1971	7.748	13.298	7.618	18.468	3.287	0.264	0.196	0.000	50.879	11.632
1972	5.135	20.125	24.054	22.993	14.991	2.050	0.054	0.000	89.402	20.114
1973	1.726	1.590	2.224	1.640	1.241	1.057	0.212	0.000	9.689	2.264
1974	1.216	2.047	0.676	2.776	1.166	0.489	0.238	0.093	8.701	2.141
1975	1.981	0.516	0.266	0.329	0.334	0.000	0.104	0.000	3.531	0.715
1976	3.632	7.331	0.877	0.088	0.139	0.361	0.423	0.189	13.041	2.962
1977	1.759	2.275	0.828	0.053	0.046	0.113	0.078	0.000	5.151	1.501
1978	3.247	7.599	0.450	0.392	0.043	0.009	0.079	0.032	11.851	3.057
1979	1.794	4.533	2.537	0.388	0.043	0.041	0.000	0.000	9.335	2.565
1980	1.463	4.506	1.202	0.426	0.000	0.000	0.000	0.000	7.597	1.957
1981	4.704	8.944	1.404	0.334	0.080	0.061	0.000	0.000	15.527	3.789
1982	2.610	29.372	8.673	1.025	0.409	0.000	0.000	0.000	42.088	8.126
1983	4.582	17.956	10.078	0.876	0.073	0.000	0.050	0.000	33.616	6.515
1984	0.719	2.217	2.400	0.659	0.000	0.000	0.000	0.000	5.994	1.365
1985	1.018	0.447	0.161	0.122	0.000	0.000	0.000	0.000	1.748	0.438
1986	0.826	1.685	0.365	0.088	0.000	0.000	0.000	0.000	2.963	0.883
1987	1.515	0.674	0.558	0.047	0.037	0.000	0.037	0.000	2.868	0.607
1988	1.261	0.388	0.173	0.195	0.048	0.000	0.000	0.000	2.065	0.496
1989	0.000	8.004	1.400	0.065	0.000	0.000	0.000	0.000	9.469	2.359
1990	0.000	0.097	2.395	0.270	0.000	0.000	0.000	0.000	2.763	0.974
1991	0.865	0.219	1.709	0.453	0.000	0.000	0.000	0.000	3.247	1.013
1992	0.261	0.062	0.180	0.337	0.012	0.000	0.000	0.000	0.852	0.229
1993	0.070	0.015	0.028	0.020	0.000	0.000	0.000	0.000	0.133	0.053
1994	0.754	0.553	0.198	0.192	0.085	0.011	0.000	0.000	1.793	0.374
1995	0.180	1.306	0.171	0.095	0.000	0.000	0.000	0.000	1.752	0.432
1996	0.653	0.290	0.258	0.025	0.000	0.000	0.000	0.000	1.226	0.266
1997	0.889	0.716	1.687	0.373	0.037	0.000	0.000	0.000	3.702	1.041
1998	1.689	2.611	0.229	0.093	0.000	0.044	0.000	0.000	4.666	1.151
mean	5.683	8.030	5.393	2.595	0.913	0.182	0.049	0.014	22.860	5.180

Table D4b. Survey indices of southern New England yellowtail abundance and biomass.

NEFSC Spring Survey

	Age									
Year	1	2	3	4	5	6	7	8+	Total	kg/tow
1968	1.662	31.719	31.913	19.002	0.886	0.168	0.067	0.000	85.416	18.624
1969	5.102	19.866	27.261	14.675	2.540	0.285	0.000	0.000	69.730	13.340
1970	1.486	10.669	19.964	14.136	4.066	1.096	0.235	0.096	51.749	11.721
1971	1.066	11.323	8.519	23.664	6.065	0.967	0.011	0.011	51.627	10.693
1972	0.492	21.844	14.735	4.596	8.813	1.360	0.257	0.000	52.098	10.728
1973	1.301	7.270	12.713	6.276	4.261	6.595	0.820	0.456	39.693	14.678
1974	0.742	2.972	2.326	2.530	1.647	0.593	0.964	0.193	11.967	5.040
1975	0.561	1.556	0.500	0.769	0.810	0.471	0.033	0.146	4.845	1.984
1976	0.026	3.259	0.528	0.250	0.302	0.250	0.157	0.051	4.823	2.452
1977	0.205	1.251	1.556	0.166	0.173	0.080	0.024	0.103	3.557	1.993
1978	2.963	9.783	2.027	0.715	0.187	0.036	0.047	0.138	15.897	5.146
1979	1.542	3.357	1.741	0.354	0.110	0.000	0.000	0.008	7.112	2.147
1980	0.370	4.303	3.278	2.711	0.291	0.116	0.006	0.039	11.115	5.949
1981	0.203	8.622	3.089	1.279	0.464	0.047	0.000	0.000	13.704	6.846
1982	0.333	14.049	7.459	1.860	0.605	0.186	0.020	0.000	24.512	6.001
1983	0.090	3.900	12.916	1.059	0.312	0.000	0.000	0.000	18.278	4.641
1984	0.000	0.500	1.648	2.612	0.665	0.223	0.000	0.000	5.649	1.625
1985	0.561	0.744	0.417	0.201	0.454	0.093	0.000	0.000	2.470	0.666
1986	0.037	4.083	1.492	0.308	0.073	0.036	0.000	0.000	6.029	1.605
1987	0.000	0.198	0.919	0.144	0.000	0.000	0.000	0.000	1.261	0.402
1988	0.327	0.692	0.177	0.245	0.127	0.000	0.000	0.000	1.568	0.399
1989	0.151	10.308	0.604	0.066	0.000	0.000	0.000	0.000	11.129	2.433
1990	0.091	0.368	18.994	3.794	0.031	0.000	0.000	0.000	23.278	7.828
1991	0.438	0.340	1.573	4.484	0.510	0.111	0.000	0.000	7.455	2.786
1992	0.081	0.269	0.275	1.196	0.112	0.000	0.000	0.000	1.933	0.653
1993	0.037	0.533	0.221	0.517	0.097	0.000	0.000	0.000	1.405	0.506
1994	0.031	0.494	0.040	0.019	0.045	0.015	0.000	0.000	0.643	0.219
1995	0.054	0.944	0.284	0.072	0.030	0.011	0.018	0.000	1.413	0.360
1996	0.000	0.528	2.442	0.314	0.063	0.000	0.000	0.000	3.347	1.054
1997	0.119	1.816	1.735	0.274	0.081	0.000	0.000	0.000	4.025	1.183
1998	0.187	4.509	0.528	0.282	0.094	0.000	0.000	0.000	5.600	1.246
1999	0.045	1.740	3.983	0.296	0.044	0.000	0.000	0.000	6.107	2.257
mean	0.634	5.744	5.808	3.402	1.061	0.398	0.083	0.039	17.170	4.600

Table D4c. Survey indices of southern New England yellowtail abundance and biomass.

NEFSC Winter Survey

	Age									
Year	1	2	3	4	5	6	7	8+	Total	kg/tow
1992	0.000	2.884	1.881	6.418	1.295	0.000	0.000	0.000	12.478	4.402
1993	1.349	3.853	0.711	1.841	0.306	0.000	0.000	0.000	8.060	1.968
1994	0.586	17.778	1.363	2.917	1.258	0.199	0.000	0.000	24.101	6.809
1995	0.368	7.615	4.474	1.317	0.493	0.123	0.036	0.000	14.426	4.059
1996	0.092	2.304	11.703	1.552	0.207	0.109	0.033	0.000	16.000	5.159
1997	0.301	3.976	9.141	2.625	0.508	0.000	0.000	0.000	16.551	5.831
1998	0.326	3.855	1.476	0.445	0.000	0.000	0.050	0.000	6.152	1.640
1999*	0.567	6.112	18.823	0.918	0.184	0.081	0.000	0.000	26.686	8.987
mean	0.449	6.047	6.197	2.254	0.531	0.064	0.015	0.000	15.557	5.421

* preliminary, based on unaudited data.

Scallop Survey

Year	age-1
1982	0.584
1983	0.891
1984	0.205
1985	0.647
1986	0.282
1987	0.601
1988	1.343
1989	0.169
1990	0.026
1991	1.060
1992	0.411
1993	0.419
1994	1.265
1995	0.551
1996	0.608
1997	2.744
1998	0.289
mean	0.711

Table D5a. Estimates of abundance at age of southern New England yellowtail flounder.

STOCK NUMBERS (Jan 1) in thousands - C:\Program Files\WHAT\sneyt99.3

	1973	1974	1975	1976	1977	1978	1979
1	42144	9234	28866	12910	47571	52422	30090
2	15230	34335	6784	15635	10376	34024	35049
3	19877	7894	2473	2135	6829	4179	15812
4	10100	8765	2197	670	922	1997	2068
5	3810	4041	2563	909	327	400	707
6	3446	1567	1046	961	439	82	179
7	700	1968	883	863	483	172	44
1+	95307	67803	44812	34082	66949	93276	83950

	1980	1981	1982	1983	1984	1985	1986
1	41943	126925	53147	14583	16730	19837	6969
2	24451	33446	103883	43360	9654	13236	14223
3	11300	10973	21280	53266	18824	2719	4489
4	5371	3513	2888	5033	8670	1982	854
5	759	1123	661	786	1077	1071	435
6	192	194	120	175	303	212	177
7	50	21	11	55	25	48	32
1+	84066	176195	181989	117259	55284	39104	27179

	1987	1988	1989	1990	1991	1992	1993
1	13987	121993	16403	6853	3548	1981	908
2	5287	10013	94542	13408	5437	2502	1190
3	2886	1249	6343	60018	9124	2998	734
4	1032	524	563	2385	10968	2901	661
5	192	119	60	89	121	394	251
6	63	31	06	07	01	15	70
7	12	11	00	00	22	04	00
1+	23459	133939	117916	82760	29221	10794	3814

	1994	1995	1996	1997	1998	1999
1	1918	2978	4316	12189	7634	00
2	732	1562	2432	3515	9978	6250
3	592	463	1055	1715	2827	7819
4	260	284	232	415	1087	1882
5	156	64	42	53	204	728
6	94	08	25	08	30	136
7	02	06	11	13	06	24
1+	3753	5365	8113	17907	21765	16838

Table D5b. Estimates of fishing mortality at age of southern New England yellowtail flounder.

	1973	1974	1975	1976	1977	1978	1979
1	0.005	0.108	0.413	0.018	0.135	0.203	0.008
2	0.457	2.431	0.956	0.628	0.710	0.566	0.932
3	0.619	1.079	1.106	0.639	1.030	0.503	0.880
4	0.716	1.030	0.682	0.517	0.634	0.838	0.803
5	0.689	1.151	0.781	0.527	1.180	0.608	1.105
6	0.666	1.109	0.867	0.597	1.011	0.610	0.902
7	0.666	1.109	0.867	0.597	1.011	0.610	0.902

	1980	1981	1982	1983	1984	1985	1986
1	0.026	0.000	0.004	0.212	0.034	0.133	0.076
2	0.601	0.252	0.468	0.634	1.067	0.881	1.395
3	0.968	1.135	1.242	1.615	2.051	0.958	1.270
4	1.365	1.471	1.101	1.342	1.891	1.316	1.294
5	1.163	2.039	1.127	0.752	1.426	1.602	1.730
6	1.122	1.305	1.274	1.680	2.195	1.218	1.365
7	1.122	1.305	1.274	1.680	2.195	1.218	1.365

	1987	1988	1989	1990	1991	1992	1993
1	0.134	0.055	0.002	0.031	0.149	0.309	0.016
2	1.243	0.257	0.254	0.185	0.395	1.027	0.499
3	1.507	0.597	0.778	1.500	0.946	1.312	0.836
4	1.963	1.961	1.645	2.784	3.127	2.245	1.246
5	1.618	2.822	1.972	3.992	1.911	1.529	0.787
6	1.726	0.925	0.853	1.629	1.726	1.785	1.002
7	1.726	0.925	0.853	1.629	1.726	1.785	1.002

	1994	1995	1996	1997	1998
1	0.005	0.003	0.005	0.000	0.000
2	0.257	0.193	0.149	0.018	0.044
3	0.535	0.492	0.734	0.256	0.207
4	1.205	1.703	1.273	0.511	0.201
5	2.776	0.732	1.416	0.374	0.204
6	0.863	0.815	0.846	0.305	0.204
7	0.863	0.815	0.846	0.305	0.204

Age3-6	1973	1974	1975	1976	1977	1978	1979
3,6	0.67	1.09	0.86	0.57	0.96	0.64	0.92
	1980	1981	1982	1983	1984	1985	1986
3,6	1.15	1.49	1.19	1.35	1.89	1.27	1.41
	1987	1988	1989	1990	1991	1992	1993
3,6	1.70	1.58	1.31	2.48	1.93	1.72	0.97
	1994	1995	1996	1997	1998		
3,6	1.34	0.94	1.07	0.36	0.20		

Biomass Weighted F

1973	1974	1975	1976	1977	1978	1979
0.39	1.39	0.62	0.41	0.37	0.38	0.62
1980	1981	1982	1983	1984	1985	1986
0.47	0.23	0.43	1.06	1.16	0.60	1.03
1987	1988	1989	1990	1991	1992	1993
0.57	0.08	0.25	1.08	1.32	1.35	0.71
1994	1995	1996	1997	1998		
0.48	0.28	0.25	0.08	0.09		

Table D5c. Estimates of mean biomass (mt) of southern New England yellowtail flounder.

MEAN BIOMASS (using catch mean weights at age)

	1973	1974	1975	1976	1977	1978	1979
1	8002	1613	4704	2644	8690	10098	5136
2	3327	3730	1166	3221	1935	7035	6315
3	5171	1599	532	617	1513	1206	3539
4	2778	2164	641	253	326	675	622
5	1086	1057	712	344	94	195	233
6	1167	416	302	376	123	45	74
7	286	569	280	358	171	80	18
1+	21815	11148	8336	7814	12853	19333	15937

	1980	1981	1982	1983	1984	1985	1986
1	7732	16103	10868	2091	2715	3088	1133
2	4727	7049	19930	7704	1308	2136	2026
3	2560	2077	3989	8377	2230	596	788
4	1355	826	811	1280	1410	437	208
5	286	277	242	340	264	269	115
6	95	67	51	66	75	70	55
7	33	05	05	21	07	22	13
1+	16786	26405	35896	19879	8008	6617	4338

	1987	1988	1989	1990	1991	1992	1993
1	2937	29075	4620	1842	617	259	100
2	750	2355	25604	3639	1073	456	307
3	500	343	1574	10909	1825	567	196
4	174	107	140	350	1316	466	165
5	48	25	18	17	34	112	103
6	17	18	03	03	01	05	42
7	05	06	00	00	06	02	00
1+	4430	31929	31960	16759	4871	1867	913

	1994	1995	1996	1997	1998
1	187	332	574	1580	899
2	188	410	768	932	2506
3	146	137	280	585	927
4	58	58	57	147	473
5	28	28	12	28	116
6	41	04	10	06	20
7	01	03	06	09	04
1+	650	972	1707	3286	4944

Table D5d. Estimates of spawning stock biomass of southern New England yellowtail flounder.

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

	1973	1974	1975	1976	1977	1978	1979
1	1056	214	632	349	1155	1347	678
2	2548	2592	896	2476	1488	5402	4853
3	5262	1623	539	628	1537	1225	3604
4	2887	2243	666	262	339	701	646
5	1128	1093	740	357	97	203	241
6	1212	430	313	391	128	46	77
7	297	588	291	372	178	83	19
1+	14390	8784	4077	4834	4922	9007	10117

	1980	1981	1982	1983	1984	1985	1986
1	1021	2124	1434	279	359	410	150
2	3631	5363	15272	5921	1003	1642	1535
3	2603	2105	4029	8304	2136	606	795
4	1389	843	839	1314	1398	449	214
5	295	271	250	354	270	272	116
6	98	69	53	66	72	72	56
7	34	05	05	21	07	23	13
1+	9073	10780	21882	16259	5244	3474	2880

	1987	1988	1989	1990	1991	1992	1993
1	390	3847	609	243	82	35	13
2	572	1792	19481	2760	821	349	235
3	499	349	1603	10889	1857	571	200
4	171	106	142	314	1123	447	170
5	48	22	18	12	34	114	107
6	17	18	04	03	01	05	44
7	05	06	00	00	06	02	00
1+	1702	6140	21856	14221	3922	1523	769

	1994	1995	1996	1997	1998
1	25	44	76	208	119
2	143	311	581	700	1886
3	149	139	286	590	932
4	60	59	58	152	485
5	25	29	13	28	119
6	43	05	11	06	20
7	01	03	06	09	04
1+	445	589	1030	1694	3564

Table D6. Summary of results from stochastic projection of southern New England yellowtail flounder.

INPUT ASSUMPTIONS

Age	1	2	3	4	5	6	7+
Stock Wt.	0.130	0.318	0.398	0.473	0.636	0.785	0.850
Landed Wt.	0.254	0.326	0.398	0.475	0.639	0.783	0.830
Discard Wt.	0.13	0.28	0.4	0.53	0.69	0.79	0.71
Maturity	0.13	0.74	0.98	1.00	1.00	1.00	1.00
PR	0.01	0.12	0.53	1.00	1.00	1.00	1.00
% Discard	1.00	0.44	0.17	0.15	0.25	0.31	0.20

F-BASED PROJECTIONS

TIME-VARYING F

YEAR	F
1999	0.200
2000	0.000
2001	0.000
2002	0.000
2003	0.000
2004	0.000
2005	0.000
2006	0.000
2007	0.000
2008	0.000
2009	0.000

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1999	3.584	4.128	4.317	4.838	5.510	6.230	7.061	7.585	8.635
2000	3.923	4.662	4.975	5.639	6.610	7.960	9.735	11.676	16.257
2001	5.245	6.184	6.893	8.159	10.526	15.002	21.196	27.714	38.847
2002	7.056	8.505	9.618	12.043	16.900	24.456	35.818	44.906	67.187
2003	8.829	11.070	12.933	16.978	24.059	34.988	49.624	61.234	95.219
2004	11.174	14.198	16.743	22.701	32.157	46.327	66.811	83.769	126.580
2005	13.411	17.980	21.299	28.737	41.066	58.711	83.508	103.297	154.428
2006	15.895	21.517	25.744	34.978	48.925	70.824	99.667	125.004	180.972
2007	18.701	25.369	30.290	41.663	57.758	82.208	115.411	140.787	215.165
2008	21.630	30.055	34.996	47.074	65.816	92.485	129.031	154.470	239.580
2009	24.040	33.758	39.435	52.216	71.552	100.648	138.853	168.715	262.813

PERCENTILES OF MEAN STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1999	3.802	4.556	4.934	5.591	6.607	7.718	9.865	12.760	17.970
2000	4.990	5.953	6.612	7.991	10.688	15.951	24.282	32.408	47.721
2001	6.972	8.398	9.456	12.139	17.418	26.073	38.117	47.970	75.616
2002	8.660	11.636	13.288	17.710	25.277	36.841	53.125	66.824	100.042
2003	11.490	15.047	17.615	23.623	33.574	48.823	69.857	88.168	139.503
2004	14.088	18.501	21.783	29.495	42.483	60.850	86.202	106.594	163.487
2005	16.296	22.407	26.687	36.625	50.713	72.936	102.197	131.214	196.289
2006	19.483	26.657	31.660	43.571	60.286	85.241	119.191	145.238	233.720
2007	22.377	31.514	37.153	49.986	69.502	96.973	135.045	160.800	252.330
2008	25.556	35.923	42.068	55.371	75.824	107.320	148.007	175.375	266.105
2009	28.712	39.519	46.304	60.512	82.156	115.251	153.739	190.201	301.637

ANNUAL PROBABILITY THAT MEAN BIOMASS EXCEEDS THRESHOLD: 62.870 THOUSAND MT

YEAR	Pr(MEAN B > Threshold Value)
1999	0.000
2000	0.004
2001	0.021
2002	0.059
2003	0.136
2004	0.228
2005	0.350
2006	0.471
2007	0.575
2008	0.649
2009	0.718

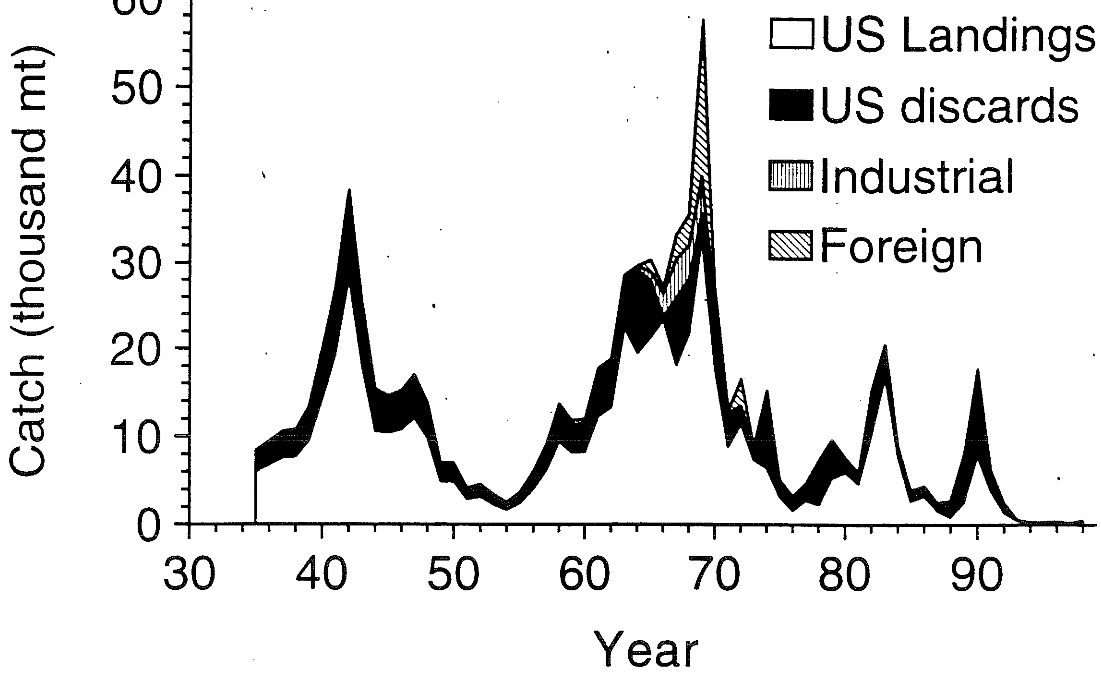

Figure D1. Total catch of southern New England yellowtail flounder.

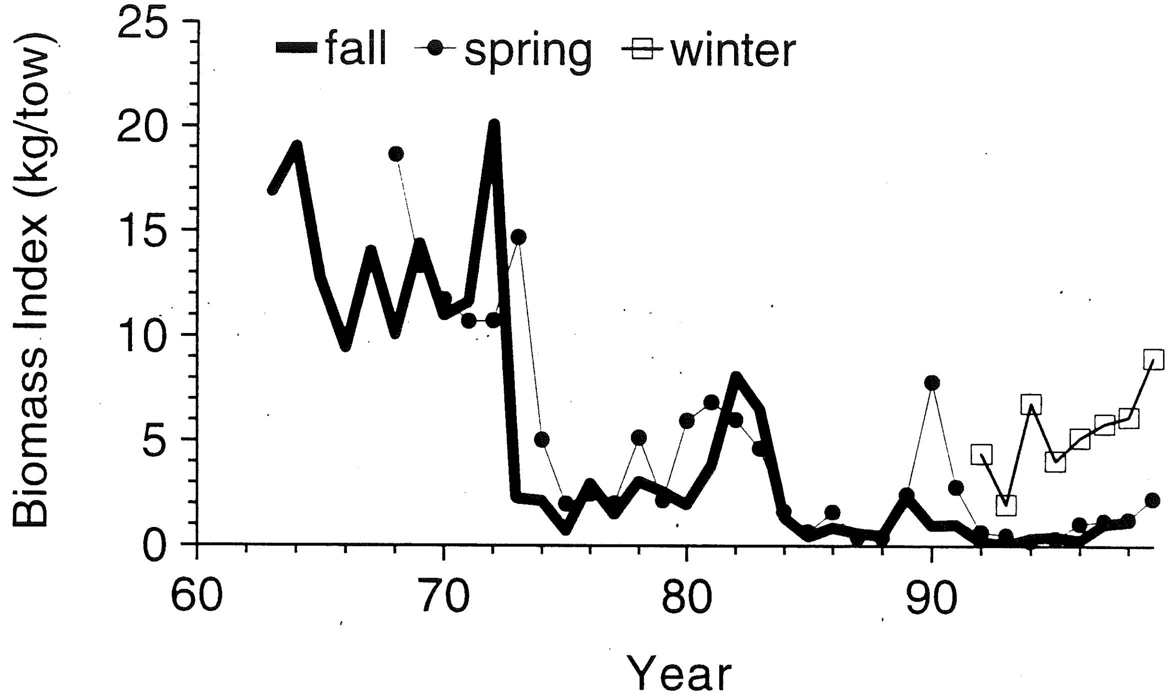

Figure D2. Survey indices of southern New England yellowtail flounder biomass.

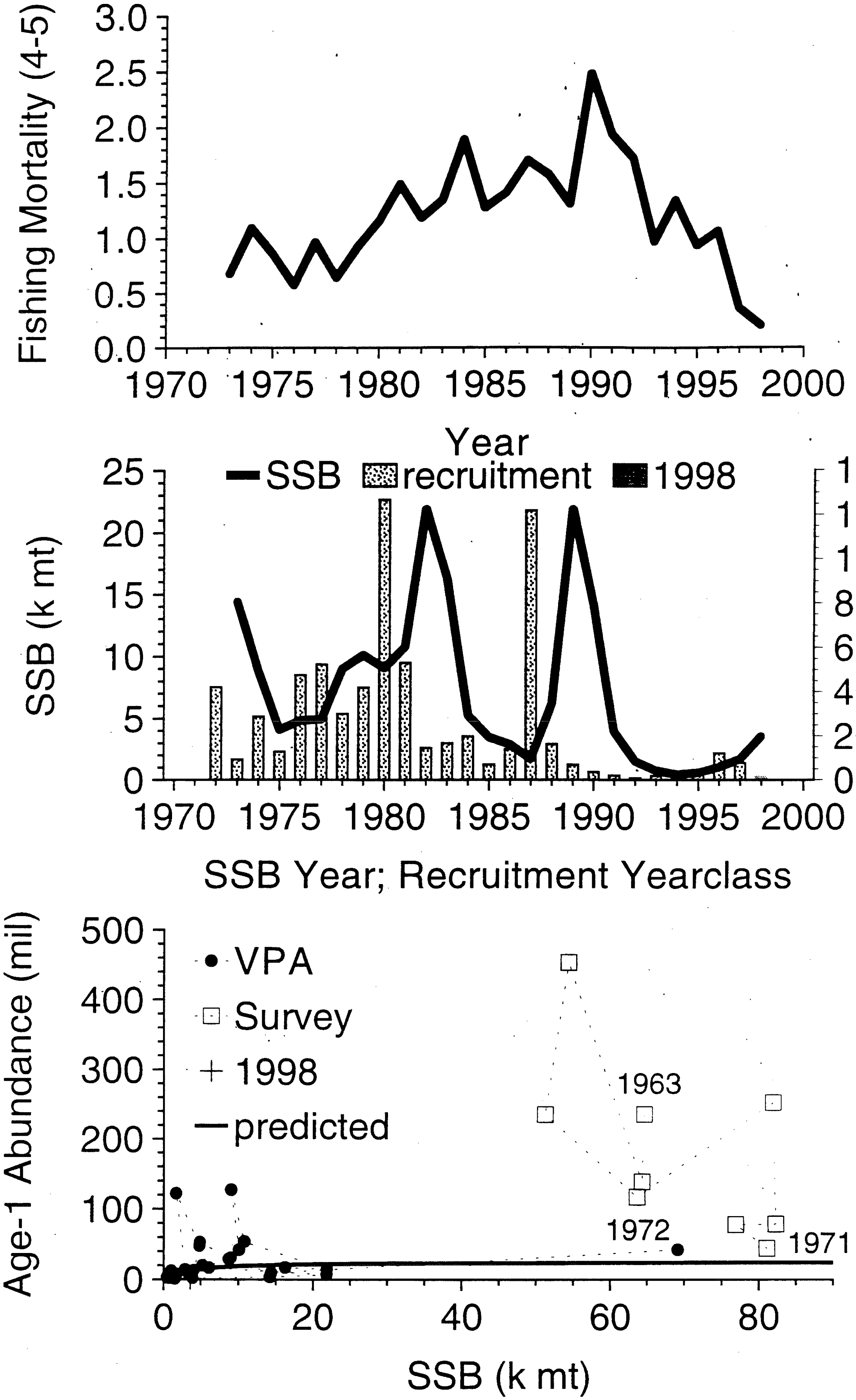

Figure D3. Summary of southern New England yellowtail VPA results.

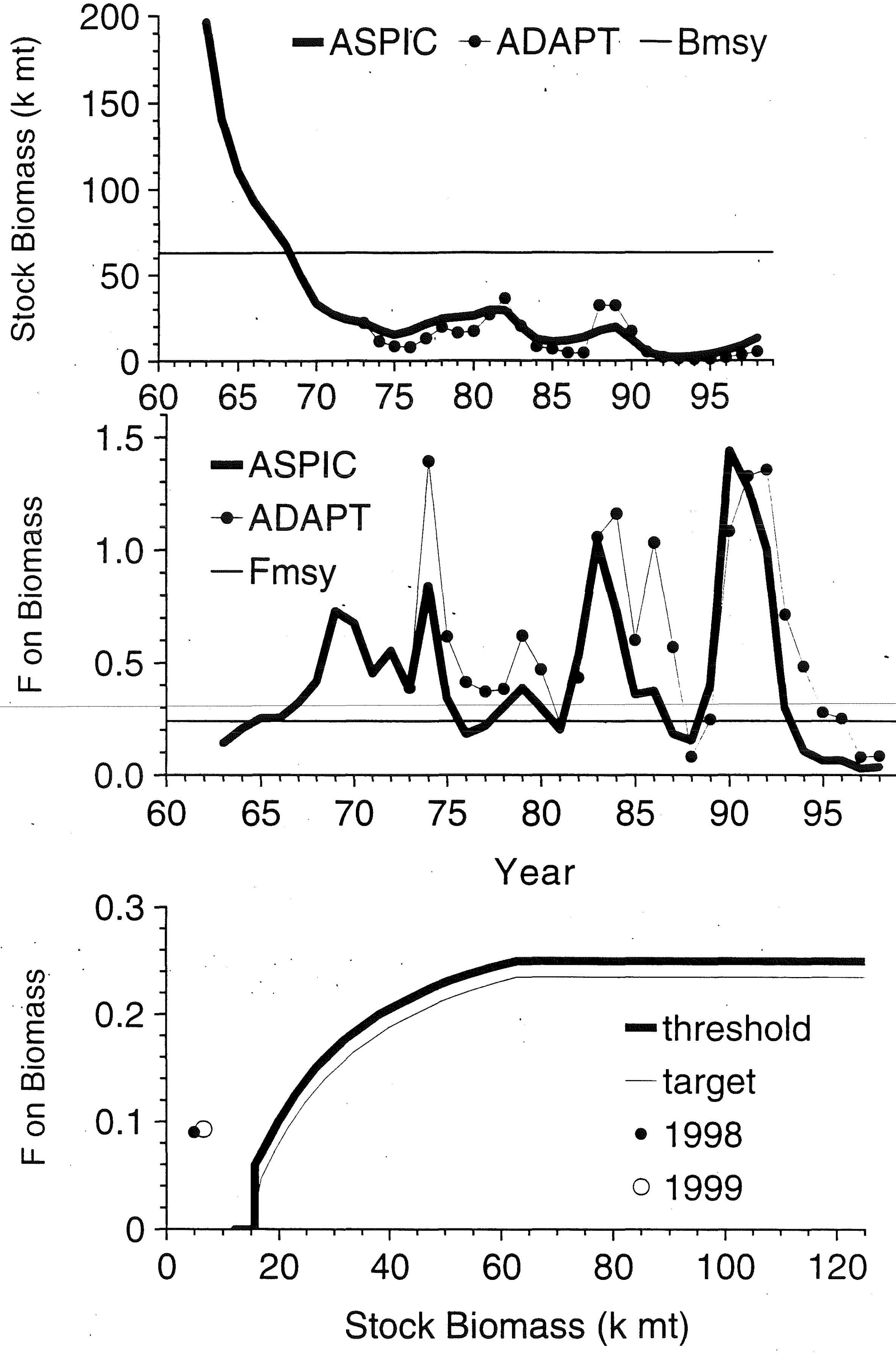

Figure D4. Status of the southern New England yellowtail flounder stock.

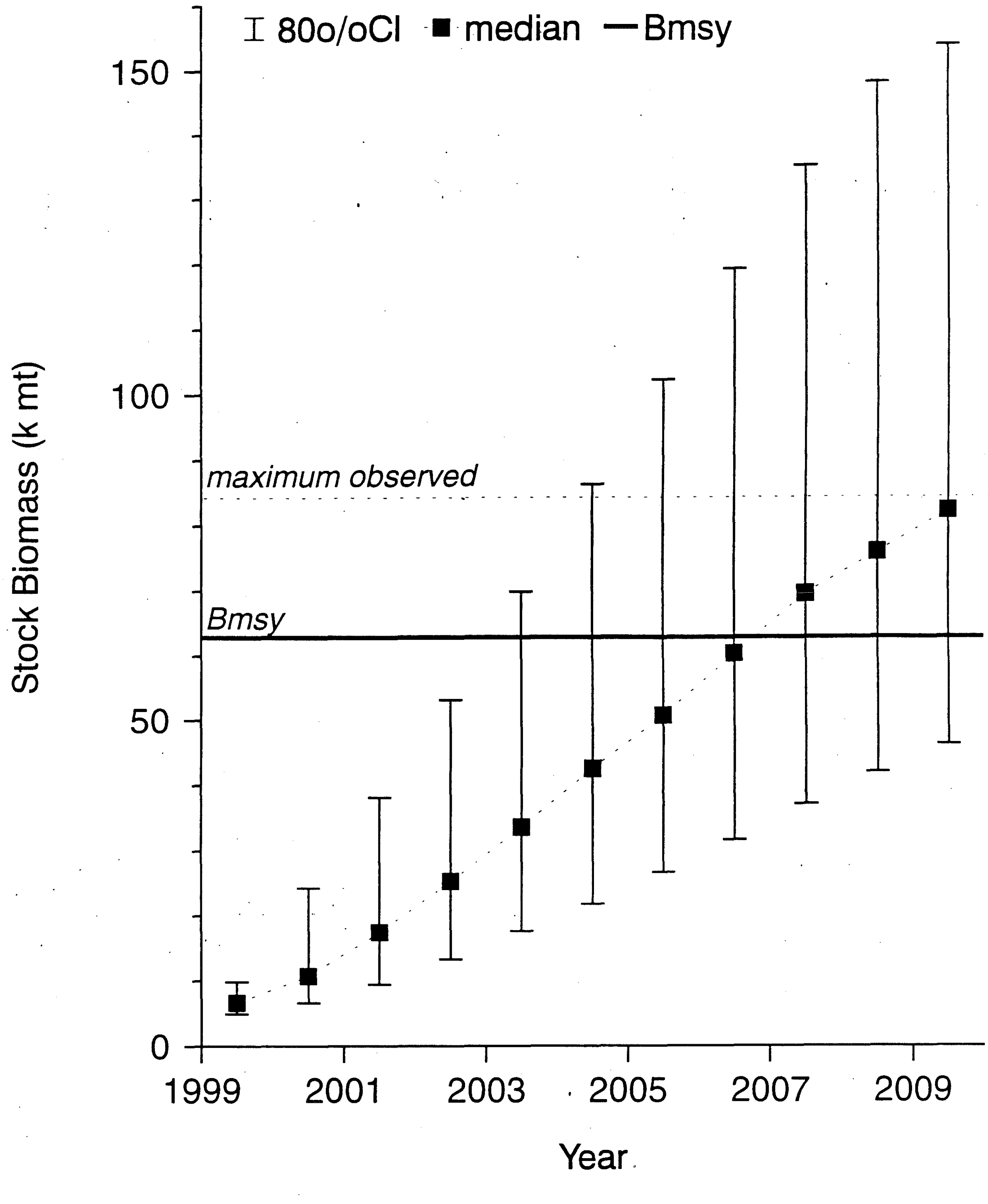

Figure D5. Projection ofsouthern New England yellowtail flounder biomass at the Amendment #9 long-term fishing target in 2000-2009.

E. Cape Cod Yellowtail Flounder by S.X. Cadrin

1.0 Background

The Cape Cod yellowtail flounder stock was at a medium biomass (44% of B_{MSY}) and was overexploited (fully recruited F was 1.01) in 1997 (Cadrin et al. 1999). This report updates catch and survey indices, updates estimates of stock size and fishing mortality and evaluates medium-term projections.

2.0 1999 Assessment

2.1 1998 Landings

U.S. landings were prorated as described in Cadrin et al. (1999; Table E1; Figure E1). Landings from the Cape Cod stock increased 12%, and Mid-Atlantic landings decreased by 60%.

Sampling intensity of landings in 1998 was poor. The large market category from the Cape Cod grounds, which comprised nearly half of the stock's landings, was entirely unsampled. Landings at length were estimated by half year categorized as unclassified. Landings at age and mean weights at age are reported in Table E2.

2.2 1998 Discards

Discarded catch was estimated from logbook information on discard to kept ratios by half-year and gear (NEFSC 1998; Table E4). However, discards of Cape Cod yellowtail are substantially less than those estimated in recent years, presumably because previous estimates were based on observer data by fishery. Therefore, the level of discards for Cape Cod yellowtail may be underestimated and should be considered preliminary. Discards at age were estimated from sea sampled lengths and pooled commercial-survey age-length keys. Discards at age and recent mean weights at age are reported in Table E3.

2.3 1998-1999 Survey Indices

Survey abundance and biomass indices are reported in Table E4. Estimates are from valid tows on the Cape Cod grounds (offshore strata 25, 26; inshore strata 56-66; Massachusetts strata 17-36) standardized according to net, vessel, and door changes (NEFSC 1998). Relative change in survey indices of Cape Cod yellowtail were equivocal (Figure E2).

3.0 Assessment Results

3.1 Age-Based Analysis

An updated VPA calibration of Cape Cod yellowtail is summarized in Table E5. This analysis updates the assessment reported in Cadrin and King (1999) by including 1998 landings and provisional discards, 1998 fall indices, and 1999 spring indices (the provisional Massachusetts age-1 index is based on observed lengths). Results indicate that F decreased (F_{4-5} = 0.41) and biomass increased in 1998 (2,000 mt of spawning biomass and 3,000 mt of mean total biomass; Figures 3 and 4). Retrospective analysis indicates a tendency toward underestimating F in the most recent years, but the pattern does not persist further back in time. Bootstrap analysis indicates that abundance was estimated with with moderate precision (CV=31-40%).

4.0 Forecasts

Stochastic projections were performed using bootstrap distributions of January 1, 1999 stock abundance at age, assuming F in 1999 was equal to F in 1998, and F in 2000-2009 were from the Amendment 9 control rule targets. Age-1 abundance in 1999 was estimated from multiple survey indices in the terminal year. Recruitment in subsequent years was estimated from Beverton-Holt stock-recruitment relationships estimated from VPA estimates (Overholtz and Brodziak 1999). Mean weight at age, exploitation pattern, and proportion discard at age was assumed to be equal to the 1994-1998 average.

Projection of the Cape Cod stock suggests that at status quo F in 1999, the stock increases to greater than 25% B_{MSY} (Table E6; Figure E5). At the rebuilding target, the stock is projected to grow to greater than B_{MSY} within ten years (greater than 6,100 mt total biomass after 2001).

5.0 Sources of Uncertainty

- Estimates of catch at age may not be reliable due to poor sampling intensity. Therefore VPA and age-based projections may be misleading. Extreme estimates of mean weights (e.g. ages 2-3), odd exploitation patterns, and retrospective patterns may indicate inadequate sampling and mis-allocation of catch at age.
- Retrospective patterns indicate that VPA estimates of biomass and F may be overly optimistic. Updated VPAs may indicate that 1998 biomass levels are lower, and 1998 F was greater than reported here.
- Stock-recruit observations used to derive the relationships assumed in long-term projections are limited to a short time series of relatively low stock sizes. Therefore, long-term forecasts at relatively high stock sizes may be substantially biased.
- Estimates of prorated landings and discard ratios are based on preliminary logbook data and are subject to change.
- The magnitude of discards in 1998 are probably underestimated.

6.0 References

Cadrin, S., J. King, and L. Suslowicz. 1999. Status of the Cape Cod yellowtail flounder stock for 1998. NEFSC Ref. Doc. 99-04.

Overholtz, W. and J. Brodziak. 1999. Background stock-recruit data for eleven groundfish stocks. NEFSC NDS Working Paper No. 10.

Table E1. Landings of Cape Cod yellowtail flounder (mt).

	Landings (mt)	Discards (mt)	Percent Discard	Total (mt)
1960	1,500	500	32	2,000
1961	1,800	600	32	2,400
1962	1,900	600	32	2,500
1963	3,600	1,000	28	4,600
1964	1,851	600	32	2,451
1965	1,498	500	33	1,998
1966	1,808	300	17	2,108
1967	1,542	800	52	2,342
1968	1,569	600	38	2,169
1969	1,346	300	22	1,646
1970	1,185	400	34	1,585
1971	1,662	700	42	2,362
1972	1,364	300	22	1,664
1973	1,662	0	0	1,662
1974	2,054	200	10	2,254
1975	2,027	0	0	2,027
1976	3,587	100	3	3,687
1977	3,469	0	0	3,469
1978	3,683	400	11	4,083
1979	4,163	500	12	4,663
1980	5,106	600	12	5,706
1981	3,149	600	19	3,749
1982	3,150	400	13	3,550
1983	1,884	300	16	2,184
1984	1,121	20	2	1,141
1985	967	77	8	1,044
1986	1,041	305	29	1,346
1987	1,159	198	17	1,357
1988	1,085	283	26	1,368
1989	909	390	43	1,299
1990	2,984	1,141	38	4,125
1991	1,472	405	28	1,877
1992	828	637	77	1,465
1993	628	90	14	718
1994	978	192	20	1,170
1995	1,207	233	19	1,440
1996	1,064	182	17	1,246
1997	1,040	257	25	1,297
1998	1,169	75	6	1,244
mean	1,903	379	23	2,284

Table E2. Landings at age (above) and mean weight at age (below) of Cape Cod yellowtail flounder.

Landings at age (thousands)				age				
	1	2	3	4	5	6	7	8+
1985	5	738	700	522	268	89	3	7
1986	0	1,998	579	223	32	6	0	1
1987	0	609	1,786	268	100	29	12	5
1988	1	802	1,043	625	172	36	0	0
1989	0	726	989	231	31	3	2	2
1990	0	692	6,191	416	32	16	7	3
1991	0	311	903	1,455	249	33	27	1
1992	0	338	807	514	150	6	5	1
1993	0	25	684	573	90	24	15	7
1994	0	87	1,023	650	236	65	38	9
1995	0	233	1,730	808	152	78	5	0
1996	0	150	1,097	798	287	11	5	2
1997	0	481	1,086	702	160	13	0	1
1998	0	257	1,681	472	141	41	3	0
mean	0	532	1,450	590	150	32	9	3

Landed weight at age (kg)				age				
	1	2	3	4	5	6	7	8+
1985	0.19	0.32	0.37	0.49	0.60	0.73	1.20	1.39
1986	----	0.32	0.46	0.57	0.73	0.90	----	1.40
1987	----	0.31	0.42	0.55	0.65	0.81	1.03	1.18
1988	0.11	0.31	0.37	0.53	0.70	0.85	----	----
1989	----	0.38	0.45	0.65	0.92	1.41	1.24	1.24
1990	----	0.31	0.41	0.56	0.82	0.90	0.99	1.17
1991	----	0.35	0.39	0.54	0.74	0.99	1.06	1.01
1992	----	0.32	0.41	0.53	0.61	0.73	1.53	1.91
1993	----	0.31	0.38	0.43	0.74	0.95	1.01	1.17
1994	----	0.29	0.38	0.50	0.62	0.68	1.04	1.11
1995	----	0.35	0.36	0.43	0.61	0.78	1.11	----
1996	----	0.32	0.42	0.50	0.53	0.91	1.19	1.18
1997	----	0.39	0.41	0.47	0.57	0.78	1.30	1.31
1998	----	0.33	0.41	0.55	0.63	1.00	1.62	----
mean	0.15	0.33	0.40	0.52	0.68	0.89	1.19	1.28

Table E3. Discards at age (above) and mean weights at age (below) of Cape Cod yellowtail flounder.

Discards at age (thousands)				age			
	1	2	3	4	5	6	sum
1985	340	184	34	0	0	0	558
1986	79	1,657	75	26	0	0	1,837
1987	14	877	168	0	0	0	1,059
1988	360	1,328	177	0	0	0	1,864
1989	114	1,405	396	1	0	0	1,917
1990	81	2,047	2,501	19	0	0	4,648
1991	460	895	561	100	7	0	2,023
1992	1,688	3,543	731	29	3	0	5,994
1993	138	324	173	30	0	0	665
1994	60	383	279	49	4	1	776
1995	453	469	652	50	2	0	1,627
1996	7	397	327	94	11	0	837
1997	1	399	351	117	22	1	891
1998	8	39	171	29	6	0	255
mean	272	996	471	39	4	0	1,782

Discarded weight at age (kg)				age		
	1	2	3	4	5	6
1985	0.13	0.15	0.15			
1986	0.10	0.17	0.19	0.18		
1987	0.06	0.19	0.19			
1988	0.12	0.15	0.20			
1989	0.13	0.21	0.25	0.36		
1990	0.08	0.24	0.27	0.33		
1991	0.12	0.19	0.27	0.37	0.54	
1992	0.05	0.11	0.22	0.31	0.36	
1993	0.09	0.15	0.27	0.33	0.63	
1994	0.08	0.20	0.29	0.32	0.38	0.34
1995	0.07	0.16	0.23	0.33	0.48	
1996	0.04	0.15	0.28	0.36	0.50	
1997	0.03	0.21	0.29	0.39	0.54	0.65
1998	0.03	0.26	0.35	0.44	0.56	0.59
mean	0.08	0.18	0.25	0.34	0.50	0.53

Table E4a. Survey indices of Cape Cod yellowtail abundance and biomass.

NEFSC Fall Survey				age						
year	1	2	3	4	5	6	7	8+	sum	kg/tow
1979	7.87	8.02	2.41	0.60	0.11	0.03	0.00	0.00	19.04	5.34
1980	20.70	17.63	8.00	3.04	0.67	0.00	0.07	0.00	50.11	13.52
1981	6.34	9.64	1.74	0.45	0.29	0.00	0.00	0.00	18.46	4.11
1982	1.13	5.39	5.18	0.63	0.70	0.06	0.00	0.00	13.09	4.32
1983	0.66	0.88	0.55	0.04	0.00	0.00	0.00	0.00	2.13	0.49
1984	0.64	2.25	1.04	1.31	0.93	0.30	0.15	0.15	6.77	2.79
1985	9.03	3.48	2.65	0.40	0.00	0.00	0.00	0.00	15.56	3.25
1986	2.62	7.14	0.60	0.00	0.00	0.00	0.00	0.00	10.36	1.98
1987	1.08	2.60	0.91	0.11	0.09	0.00	0.00	0.00	4.79	1.12
1988	6.16	9.01	0.89	0.17	0.00	0.00	0.00	0.00	16.23	2.29
1989	3.53	11.39	4.19	0.74	0.00	0.00	0.00	0.14	19.99	4.70
1990	7.01	11.90	5.58	0.09	0.02	0.00	0.00	0.00	24.60	4.76
1991	3.57	3.33	2.88	0.59	0.00	0.00	0.00	0.00	10.37	2.34
1992	4.82	5.29	3.68	1.52	0.36	0.27	0.00	0.00	15.94	3.81
1993	8.76	8.60	1.01	0.15	0.00	0.00	0.00	0.00	18.52	2.15
1994	4.78	14.27	5.13	1.40	0.43	0.00	0.00	0.00	26.01	5.38
1995	1.18	1.64	1.57	0.34	0.08	0.00	0.00	0.00	4.81	1.49
1996	2.07	5.36	8.78	2.31	0.26	0.00	0.00	0.00	18.78	5.12
1997	2.07	4.79	5.45	2.46	1.33	0.23	0.00	0.00	16.33	4.63
1998	1.96	5.60	2.35	1.71	0.48	0.00	0.00	0.00	12.10	3.24
mean	4.80	6.91	3.23	0.90	0.29	0.04	0.01	0.01	16.20	3.84

NEFSC Spring Survey				age						
year	1	2	3	4	5	6	7	8+	sum	kg/tow
1979	0.55	0.71	1.33	0.85	0.04	0.03	0.00	0.00	3.51	1.20
1980	0.00	7.14	4.08	1.43	0.29	0.00	0.00	0.00	12.94	4.89
1981	0.10	6.30	4.27	0.93	1.06	0.51	0.66	0.00	13.83	4.41
1982	0.08	2.79	7.23	3.71	1.00	0.57	0.63	0.16	16.17	7.16
1983	2.36	6.33	5.09	2.09	0.22	0.15	0.00	0.00	16.24	4.78
1984	0.09	2.39	1.42	0.92	0.60	0.05	0.07	0.16	5.70	1.99
1985	0.13	1.86	1.81	0.43	0.25	0.10	0.00	0.00	4.58	1.37
1986	0.04	4.33	0.37	0.10	0.24	0.00	0.00	0.00	5.08	1.04
1987	0.15	3.44	5.15	0.84	1.30	1.31	1.52	0.74	14.45	7.14
1988	2.13	9.11	1.87	1.22	0.47	0.18	0.08	0.00	15.06	2.51
1989	0.53	6.33	3.88	0.35	0.17	0.00	0.00	0.00	11.26	1.93
1990	0.00	5.51	13.35	0.35	0.00	0.24	0.00	0.00	19.45	4.38
1991	0.96	8.23	5.67	1.80	0.42	0.00	0.11	0.00	17.19	3.76
1992	0.37	2.25	3.52	0.98	0.04	0.00	0.00	0.00	7.16	1.67
1993	0.15	1.51	1.75	0.87	0.00	0.00	0.00	0.00	4.28	0.93
1994	0.80	5.64	2.33	0.90	0.33	0.19	0.00	0.00	10.19	1.79
1995	0.32	2.10	7.33	4.74	0.46	0.11	0.00	0.00	15.06	3.68
1996	0.03	0.85	1.18	0.63	0.00	0.00	0.00	0.00	2.69	0.62
1997	0.05	1.98	3.15	2.54	0.56	0.00	0.00	0.00	8.28	2.43
1998	0.00	1.71	5.03	1.83	0.42	0.00	0.00	0.00	8.98	2.32
1999	0.04	1.57	5.05	3.61	0.70	0.26	0.00	0.00	11.24	3.65
mean	0.42	3.91	4.04	1.48	0.41	0.18	0.15	0.05	10.64	3.03

Table E4b. Survey indices of Cape Cod yellowtail abundance and biomass.

MADMF Fall Survey

	age										
year	0	1	2	3	4	5	6	7	8+	sum	kg/tow
1978	0.04	7.13	7.74	1.45	0.11	0.00	0.01	0.00	0.00	16.48	2.80
1979	0.03	24.11	22.82	1.78	0.06	0.00	0.00	0.00	0.00	48.80	7.33
1980	0.03	26.54	12.38	2.70	0.35	0.00	0.00	0.00	0.00	42.00	5.90
1981	0.00	2.93	6.54	1.54	0.23	0.17	0.00	0.00	0.00	11.41	2.76
1982	0.00	9.58	3.36	5.54	0.30	0.08	0.00	0.00	0.00	18.86	4.20
1983	0.00	9.68	6.68	1.60	0.13	0.00	0.00	0.00	0.00	18.09	3.39
1984	0.04	1.91	3.00	0.86	0.39	0.10	0.02	0.00	0.04	6.37	1.18
1985	0.04	5.70	1.63	1.03	0.00	0.00	0.00	0.00	0.02	8.42	1.17
1986	0.01	2.60	4.95	0.20	0.03	0.01	0.00	0.00	0.00	7.80	1.36
1987	0.44	5.85	2.30	0.49	0.07	0.02	0.00	0.00	0.00	9.17	1.09
1988	0.00	8.96	11.24	2.27	0.15	0.00	0.00	0.00	0.00	22.62	3.71
1989	0.00	2.64	5.22	0.96	0.10	0.00	0.00	0.00	0.00	8.92	1.52
1990	0.00	5.20	11.93	4.84	0.01	0.00	0.00	0.00	0.00	21.98	4.16
1991	0.00	3.76	5.14	5.03	0.86	0.00	0.00	0.00	0.00	14.78	3.23
1992	0.20	7.18	3.62	2.08	0.47	0.20	0.00	0.00	0.00	13.75	2.00
1993	0.00	8.39	7.29	5.80	1.43	0.00	0.00	0.00	0.00	22.91	3.99
1994	0.00	3.56	8.39	3.06	0.96	0.12	0.00	0.00	0.00	16.09	3.27
1995	0.00	11.54	11.97	4.71	1.18	0.00	0.00	0.00	0.00	29.40	5.75
1996	0.01	1.87	3.94	2.18	0.17	0.00	0.00	0.00	0.00	8.17	1.56
1997	0.00	1.01	7.38	1.14	0.16	0.10	0.00	0.00	0.00	9.79	2.10
1998	0.00	7.05	7.44	1.56	0.00	0.00	0.00	0.00	0.00	16.05	2.68
mean	0.04	7.51	7.38	2.46	0.36	0.04	0.00	0.00	0.00	17.79	3.12

MADMF Spring Survey

	age									
year	1	2	3	4	5	6	7	8+	sum	kg/tow
1978	2.71	20.69	11.82	1.60	0.63	0.54	0.10	0.13	38.22	10.16
1979	2.63	22.58	13.85	3.68	0.86	0.00	0.17	0.00	43.77	11.38
1980	2.68	17.62	10.10	2.30	0.15	0.00	0.00	0.00	32.85	10.03
1981	5.61	58.83	9.00	2.26	1.59	0.27	0.00	0.00	77.56	16.35
1982	0.69	17.06	17.04	4.45	0.94	0.06	0.04	0.00	40.28	12.85
1983	3.13	8.50	11.51	4.28	0.04	0.17	0.03	0.00	27.66	9.00
1984	0.57	15.38	8.17	3.51	1.48	0.04	0.06	0.04	29.26	7.37
1985	1.97	8.27	7.15	1.52	0.59	0.39	0.05	0.05	19.99	5.21
1986	1.73	15.39	1.74	0.24	0.21	0.04	0.00	0.00	19.36	4.52
1987	2.53	4.95	5.31	0.97	0.27	0.11	0.08	0.00	14.22	3.67
1988	3.10	14.46	2.52	0.60	0.05	0.02	0.00	0.00	20.74	3.83
1989	0.67	22.26	3.18	1.08	0.06	0.00	0.00	0.00	27.25	4.73
1990	0.63	11.77	15.57	0.63	0.14	0.01	0.02	0.01	28.77	6.60
1991	0.06	5.34	3.31	2.15	0.48	0.12	0.05	0.00	11.50	3.32
1992	1.30	11.03	9.71	2.38	1.45	0.03	0.03	0.00	25.94	6.54
1993	0.63	7.99	6.31	1.94	0.23	0.06	0.20	0.03	17.38	4.60
1994	2.67	24.02	7.53	1.49	0.33	0.12	0.00	0.00	36.15	6.23
1995	7.51	14.64	24.96	2.88	1.20	0.02	0.02	0.00	51.22	10.38
1996	1.17	18.03	14.70	6.78	1.74	0.00	0.04	0.00	42.46	9.25
1997	0.52	16.94	12.22	4.04	0.54	0.00	0.00	0.00	34.26	7.55
1998	0.55	4.96	13.50	1.24	0.18	0.03	0.00	0.00	20.46	5.17
1999*	0.19								18.59	5.05
mean	2.05	16.22	9.96	2.38	0.63	0.10	0.04	0.01	31.40	7.56

* preliminary, based on unaudited data.

Table E5a. Estimates of abundance at age of Cape Cod yellowtail flounder.

STOCK NUMBERS (Jan 1) in thousands - C:\Program Files\WHAT\ccyt99.5

	1985	1986	1987	1988	1989	1990	1991
1	9891	4712	6755	21229	7698	6285	9157
2	2702	7787	3787	5518	17054	6200	5072
3	1443	1378	3068	1756	2590	12035	2598
4	657	517	536	744	334	868	1988
5	326	65	197	196	43	63	317
6	116	14	89	39	11	50	73
1+	15133	14473	14432	29482	27731	25500	19205

	1992	1993	1994	1995	1996	1997	1998
1	7216	7237	6079	6584	6864	4392	4716
2	7080	4381	5800	4923	4981	5614	3595
3	3062	2285	3271	4322	3395	3583	3800
4	803	1115	1096	1501	1384	1490	1633
5	221	166	368	265	452	326	479
6	17	82	170	140	27	25	149
1+	18398	15266	16783	17734	17103	15429	14372

	1999
1	00
2	3854
3	2676
4	1435
5	884
6	340
1+	9189

Table E5b. Estimates of fishing mortality at age of Cape Cod yellowtail flounder.

FISHING MORTALITY - C:\Program Files\WHAT\ccyt99.5

	1985	1986	1987	1988	1989	1990	1991
1	0.04	0.02	0.00	0.02	0.02	0.01	0.06
2	0.47	0.73	0.57	0.56	0.15	0.67	0.30
3	0.83	0.74	1.22	1.46	0.89	1.60	0.97
4	2.11	0.76	0.80	2.64	1.47	0.81	2.00
5	2.40	0.78	0.82	3.43	1.56	0.83	2.24
6	2.40	0.78	0.82	3.43	1.56	0.83	2.24

	1992	1993	1994	1995	1996	1997	1998
1	0.30	0.02	0.01	0.08	0.00	0.00	0.00
2	0.93	0.09	0.09	0.17	0.13	0.19	0.10
3	0.81	0.54	0.58	0.94	0.62	0.59	0.77
4	1.38	0.91	1.22	1.00	1.25	0.93	0.41
5	1.45	0.93	1.27	1.03	1.30	0.96	0.41
6	1.45	0.93	1.27	1.03	1.30	0.96	0.41

Average F for 4,5

	1985	1986	1987	1988	1989	1990	1991
4,5	2.25	0.77	0.81	3.03	1.52	0.82	2.12

	1992	1993	1994	1995	1996	1997	1998
4,5	1.41	0.92	1.25	1.02	1.27	0.95	0.41

Biomass Weighted F

1985	1986	1987	1988	1989	1990	1991
0.48	0.61	0.72	0.40	0.24	1.09	0.66

1992	1993	1994	1995	1996	1997	1998
0.86	0.35	0.41	0.56	0.53	0.44	0.41

Table E5c. Estimates of mean biomass and spawning biomass of Cape Cod yellowtail flounder.

MEAN BIOMASS (using catch mean weights at age)

	1985	1986	1987	1988	1989	1990	1991
1	1144	423	367	2288	900	453	969
2	551	1267	634	813	3888	1077	916
3	325	383	656	291	614	2065	520
4	126	176	186	131	106	301	426
5	70	30	80	37	19	32	87
6	33	09	51	09	07	30	28
1+	2247	2288	1974	3569	5533	3957	2945

	1992	1993	1994	1995	1996	1997	1998
1	284	584	439	402	249	119	128
2	551	608	1106	905	806	1441	996
3	617	583	818	851	902	943	996
4	210	290	287	367	358	410	659
5	66	73	119	93	124	110	226
6	10	49	74	64	14	12	116
1+	1737	2187	2841	2682	2454	3035	3120

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

	1985	1986	1987	1988	1989	1990	1991
1	00	00	00	00	00	00	00
2	46	106	53	68	319	93	76
3	275	324	551	243	519	1705	439
4	123	183	194	121	108	205	422
5	66	32	84	30	19	33	84
6	31	09	53	07	07	32	27
1+	541	654	935	469	972	2068	1048

	1992	1993	1994	1995	1996	1997	1998
1	00	00	00	00	00	00	00
2	46	50	94	91	66	118	84
3	521	491	690	698	762	795	842
4	217	302	297	328	364	418	620
5	68	77	124	95	128	112	234
6	10	51	76	67	15	12	122
1+	861	971	1281	1279	1334	1457	1901

Table E6. Summary of results from stochastic projections of Cape Cod yellowtail flounder.

INPUT ASSUMPTIONS

Age	1	2	3	4	5	6+
Stock Wt.	0.051	0.254	0.375	0.468	0.592	0.870
Landed Wt.	0.150	0.337	0.399	0.478	0.595	0.873
Discard Wt.	0.06	0.18	0.27	0.35	0.48	0.49
Maturity	0.00	0.08	0.81	1.00	1.00	1.00
PR	0.02	0.13	0.68	1.00	1.00	1.00
Discard	1.00	0.56	0.21	0.09	0.05	0.03

F-BASED PROJECTIONS

TIME-VARYING F

YEAR	F
1999	0.410
2000	0.070
2001	0.070
2002	0.070
2003	0.070
2004	0.070
2005	0.070
2006	0.070
2007	0.070
2008	0.070
2009	0.070

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1999	1.112	1.334	1.484	1.629	1.887	2.089	2.333	2.467	2.699
2000	1.669	1.874	1.964	2.278	2.525	2.879	3.330	3.522	3.773
2001	2.271	2.393	2.598	2.947	3.294	3.896	4.527	4.780	5.256
2002	3.080	3.444	3.672	4.100	4.682	5.403	6.124	6.561	7.822
2003	3.999	4.509	4.800	5.365	6.109	6.960	7.863	8.457	9.934
2004	4.865	5.414	5.758	6.421	7.279	8.264	9.252	9.944	11.571
2005	5.712	6.383	6.779	7.530	8.471	9.548	10.680	11.380	12.982
2006	6.490	7.187	7.619	8.438	9.425	10.552	11.731	12.490	14.031
2007	7.111	7.835	8.297	9.163	10.195	11.391	12.567	13.361	14.949
2008	7.623	8.432	8.890	9.772	10.853	12.098	13.319	14.160	15.762
2009	8.115	8.928	9.428	10.325	11.449	12.728	13.994	14.844	16.483

PERCENTILES OF MEAN STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1999	2.468	2.651	2.830	3.262	3.640	4.241	4.803	5.065	5.589
2000	3.097	3.428	3.662	4.071	4.642	5.366	6.143	6.549	7.627
2001	4.172	4.688	4.981	5.566	6.321	7.195	8.087	8.739	10.341
2002	5.312	5.924	6.284	6.989	7.890	8.904	9.938	10.649	12.332
2003	6.408	7.084	7.509	8.311	9.315	10.449	11.617	12.391	14.131
2004	7.258	8.047	8.521	9.403	10.495	11.736	13.020	13.859	15.658
2005	8.204	9.065	9.577	10.567	11.731	13.071	14.415	15.348	17.112
2006	9.031	9.924	10.467	11.505	12.750	14.188	15.571	16.523	18.350
2007	9.727	10.658	11.227	12.299	13.605	15.108	16.557	17.535	19.494
2008	10.280	11.328	11.937	13.014	14.368	15.879	17.412	18.467	20.331
2009	10.866	11.917	12.550	13.659	15.051	16.617	18.183	19.200	21.208

ANNUAL PROBABILITY THAT MEAN BIOMASS EXCEEDS THRESHOLD: 6.100 THOUSAND MT

YEAR	Pr(MEAN B > Threshold Value)
1999	0.005
2000	0.106
2001	0.573
2002	0.929
2003	0.996
2004	1.000
2005	1.000
2006	1.000
2007	1.000
2008	1.000
2009	1.000

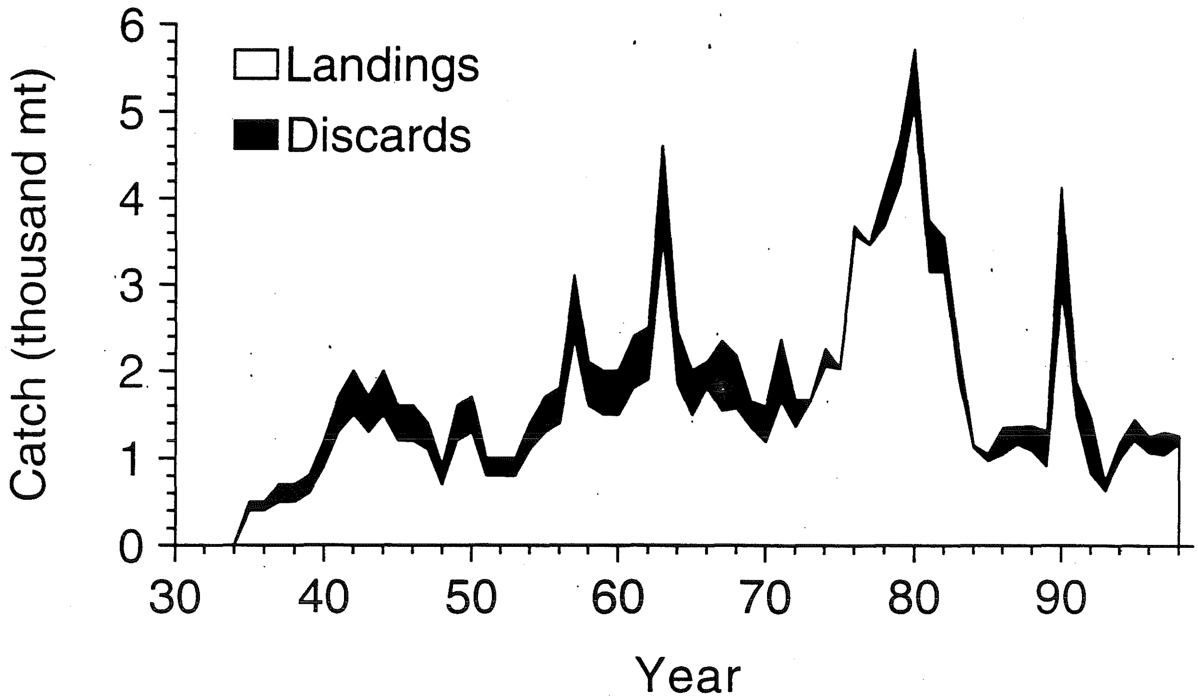

Figure E1. Total catch of Cape Cod yellowtail flounder.

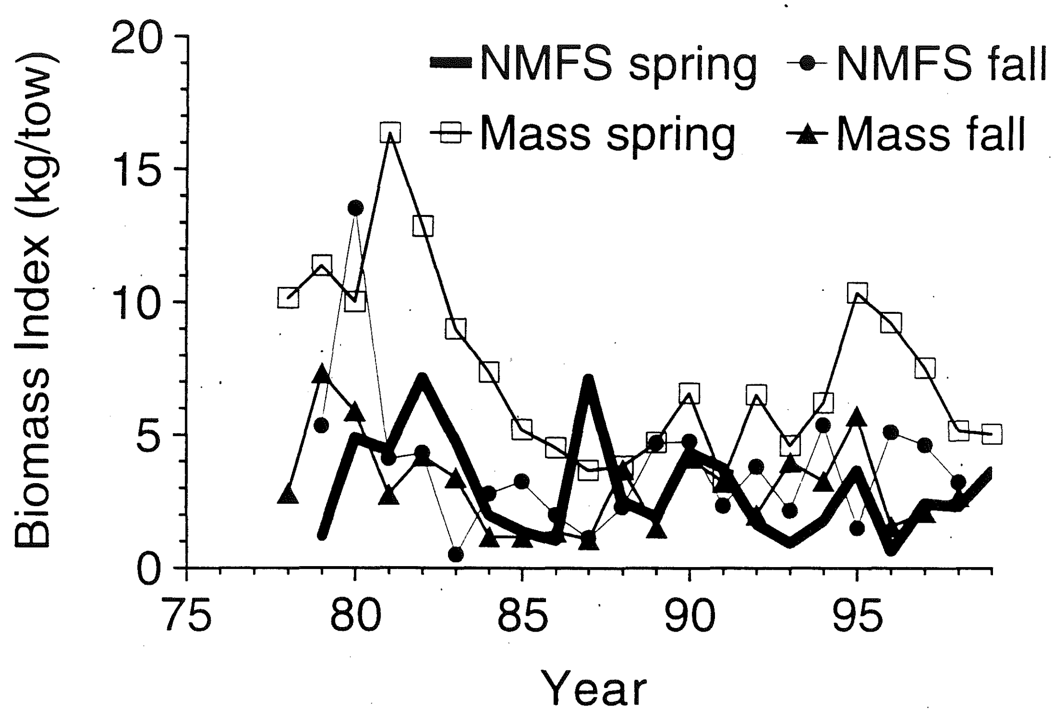

Figure E2. Survey indices of Cape Cod yellowtail flounder biomass.

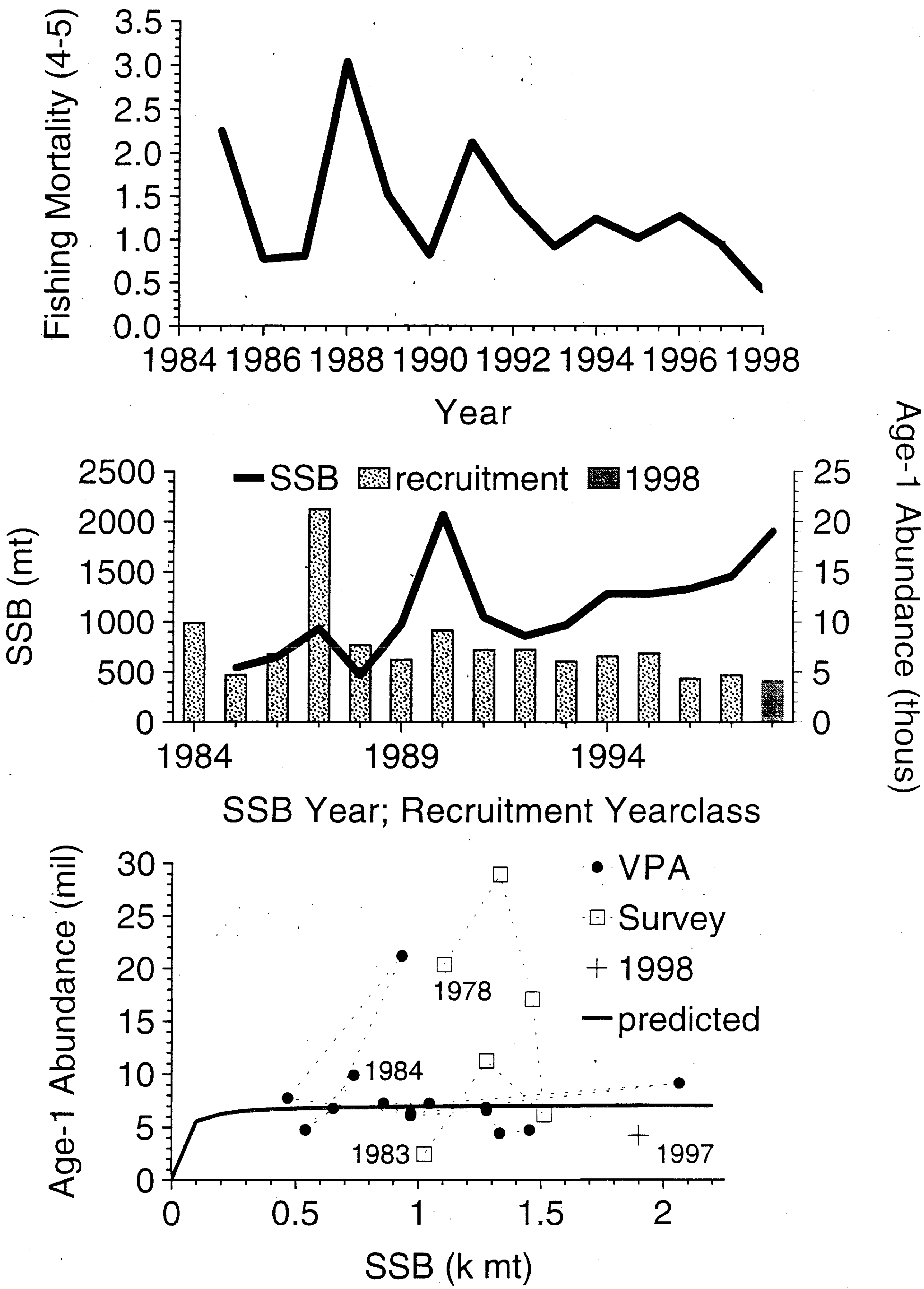

Figure E3. Summary of Cape Cod yellowtail VPA results.

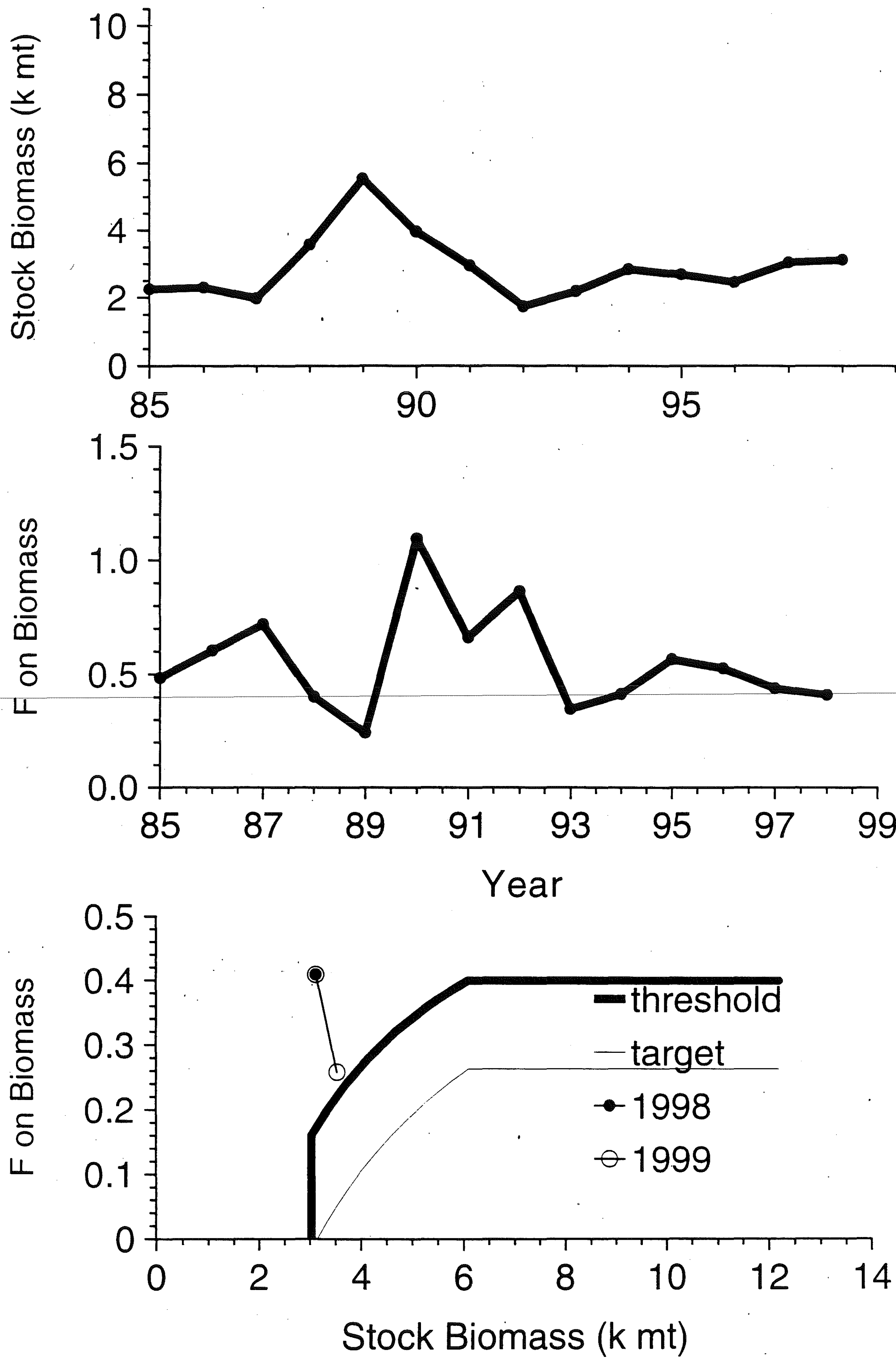

Figure E4. Status of the Cape Cod yellowtail flounder stock.

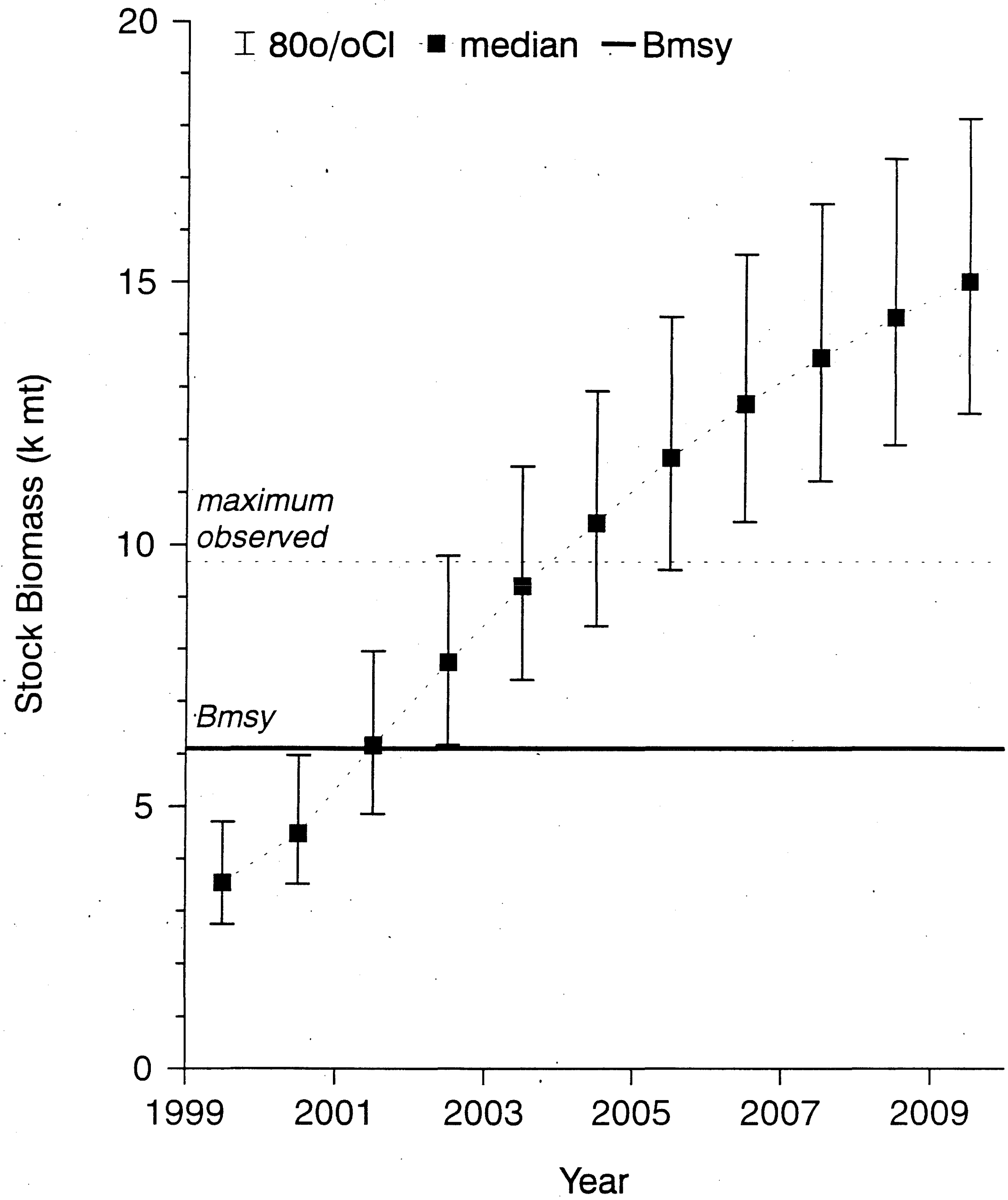

Figure E5. Projection of Cape Cod yellowtail flounder biomass at the Amendment #9 long-term fishing target in 2000-2009.

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

1.0 Background

The Gulf of Maine cod stock was last assessed in 1998, and the assessment was reviewed at SAW 27. At that time, fully recruited fishing mortality (ages 4+) in 1997 was estimated to be 0.75, a decline from an average of 1.0 in 1995 and 1996. Spawning stock biomass was estimated to have declined to 8,600 mt in 1997, a decline from a recent high of 14,300 mt in 1995. The strength of the most recent recruiting year classes was estimated to be very low. The 1994, 1995 and 1996 year classes were estimated to have been 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 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 1994 and 1993, respectively, and have only increased slightly since that time. 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.

2.0 1999 Assessment

Fishery

Commercial landings of Gulf of Maine cod declined to 4,156 metric tons (mt) in 1998, a 23 % decline from 1997 (Table F1; Figure F1). No discard estimates were derived for 1998. The estimated recreational catch of Gulf of Maine cod (retained component only) equaled 824 mt in 1998. The number of commercial port samples for this stock declined from 74 in 1997 to 46 in 1998. Sampling was not well distributed among quarters and market categories, requiring substantial pooling over quarter. Market cod samples were pooled on a semi-annual basis, and both Large and Scrod samples were pooled on an annual basis. As has generally been the case, the landings at age in 1998 were dominated by age 3 and 4 cod.

Input Data and Analyses

The present assessment represents a one-year update to the previous assessment (Mayo et al. 1998; NEFSC 1998). The same VPA formulation used in the previous assessment was employed in the present update, except for the addition of current year (1999) spring survey data. Catch at age data for 1998, and NEFSC and Mass. DMF survey abundance indices (stratified mean number per tow at age) were updated through spring 1999. As in the most recent VPA, commercial CPUE indices were included only through 1993.

Precision of the 1999 stock sizes and 1998 fishing mortality and SSB estimates was derived from 1000 bootstrap simulations of the 1999 VPA formulation. A retrospective analysis of terminal year estimates of stock sizes, fully recruited fishing mortality and SSB was carried out back to 1994.

3.0 Assessment Results

NEFSC research vessel bottom trawl survey abundance and biomass indices for Gulf of Maine cod remained relatively low through autumn 1998 and spring 1999 (Table F2; Figure F2). The autumn 1998 indices declined slightly from the 1997 levels, while the spring 1999 indices increased slightly from the 1998 levels, but remain no higher than indices observed in 1996 and 1997. Recruitment indices for the 1994-1997 year classes derived from the NEFSC and Commonwealth of Massachusetts bottom trawl surveys are among the lowest in the respective series, although an index for the 1998 year class appears to be above the recent average.

Fully recruited fishing mortality (ages 4+) in 1998 is estimated to be 0.64 (Table F3a), a decline from 0.75 in 1997, as reported in the previous assessment. However, the 1997 fully recruited F is now estimated to have been 0.85 (Table F3a; Figure F3). Spawning stock biomass is estimated at 8,300 mt in 1998, a decline from 9,900 mt in 1997 (Table F3b; Figure F4). The most recent high level of SSB (14,200 mt) occurred in 1995.

Recent recruiting year classes continue to be poor (Table F3a; Figure F3). The 1994, 1995 and 1996 year classes are still estimated to be the lowest in the VPA series dating back to 1982 (1980 year class), and the recruit/SSB survival ratios for these most recent year classes are also low compared to year classes prior to 1987. Biomass weighted fishing mortality (ages 1+) has declined slightly from 0.43 in 1997 to 0.36 in 1998 (Table F3d; Figure F3), and mean biomass (ages 1+) declined from 28,600 mt in 1991 to 11,800 mt in 1998 (Table F3c; Figure F4).

<u>VPA Diagnostics</u>

Estimates of 1999 stock sizes at age 2-6 were estimated with reasonable precision (C.Vs ranged from 27-39%). There were no outstanding residual patterns in the NEFSC Spring surveys, but the NEFSC Autumn survey residuals suggest that stock sizes at most ages were estimated by the VPA to be higher than indicated by the surveys. Accounting for the precision in the current assessment, there is a 90% probability that fully recruited F in 1998 was greater than 0.52, and that SSB in 1998 was less than 9,700 mt. There were substantial retrospective patterns in this assessment carrying back to 1994. Average fully recruited fishing mortality on ages 4 and 5 in the terminal year would have been consistently under-estimated since 1994, and recruitment at age 2 would have been under-estimated since 1996. No significant retrospective pattern was detected for SSB.

4.0 Forecasts

Forecasts of stock size and landings were performed over the short term (1999-2000) using stochastic projection software. Long-term (1982-1998) mean stock and catch weights, current (1995-1998) average partial recruitment and maturation at age were employed in all forecasts (Table F4).

1999 Results

In contrast to past analyses, forecasts included age 1 as recruits rather than age 2. This was done for consistency between the projected mean biomass and biomass-weighted F and the estimate of Bmsy and Fmsy incorporated in the SFA control rule. To accomplish this, it was necessary to estimate age 1 recruits in 1999 (1998 year class). NEFSC and Mass. DMF autumn surveys conducted in 1998 and and spring surveys conducted in 1999 provided some information on the strength of the 1998 year class. Abundance indices for the 1998 year class from these 4 surveys were included in a regression model to evaluate the degree to which age 0 and 1 survey indices could be used as a predictor of age 1 year class strength.

Results indicated statistically poor fits for all 4 surveys; no survey explained more than 26 % of the variation in the historical VPA estimates of age 1 recruitment, and the autumn age 0 surveys explained only 8% of the variation. It was therefore concluded that the survey indices at age 0 and 1 do not contain sufficient information to characterize the potential strength of the 1998 year class For this reason, the strength of the 1998 year class was determined in the same manner as described below for the first three years of the forecast.

Forecasts commenced using 1999 ages 1-7+ survivors as estimated by the 1000 bootstrapped VPA outcomes. Fully recruited fishing mortality in 1999 was assumed equal to that in 1998 (0.64, fully recruited), given that the 1999 annual catch is not directly controlled by current fishing regulations. SSB is estimated to have increased slightly from 8,300 mt in 1998 to 8,800 mt in 1999. Mean biomass (ages 1+) also increased slightly to 12,900 mt in 1999 from an estimated 11,800 mt in 1998.

2000-2009 Forecast

For 2000-2009, forecasts utilized a stochastic re-sampling scheme in which observed recruitment estimates derived from the VPA corresponding to the 1980-1996 year classes was used during the 10 years of the projection horizon. The re-sampling scheme was divided into 3 phases. In the first phase, recruitment for 2000 and 2001 was obtained by re-sampling only the most recent 4 estimates (1993-1996 year classes; GM recruitment = 2.5 million). In the second phase, recruitment for 2002 and 2005 was obtained by re-sampling the most recent 9 estimates (1988-1996 year classes; GM recruitment = 3.6 million. Finally, in the last phase, recruitment for 2006-2009 was derived by re-sampling all of the observed recruitment estimates (1980-1996 year classes; GM recruitment = 5.3 million).

The concept underlying this approach is that recruitment to be expected in the most recent years is more likely to be in accordance with the most recent observations when SSB and R/SSB was relatively low. As the forecast moves further away from the current period and SSB increases, the distribution of expected recruitment may be more similar to that observed over a longer period of the past. Thus, as SSB gradually increases, two step functions in the recruitment re-sampling allow higher recruitment values to be generated in the out years of the projections.

According to the SFA control rule for Gulf of Maine cod (Figure F5). 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. According to the 1999 assessment, mean biomass was estimated to be 12,969 mt in 1999, so a biomass-weighted fishing mortality rate (0.15; equals 0.22, fully recruited F), corresponding to this position on the control rule was applied throughout the 10-year forecast horizon. Biomass trajectories for the 2000-2009 period are given in Table F6 and Figure F6.

The medium-term forecasts suggest that under the control rule F scenario, B_{msy} may be achieved with at least a 50% probability in 2006, and at least a 90% probability in 2009.

5.0 Sources of Uncertainty

* Poor biological sampling in 1998.

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 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.

* Retrospective pattern inVPA.

Fully recruited F has been under-estimated since 1995. Recruitment has been under-estimated since 1994. Therefore, short-term projections are likely to be optimistic if fishing mortality is actually higher in 1998 than initially estimated. As well, the actual estimated recruitment at age 2 appears to have been underestimated in recent terminal years, although recruitment is still estimated to have declined substantially in recent years..

* Catch at Age

Leaving recreational and discards out of assessment especially if recreational catch becomes a greater percentage of total catch is a source of uncertainty. The SARC previously rejected putting in recreational catch because of very poor sampling of recreational catch. This should only be a scaling factor if age structure is the same.

6.0 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.

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.

Table F1.Commercial landings (metric tons, live) of Atlantic cod the Gulf of Maine (NAFO Division 5Y),1960 - 1998.

	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

* Provisional

USA 1960-1993 landings from NMFS, NEFSC Detailed Weighout Files and Canvass data.
USA 1994-1998 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 - 1998 [a,b]

	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		

[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 F3a. 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 - D:\ASSESS\gmcod\gmcod99\gmcod99.3.out

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	6162	5534	7746	4914	7410	9954	21648	3376	3391
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	31323	25560

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	5883	5309	8260	3090	2912	1983	2204	3490	0
2	2776	4817	4346	6763	2530	2384	1624	1805	2858
3	2077	1962	3660	3490	5511	1874	1893	1281	1393
4	8532	856	1127	1651	1938	3716	1006	1153	696
5	1334	3220	263	342	325	543	1469	430	454
6	277	323	811	98	20	91	131	450	203
7+	151	131	63	114	55	20	15	23	204
1+	21031	16617	18529	15549	13290	10611	8342	8633	5807

FISHING MORTALITY - D:\ASSESS\gmcod\gmcod99\gmcod99.3.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	0.60	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	1998
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.15	0.07	0.02	0.00	0.10	0.03	0.04	0.06
3	0.69	0.35	0.60	0.39	0.19	0.42	0.30	0.41
4	0.77	0.98	0.99	1.43	1.07	0.73	0.65	0.73
5	1.22	1.18	0.78	2.65	1.08	1.22	0.98	0.55
6	0.84	1.18	0.98	1.66	1.11	0.80	0.85	0.64
7+	0.84	1.18	0.98	1.66	1.11	0.80	0.85	0.64
Avg 4-5 u	1.00	1.08	0.89	2.04	1.08	0.98	0.82	0.64
Avg 4-5 w	0.83	1.14	0.95	1.64	1.07	0.79	0.85	0.68

Table F3b. 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	22585
2+	22456	17764	13585	15130	14347	14079	17091	26084	22295

Age	1991	1992	1993	1994	1995	1996	1997	1998
1	432	424	623	79	74	50	64	102
2	740	1514	1266	2836	1115	1074	741	704
3	1300	1476	3055	4463	7665	2824	3011	1960
4	12114	1174	1645	3042	3604	6731	2191	2521
5	3002	6598	713	626	1057	1364	3323	1347
6	1275	1142	2838	372	85	473	452	1435
7+	1451	1108	570	839	573	196	159	206
1+	20313	13438	10710	12258	14173	12711	9940	8275
2+	19881	13014	10087	12179	14099	12661	9876	8173

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	1998
1	11	11	11	4	4	4	4	4
2	28	28	28	38	38	38	38	38
3	56	56	56	89	89	89	89	89
4	81	81	81	99	99	99	99	99
5	93	93	93	100	100	100	100	100
6	98	98	98	100	100	100	100	100
7+	100	100	100	100	100	100	100	100

Table F3c. Estimates of Mean Stock Biomass (000s mt) for Gulf of Maine cod obtained from Virtual Population Analysis (VPA).

MEAN BIOMASS DURING THE CALENDAR YEAR

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	5013	4514	6317	4008	6044	8119	17658	2754	2766
2	8746	4788	4504	6987	4701	7081	9266	19827	2575
3	5090	7269	3938	3872	5877	4407	6729	9071	18830
4	4981	3186	5021	2490	2355	3869	3355	4604	5442
5	5582	2577	1528	2672	1067	997	1696	2025	2125
6	766	2849	1303	621	1014	437	360	416	1358
7+	4243	1685	1551	1137	905	770	410	708	1515
1+	34422	26868	24161	21786	21963	25680	39474	39404	34611
2+	29409	22354	17844	17778	15919	17561	21816	36650	31845

Age	1991	1992	1993	1994	1995	1996	1997	1998
1	4799	4330	6738	2521	2375	1618	1798	2847
2	2651	6457	5046	8867	3611	3592	2505	2030
3	2160	2894	4768	5126	8749	2981	3334	2004
4	13694	1363	1655	2571	3043	5753	2038	2235
5	2947	5347	728	390	944	1057	2751	1268
6	1258	875	2943	274	91	423	376	1282
7+	1072	757	408	519	397	146	117	160
1+	28580	22023	22285	20268	19210	15569	12919	11825
2+	23781	17693	15547	17747	16835	13951	11121	8978

Table F3d. Estimates of Biomass (000s mt) weighted F for Gulf of Maine cod obtained from Virtual Population Analysis (VPA).

BIOMASS WEIGHTED F DURING THE CALENDAR YEAR

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990
1+	0.398	0.525	0.454	0.496	0.447	0.298	0.204	0.266	0.442
2+	0.464	0.631	0.615	0.608	0.617	0.435	0.370	0.286	0.481
3+	0.584	0.746	0.782	0.956	0.867	0.702	0.628	0.599	0.515
4+	0.598	0.891	0.887	1.122	1.062	1.045	0.879	0.938	0.886
5+	0.578	0.918	0.953	1.106	1.087	1.195	1.123	0.906	0.891
6+	0.610	0.900	0.890	1.160	1.080	1.050	0.820	0.970	0.900
7+	0.610	0.900	0.890	1.160	1.080	1.050	0.820	0.970	0.900

Age	1991	1992	1993	1994	1995	1996	1997	1998
1+	0.629	0.501	0.379	0.396	0.356	0.469	0.429	0.355
2+	0.756	0.624	0.544	0.453	0.406	0.524	0.498	0.467
3+	0.832	0.942	0.795	0.904	0.490	0.695	0.631	0.586
4+	0.849	1.147	0.957	1.605	1.076	0.806	0.841	0.658
5+	1.052	1.180	0.944	1.986	1.090	1.073	0.960	0.598
6+	0.840	1.180	0.980	1.660	1.110	0.800	0.850	0.640
7+	0.840	1.180	0.980	1.660	1.110	0.800	0.850	0.640

Table F4. Input data used in medium-term forecasts for Gulf of Maine cod.

Age	Partial F	M	Maturation	Catch Mean Weights	Stock Mean Weights
1	0.000	0.2	0.040	0.900	0.900
2	0.061	0.2	0.380	1.355	1.090
3	0.373	0.2	0.890	1.842	1.561
4	0.924	0.2	0.990	2.748	2.244
5	1.000	0.2	1.000	4.153	3.404
6	1.000	0.2	1.000	6.202	5.068
7+	1.000	0.2	1.000	11.129	11.129

Table F5. Results of medium-term forecasts for Gulf of Maine cod.

Year	Median Mean Stock Biomass	Prob. of Exceeding Bmsy
1999	12.969	0.000
2000	14.280	0.000
2001	16.818	0.000
2002	19.089	0.000
2003	22.558	0.000
2004	26.307	0.024
2005	28.899	0.139
2006	31.268	0.346
2007	34.692	0.632
2008	38.340	0.829
2009	42.442	0.930

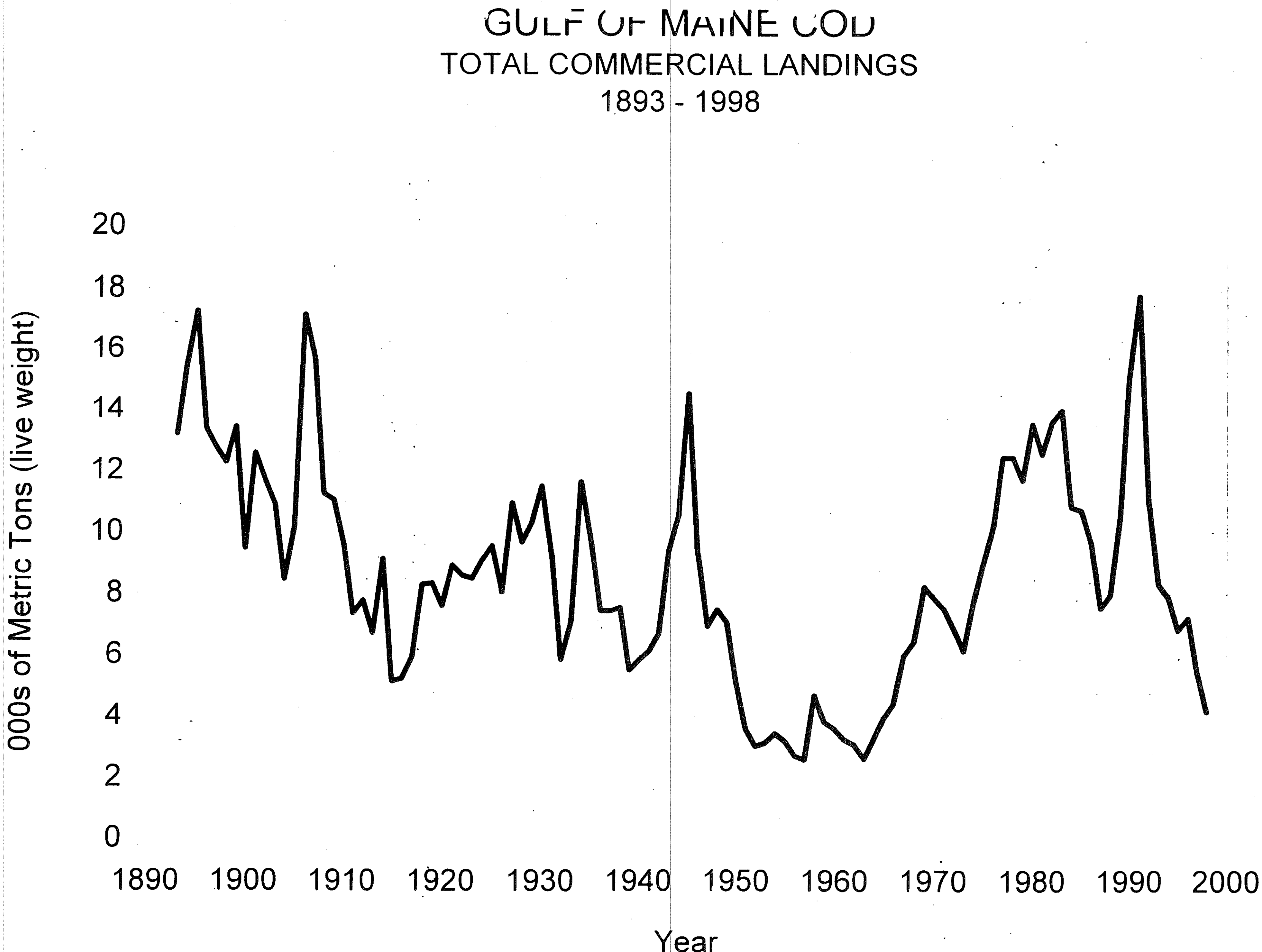

Figure F1. Total commercial landings of Gulf of Maine cod (NAFO Div. 5Y), 1893-1998.

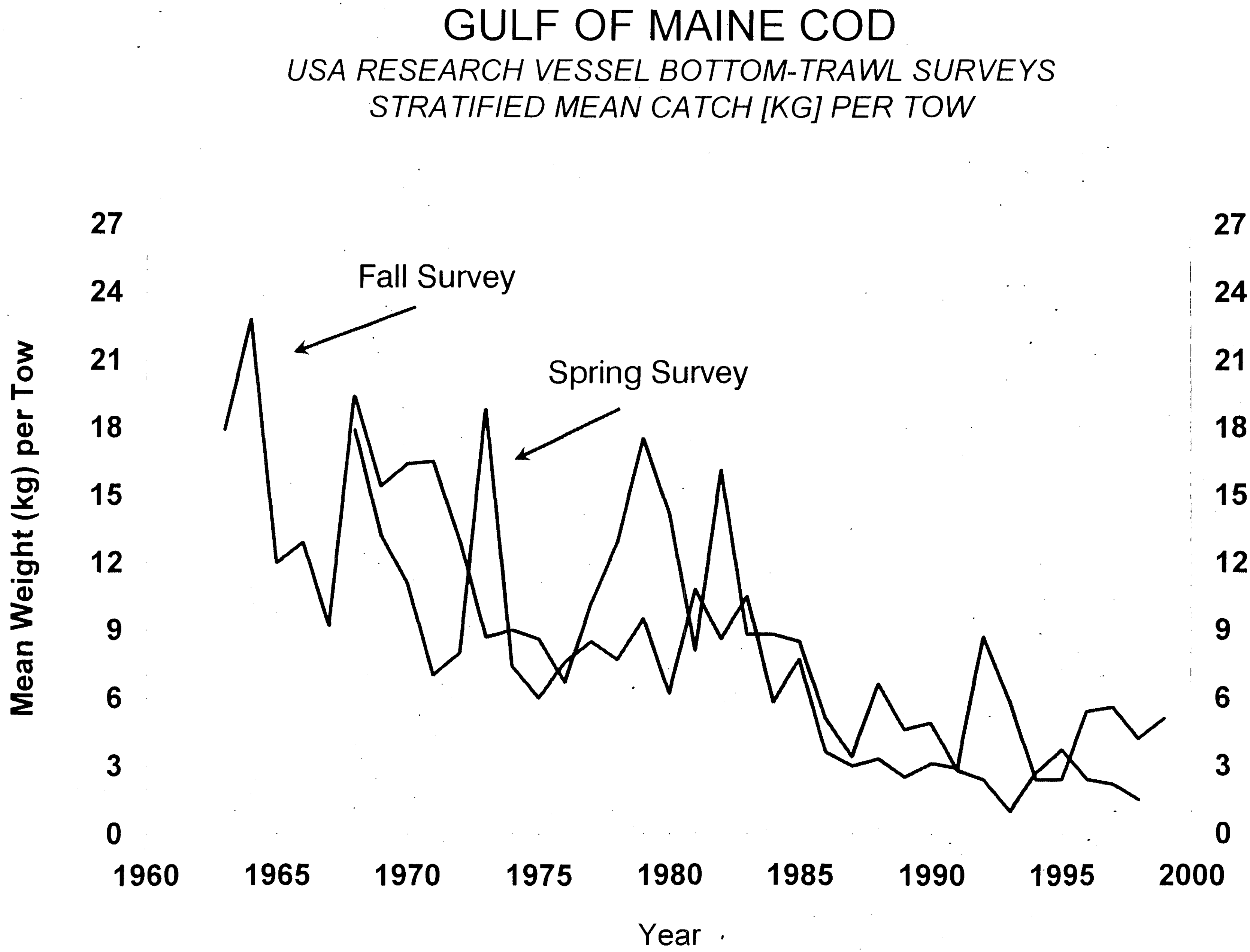

Figure F2. Standardized stratified mean catch (kg) per tow of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys in the Gulf of Maine, 1963-1999.

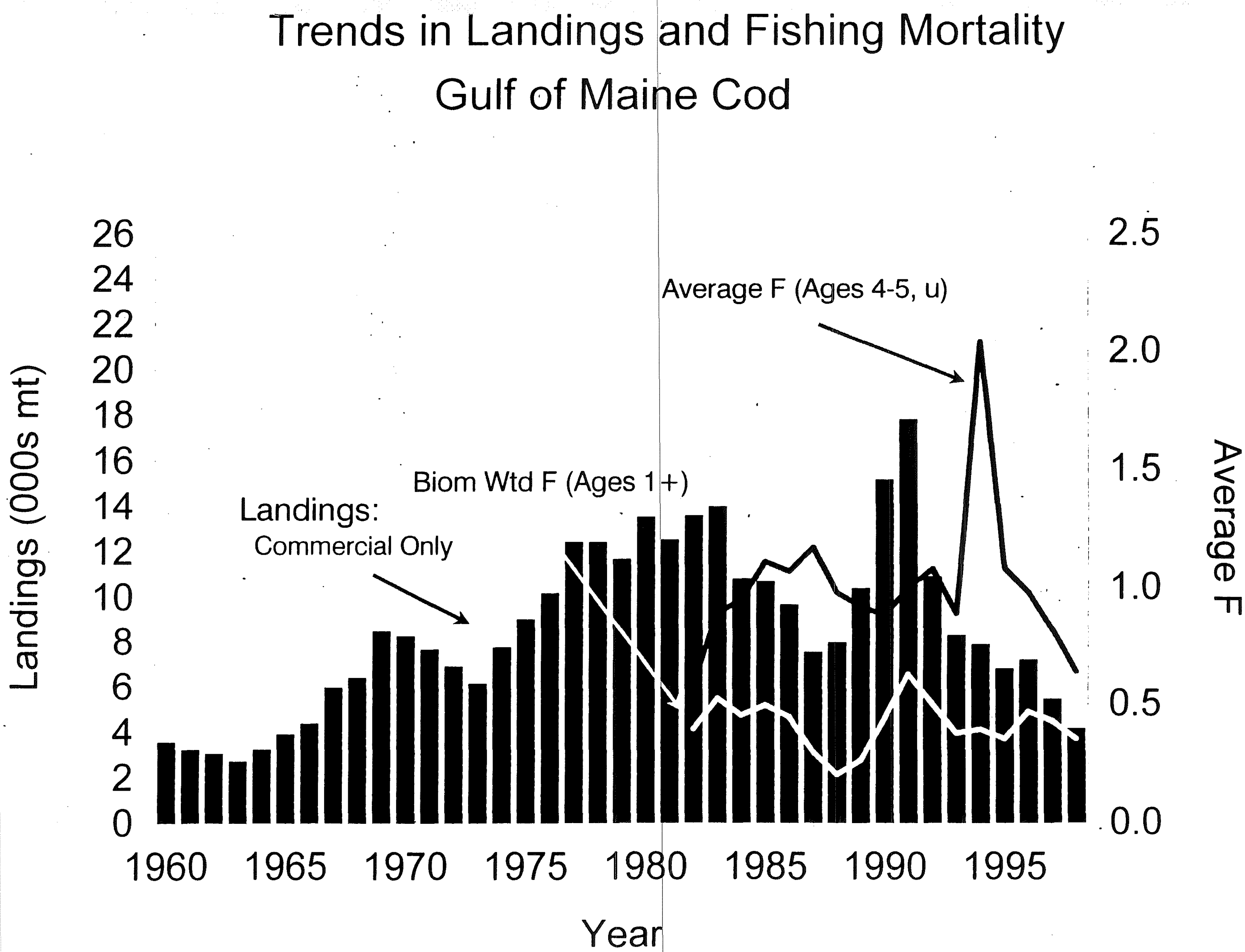

Figure F3. Trends in Landing and Fishing Mortality.

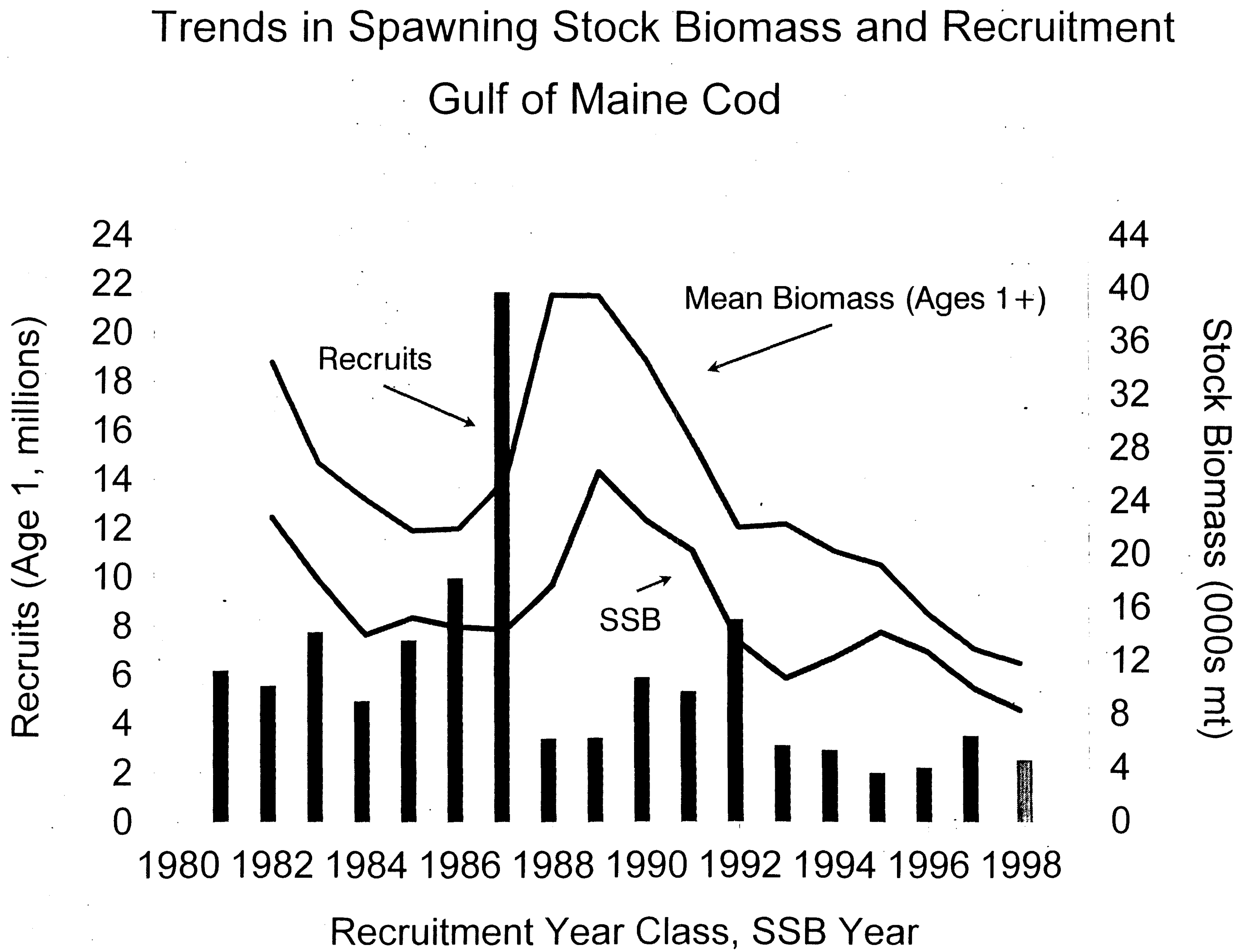

Figure F4. Trends in recruitment and stock biomass

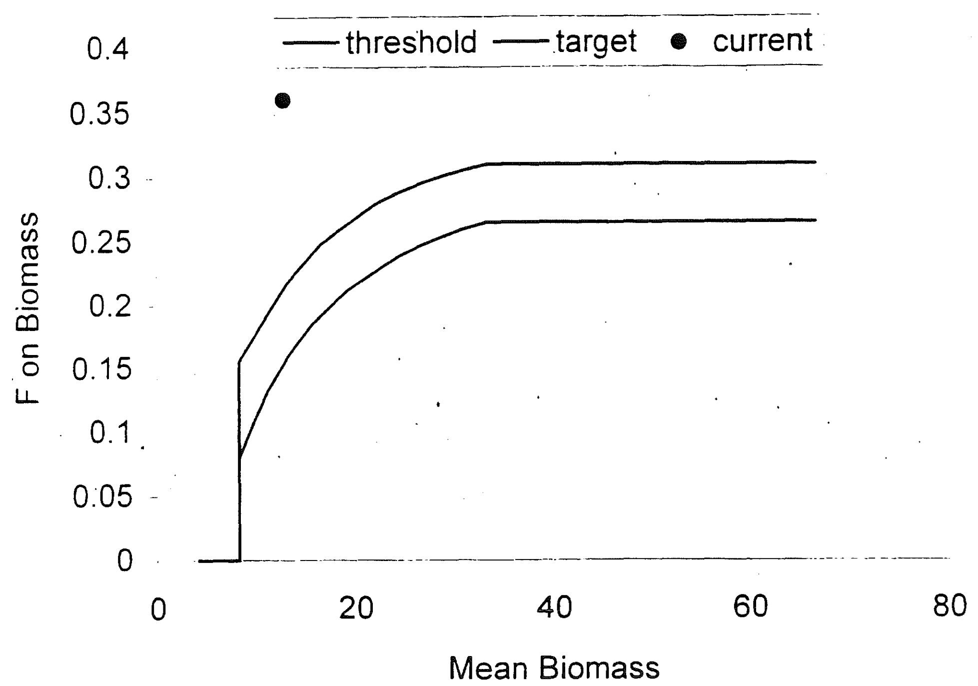

Figure F5. SFA Control rule for Gulf of Maine cod with 1999 mean biomass and biomass-weighted fishing mortality rate indicated.

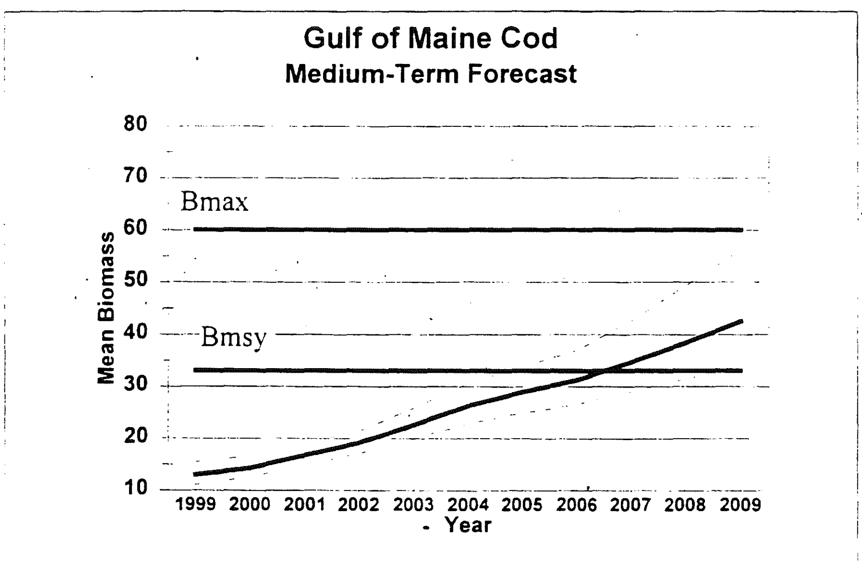

Figure F6. Medium-term forecast of mean stock biomass for Gulf of Maine Cod at SFA control rule F=0.15

G. Witch Flounder by S. E. Wigley

1.0 Background

Witch flounder was assessed in 1999 and reviewed at SAW 29 (NEFSC 1999).

2.0 Summary of Assessment Results

An analytical assessment (VPA) of USA 1982-1998 commercial catch at age data was conducted to estimate fishing mortality rates and abundance at age in 1999. Commercial catch (landings plus discards from the northern shrimp and large-mesh otter trawl fisheries) is given in Table G.1 and Figure G.1. Information on recruitment and abundance was taken from standardized NEFSC spring and autumn surveys (Table G.2, Figures G.2a and G.2b).

The accepted VPA formulation estimated ages 4-11+ using NEFSC spring and autumn bottom trawl survey indices. The VPA calibration indicated that 1999 age 3 stock size was 131 million fish, approximately 4-fold higher than any previous estimate for age 3 fish. The negative residual pattern associated with the stock size estimates of age 3 and 4 persisted regardless of alternative formulations, and, given the retrospective pattern associated with age 3 recruitment, it was determined that the best estimates of age 3 and 4 stock sizes in 1999 would come from the survey indices of recruitment. Stock sizes in 1999 for age 3 and 4 were estimated directly from the survey data using regressions of VPA stock sizes on the corresponding survey indices (using the RTC3 program of ICES). The 1999 age 3 stock size was estimated to be 38.706 million fish (1996 year class) and age 4 stock size in 1999 was estimated to be 19.457 million fish (1995 year class). To estimate age 3 fish in 1998 (the 1995 year class), the 1995 year class at age 4 was back-calculated (accounting for natural mortality) to be 22.686 million fish (Table G.3). Assessment results are summarized in Table G.3 and Figures G.3 and G.5. For more details see Wigley, Brodziak and Cadrin (1999).

Fishing moratlity: Fishing mortality (ages 7-9, unweighted) increased from 0.21 (18% exploitation) in 1982 to 0.59 (42% exploitation) in 1985, declined to 0.24 (20% exploitation) in 1990, increased to 0.86 (54% exploitation) in 1996, then dropped to 0.37 (29% exploitation) in 1998 (Figure G.3). This trend in F is generally confirmed by the trend of pooled survey Z. There is an 80% probability that the 1998 F lies between 0.28 and 0.51. Based on the ADAPT VPA, 3+ mean biomass in 1998 was 18,934 mt and the 1998 F on 3+ biomass was 0.13. Based on catch statistics to-date, the estimated 3+ biomass in 1999 is projected to be 26,048 mt and F on 3+ biomass is estimated to be 0.096 (Figure G.5).

Recruitment: Recruitment has been above average since 1992 (Figure G.4).

Mean 3+ biomass: Mean 3+ biomass declined steadily from 27,930 mt in 1982 to 7,742 mt in 1994, then sharply increased to 18,934 mt by 1998. The estimated mean 3+ biomass in 1999 is 26,048 mt (above the overfishing threshold and near Bmsy; Figure G.4).

Spawning stock biomass: Spawning stock biomass (SSB) declined from 18,000 mt in 1982 to about 4,000 mt in 1995. Following recruitment and maturation of the 1991-1993 year classes, SSB increased sharply to 8,652 mt in 1998 (Figure G.4). There is an 80% probability that the 1998 SSB lies between 7,400 mt and 11,000 mt. The age composition of the spawning stock biomass revealed that more than half the SSB in 1982 was composed of age 11+ fish, but by 1998, more than half of the SSB consisted of age 5 - 7 fish, many of which were first-time spawners. Since the mid-1980's, the age structure remains severely truncated. The low number of older fish may adversely impact the stock's reproductive potential output.

Biological Reference Points: Yield and SSB per recruit analyses updated with an assumed M = 0.15 indicate that $F_{0.1}$ = 0.16 (14% exploitation), F_{max} = 0.35 (28% exploitation), and $F_{20\%}$ = 0.37 (29% exploitation).

MSY Based Reference Points: A non-equilibrium surplus production analysis (ASPIC) was performed on total catch and survey indices of stock biomass from 1963 to 1998. The model was calibrated with NEFSC spring and autumn biomass indices, where spring indices were lagged back one year to calibrate biomass at the end of the previous year. When q was unconstrained, the intrinsic rate of increase (r) was unreasonably high for this slow growing, long-lived species; therefore, survey q's were fixed according to ADAPT VPA estimates of age 3+ biomass. Results of the final formulation estimated MSY to be 2,684 mt; B_{msy} to be 25,000 mt and that the corresponding F_{msy} = 0.106.

SFA Control Rule: The Amendment 9 control rule states that when the stock biomass exceeds B_{msy}, the overfishing threshold is F_{msy}, and target F is the lower 80[th] percentile (or 10[th] percentile) of F_{msy}. When stock biomass is less than B_{msy}, the overfishing threshold is based on maximum F that would allow rebuilding to B_{msy} in five years. When biomass is less than the biomass threshold, F = 0. The biomass threshold is defined by the minimum stock size that is projected to rebuild to B_{msy} in 5 years at F=0.

The Amendment 9 control rule was updated with the revised estimates of F_{msy} (0.106), B_{msy} (25,000 mt) and the tenth percentile of F_{msy} (0.090; Figure 5). MSY is estimated as 2,684 mt. Based on the ADAPT estimates of age 3+ mean biomass in 1998 (18,934 mt) and 1998 F on 3+ biomass (0.13), overfishing was occurring in 1998 (Figure 5). Assuming 1999 catches will equal 1998 catches, the 1999 F on fully recruited ages 7+ is estimated to be 0.20, and the target fishing mortality prescribed by the control rule for the 1999 stock size is 0.09 on biomass.

3.0 Forecasts for 1999-2009

Medium-term stochastic projections were performed to estimate meanl biomass (3+) during 1999-2009 under the control rule (F on 3+ biomass = 0.09, F fully recruited on ages 7+ = 0.11 assuming equilibrium age structure) using VPA calibrated stock sizes in 1999 (age 3 and 4 stock sizes were estimated using RCT3, where the mean and standard error were used to generate the

1,000 estimates of age 3 and 4 stock sizes from a log-normal distribution; and ages 5-11+ were estimated by the 1000 bootstrapped VPA outcomes). Catches in 1999 were assumed equal to that in 1998 based on landings to date. The fully-recruited 1999 F was projected to be 0.20 (F on 3+ biomass = 0.096). An average 1995-1997 partial recruitment, 1994-1998 maturity ogive, and the average 1982-1998 mean weights at age were used in the projections.

Spawning stock biomass and recruitment (age 3) data for witch flounder were presented in a previous section. Given the negative value for the Beverton-Holt slope parameter, the lack of a reasonable stock-recruitment relationship necessitated that recruitment (age 3 fish) in 1999-2009 be estimated by re-sampling from the empirical observations during 1982-1997 (1979-1994 year classes). Fishing mortality was apportioned among landings and discards based on the proportion landed at age during 1995-1997. The proportion of F and M which occurs before spawning equal 0.1667 (March 1); M was assumed to be 0.15.

Fishing at the control rule (F on 3+ biomass = 0.09, F on fully recruited ages 7+ = 0.11), mean biomass (3+) will increase to 40,573 mt in 2005, and then decline to 37,111 mt in 2009, 48% above B_{msy} of 25,000 mt (Table G.4, Figure G.6).

4.0 Sources of Uncertainty

- The bootstrap procedure as applied does not capture the full extent of variability and uncertainty in the VPA results, particularly that which comes from the residual pattern and the retrospective pattern, and, therefore, the percentile distributions of the projected stock parameters understate the extent of the uncertainty in the forecasts.

- Confounding of survey based estimates of discards and use of same surveys as tuning indices for VPA calibration.

- Low frequency of samples across market category and season resulting in variable mean weights at age and estimates of numbers at age.

- Low catchability of standard survey gear leading to highly variable survey indices.

- Lack of data to support direct estimates of discards at age requiring use of various surrogate survey-based methods.

- The simple biomass dynamics model used to derive MSY-reference points does not account for age structure of the stock or current recruitment.

- Estimates of current recruitment are highly variable due to the dependence on catch at younger ages which consists almost entirely of discards and highly variable and imprecise survey indices for recruiting ages.

- High recruitment and survival rates may or may not continue.

5.0 References

NEFSC [Northeast Fisheries Science Center]. 1999. Report of the 29th Northeast Regional Stock Assessment Workshop (29th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Northeast Fish. Sci. Cent. Ref. Doc. 99-14, 347 p.

Wigley, S.E., J, K.T. Brodziak, and S.X. Cadrin. 1999. Assessment of the witch flounder stock in Subareas 5 and 6 for 1999. Northeast Fish. Sci. Cent. Ref. Doc. 99-16, 153 p.

Table G1. Witch flounder landings, discards and catch (metric tons, live) from Subareas 5 and 6, by country, 1960-1998 [1960-1963 reported to ICNAF/NAFO (Burnett and Clark, 1983)].

	Landings					Total USA Catch
Year	Canada	USA [2]	Other[1]	Total	Discards	(used in VPA)
1960	-	1255	-	1255		
1961	2	1022	-	1024		
1962	1	976	-	977		
1963	27	1226	121	1374		
1964	37	1381	-	1418		
1965	22	2140	502	2664		
1966	68	2935	311	3314		
1967	63	3370	249	3682		
1968	56	2807	191	3054		
1969	-	2542	1310	3852		
1970	19	3112	130	3261		
1971	35	3220	2860	6115		
1972	13	2934	2568	5515		
1973	10	2523	629	3162		
1974	9	1839	292	2140		
1975	13	2127	217	2357		
1976	5	1871	6	1882		
1977	11	2469	13	2493		
1978	18	3501	6	3525		
1979	17	2878	-	2895		
1980	18	3128	1	3147		
1981	7	3422	-	3449		
1982	9	4906	-	4915	48	4953
1983	45	6000	-	6045	162	6162
1984	15	6660	-	6675	100	6760
1985	46	6130	-	6431	61	6191
1986	67	4610	-	5216	25	4635
1987	23	3450	-	3819	47	3497
1988	45	3262	-	3665	60	3322
1989	13	2074	-	2384	133	2207
1990	12	1478	-	1492	184	1662
1991	7	1798	-	1805	95	1893
1992	7	2246	-	2253	171	2417
1993	10	2605	-	2615	376	2981
1994	34	2670	-	2704	422	3092
1995	11	2212	-	2223	265	2477
1996	10	2088	-	2098	454	2542
1997	7	1775	-	1782	393	2168
1998	*	1849	-	1849	334	2184

[1] Includes West Germany, East Germany, Poland, Spain, Japan, & the former USSR.
[2] excluding landings from Grand Banks (subarea 3).
* 1998 Canadian landings not available.

Table G2. Stratified mean number, weight (kg) and length (cm) per tow of witch flounder in NEFSC offshore spring and autumn bottom trawl surveys in Gulf of Maine-Georges Bank region (strata 22-30,36-40), 1963-1999.

	SPRING			AUTUMN		
YEAR	Number per tow	Weight per tow	Length per tow	Number per tow	Weight per tow	Length per tow
1963	-	-	-	5.52	3.46	39.7
1964	-	-	-	2.89	2.00	44.2
1965	-	-	-	3.94	2.27	40.6
1966	-	-	-	7.80	4.56	41.2
1967	-	-	-	3.01	2.02	43.6
1968	4.76	3.34	42.5	4.82	3.49	44.8
1969	3.74	2.53	45.3	5.81	4.40	43.9
1970	6.39	4.49	44.7	4.89	3.71	45.0
1971	2.74	2.06	46.5	4.32	2.95	42.1
1972	5.35	4.01	45.8	3.24	2.42	43.9
1973	8.20	6.21	44.8	3.18	2.05	43.6
1974	6.23	3.62	39.3	2.34	1.54	40.9
1975	3.72	2.75	43.9	1.66	1.03	39.8
1976	5.50	3.70	42.3	1.34	0.94	41.9
1977	4.20	1.96	37.2	5.06	3.38	42.0
1978	3.87	2.56	41.7	4.04	2.94	42.9
1979	3.01	1.77	38.3	1.94	1.62	45.2
1980	8.46	3.89	36.0	2.62	2.04	43.6
1981	8.40	4.18	38.1	3.66	2.19	40.4
1982	3.64	1.87	37.2	0.99	0.83	44.7
1983	6.41	2.74	36.3	4.72	2.12	36.7
1984	3.00	1.66	39.9	4.37	2.34	39.7
1985	5.18	2.75	40.3	2.76	1.59	42.0
1986	2.07	1.35	44.1	1.59	1.09	43.3
1987	1.01	0.65	43.4	0.48	0.37	44.0
1988	1.43	0.85	42.3	1.38	0.57	35.2
1989	1.95	0.74	35.8	0.89	0.38	31.3
1990	0.63	0.24	35.2	2.00	0.40	24.8
1991	1.68	0.57	31.5	2.08	0.54	29.3
1992	1.26	0.50	34.8	0.94	0.24	29.5
1993	1.47	0.36	30.3	5.15	0.54	17.0
1994	3.13	0.53	27.4	2.21	0.42	24.9
1995	1.88	0.47	30.7	4.47	0.62	25.7
1996	1.36	0.28	30.5	5.38	1.02	29.7
1997	2.22	0.43	31.0	5.10	0.77	24.9
1998	4.27	0.77	29.0	3.70	0.47	24.2
1999	3.15	0.48	28.1			

Note: During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. No significant differences in catchability were found for witch flounder, therefore no adjustments have been made (Byrne and Forrester, MS 1991). No significant differences were found between research vessels, and no adjustment have been made (Byrne and Forrester, MS 1991). Spring surveys during 1973-1981 were accomplished with a 41 Yankee trawl; in all other years, a 36 Yankee trawl was used. No adjustments have been made.

Table G3. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F) and spawning stock biomass (mt) for witch flounder estimated from virtual population analysis, 1982-1998. **Bold values** in 1999 are estimated from RCT3 (regressions of VPA stock sizes and corresponding NEFSC surveys); **bold value** in 1998 was back-calculated.

STOCK NUMBERS (Jan 1) in thousands

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3	15434	17862	15866	7326	4876	2950	9502	6359	6871	8949	15279	10906	13869	27833	26142	20549	**22686**	**38706**
4	12807	13107	15061	13520	6191	4176	2519	7622	5059	5595	7293	12780	9000	11898	23361	22390	17590	**19457**
5	9766	10035	10033	11603	10546	4979	3426	2038	6155	3764	4437	5108	9322	6816	9668	19224	18322	14573
6	7903	7285	7227	6777	8022	7669	3852	2704	1693	4270	2430	3015	3079	5461	4756	6486	15185	14577
7	4566	5433	4809	4606	4037	4330	5414	2705	2035	1218	3135	1216	1742	1453	3102	2867	4296	11693
8	2990	3313	3201	2760	2550	2021	2266	3377	1621	1495	827	2028	492	731	462	1342	1525	2228
9	2341	1965	1944	1366	1218	1420	931	879	2086	955	1057	523	1201	241	381	153	605	968
10	1372	1644	1007	1027	613	665	776	429	431	1483	547	743	247	533	117	128	55	390
11+	9014	5364	4581	3459	2073	1280	1728	1203	938	1213	1711	1034	700	307	230	178	246	179
3+	66193	66008	63729	52444	40126	29490	30414	27316	26889	28942	36716	37353	39652	55273	68219	73317	80510	102771

FISHING MORTALITY

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
3	0.01	0.02	0.01	0.02	0.01	0.01	0.07	0.08	0.06	0.05	0.03	0.04	0.00	0.03	0.00	0.01	0.00
4	0.09	0.12	0.11	0.10	0.07	0.05	0.06	0.06	0.15	0.08	0.21	0.17	0.13	0.06	0.04	0.05	0.04
5	0.14	0.18	0.24	0.22	0.17	0.11	0.09	0.04	0.22	0.29	0.24	0.36	0.38	0.21	0.25	0.09	0.08
6	0.22	0.27	0.30	0.37	0.47	0.20	0.20	0.13	0.18	0.16	0.54	0.40	0.60	0.42	0.36	0.26	0.11
7	0.17	0.38	0.41	0.44	0.54	0.50	0.32	0.36	0.16	0.24	0.29	0.76	0.72	1.00	0.69	0.48	0.51
8	0.27	0.38	0.70	0.67	0.44	0.62	0.80	0.33	0.38	0.20	0.31	0.37	0.57	0.50	0.95	0.65	0.30
9	0.20	0.52	0.49	0.65	0.45	0.45	0.62	0.56	0.19	0.41	0.20	0.60	0.66	0.57	0.94	0.88	0.29
10	0.21	0.41	0.51	0.55	0.50	0.53	0.46	0.37	0.23	0.26	0.27	0.52	0.68	0.79	0.75	0.55	0.37
11+	0.21	0.41	0.51	0.55	0.50	0.53	0.46	0.37	0.23	0.26	0.27	0.52	0.68	0.79	0.75	0.55	0.37
7-9	0.21	0.43	0.53	0.59	0.48	0.53	0.58	0.42	0.24	0.28	0.27	0.58	0.65	0.69	0.86	0.67	0.37

Table 3 continued

MEAN BIOMASS

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
3	2164	2447	2214	863	402	221	384	694	385	502	1441	1211	900	1481	1477	1123	1978
4	2750	2323	3036	2837	1146	724	461	1167	819	994	1411	2214	1587	1837	3290	3976	3191
5	2785	2310	2722	2959	2700	1309	949	597	1325	1049	1395	1275	2022	1763	1865	4298	4896
6	2775	2438	2450	2269	2443	2804	1408	1000	632	1547	805	1003	931	1798	1586	1908	5600
7	2148	2186	1989	1965	1553	1788	2322	1215	1026	584	1561	428	622	485	1164	1052	1729
8	1775	1574	1431	1303	1305	965	978	1827	866	887	491	1051	243	371	198	581	829
9	1747	1139	1174	792	780	883	531	515	1500	612	732	325	684	156	198	83	414
10	1134	1231	679	713	441	474	569	324	377	1183	394	555	152	337	75	95	42
11+	10652	5580	4484	3306	2016	1213	1713	1272	1134	1412	1735	1007	601	247	187	166	253
3+	27930	21228	20179	17007	12786	10381	9315	8611	8064	8770	9965	9069	7742	8475	10040	13282	18934

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

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
3	0	0	0	5	2	1	4	3	3	0	0	0	0	0	0	0	0
4	0	88	107	368	145	79	47	96	109	6	8	17	108	100	172	189	136
5	55	486	483	1872	1729	769	522	328	787	89	114	127	913	719	814	1638	1746
6	423	1297	1175	2238	2453	2501	1255	901	577	534	344	446	854	1466	1345	1493	3658
7	1105	1859	1648	2037	1719	1858	2417	1239	964	460	1185	415	724	589	1319	1184	1617
8	1589	1708	1579	1469	1429	1074	1184	1888	932	877	486	1152	265	398	242	693	761
9	1807	1336	1237	894	846	960	614	577	1499	659	758	373	780	169	244	101	416
10	1206	1393	772	811	499	543	632	350	375	1258	438	610	192	410	95	107	46
11	11939	6633	5492	4085	2458	1491	2069	1497	1280	1609	1982	1235	771	326	244	205	272
1+	18124	14801	12493	13779	11281	9277	8743	6879	6526	5492	5315	4375	4608	4178	4475	5611	8652

Table G4. Input and results of medium-term projections for witch flounder.

Projection input:

Age	Mortality Pattern	Proportion Mature	Fish Discard Fraction	Average Weights Catch	Average Weights Stock	Average Weights Discards
3	.0130	.0000	1.00	.094	.056	0.030
4	.0730	.0800	0.89	.199	.140	0.078
5	.2330	.4500	0.62	.299	.247	0.149
6	.4730	.8500	0.12	.419	.357	0.189
7	1.0000	1.0000	0.00	.549	.484	0.235
8	1.0000	1.0000	0.00	.677	.615	0.235
9	1.0000	1.0000	0.00	.846	.764	0.235
10	1.0000	1.0000	0.00	.973	.907	0.235
11+	1.0000	1.0000	0.00	1.319	1.319	0.235

Results:

Year	Median Mean Biomass (mt)	Probability of Exceeding Bmsy
1999	25,701	0.55
2000	30,550	0.80
2001	34,503	0.90
2002	37,367	0.95
2003	39,580	0.98
2004	40,416	0.99
2005	40,573	0.99
2006	39,993	0.99
2007	39,786	0.99
2008	38,298	0.99
2009	37,111	0.98

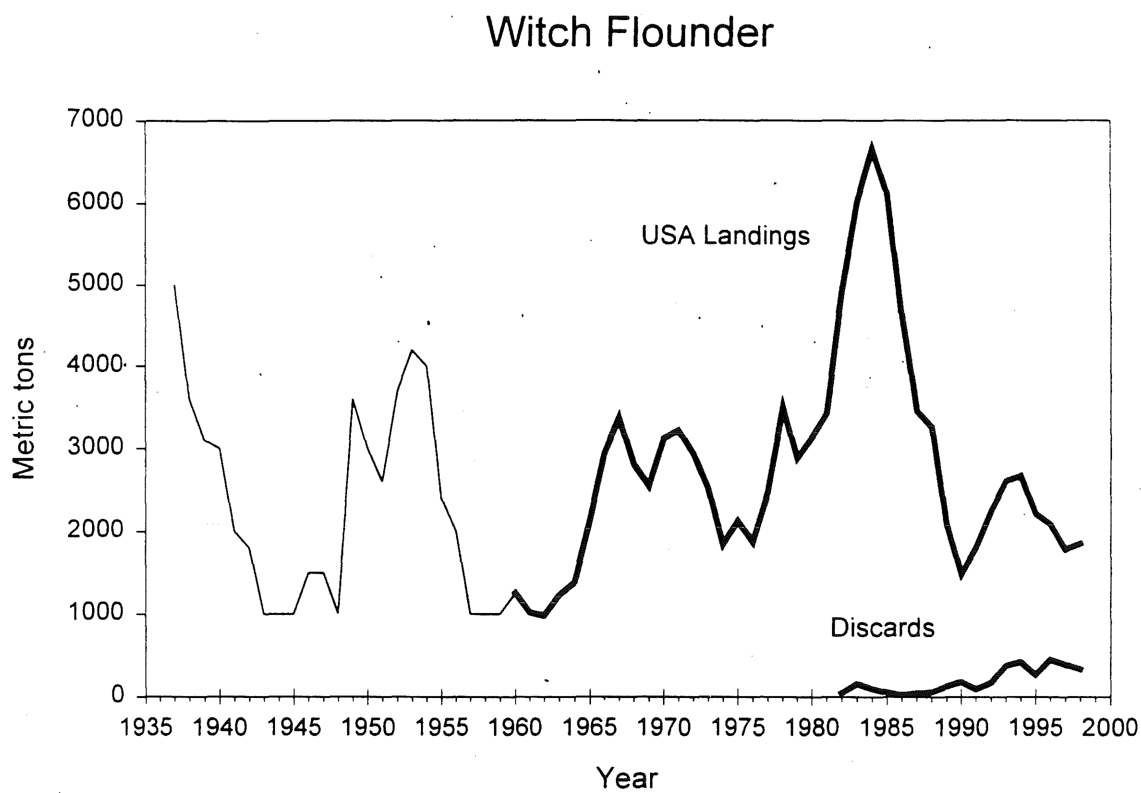

Figure G.1. Historical USA witch flounder landings (mt), excluding USA landings from the Grand Banks in the mid-1980's. Thin line represents provisional landings data taken from Lange and Lux (1978). Discards from the shrimp and large-mesh otter trawl fishery.

Witch Flounder

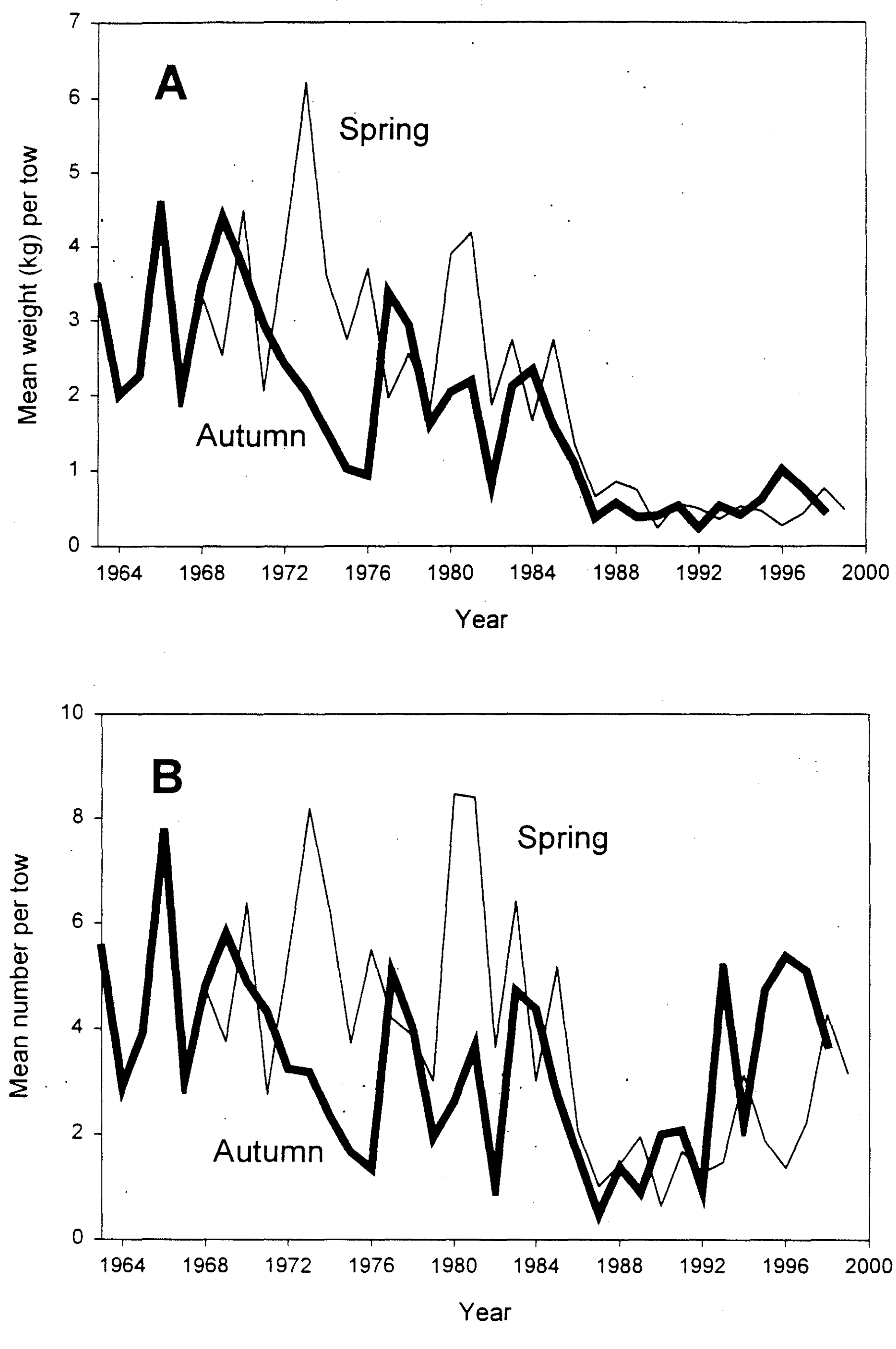

Figure G.2. Stratified mean catch (kg) per tow (A) and mean number per tow (B) of witch flounder in NEFSC spring and autumn research vessel bottom trawl surveys in the Gulf of Maine-Georges Bank region, 1963 - 1998; 1999 values are preliminary.

Witch flounder

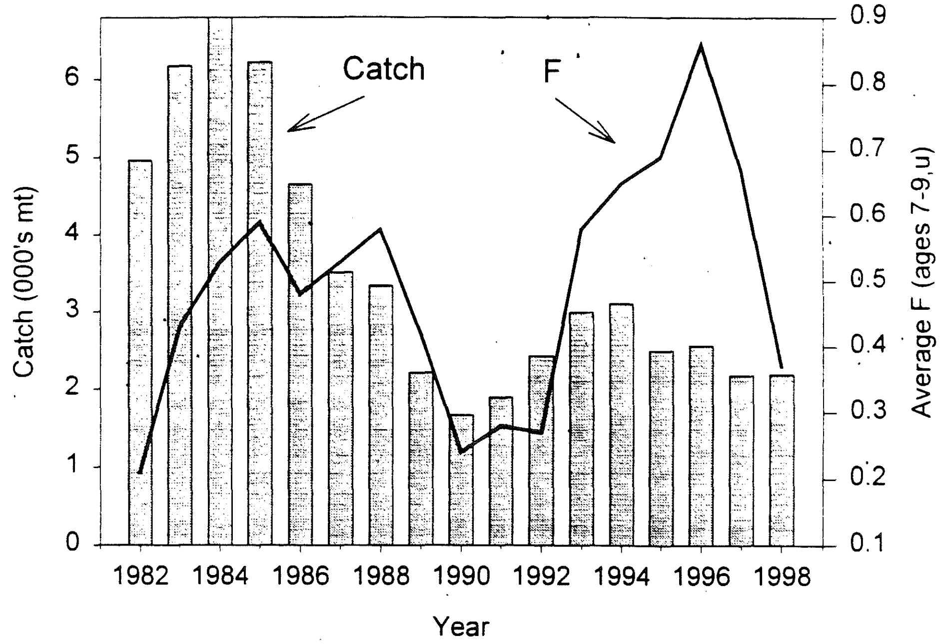

Figure G.3. Trends in total catch and fishing mortality for witch flounder, 1982-1998.

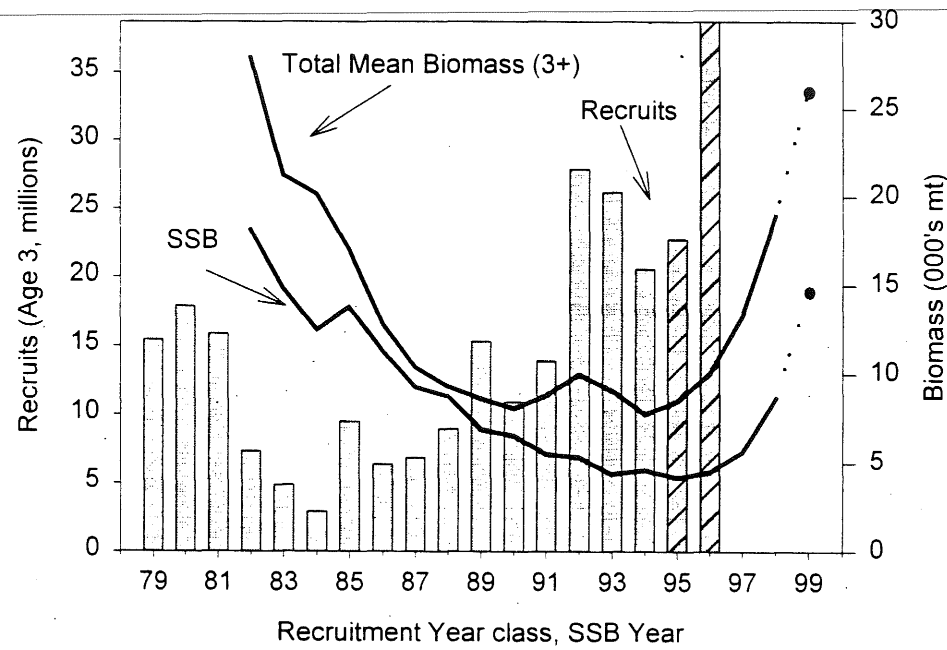

Figure G.4. Trends in spawning stock biomass, mean biomass (3+), and recruitment for witch flounder, recruitment fo the 1995 and 1996 year classes (hatched bars) estimated from log-log regression of survey and VPA stock sizes estimates.

Witch flounder

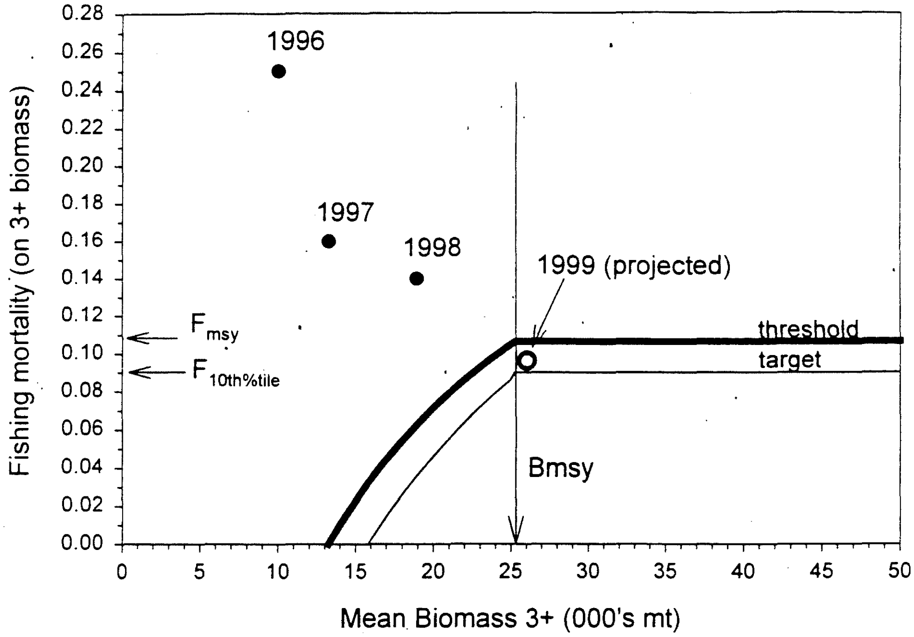

Figure G.5. MSY-based reference points and control rule for witch flounder.

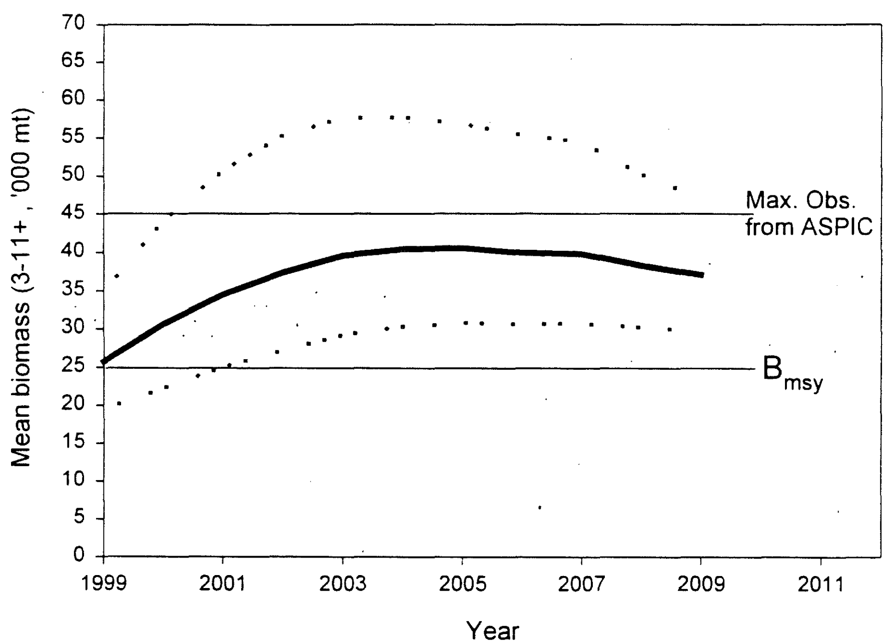

Figure G.6. Meduim-term stochastic projections for witch flounder, median mean biomass 3+ (bold line), with 80% confidence interval (dot line), and Bmsy and maximum observed mean biomass from ASPIC (thin lines).

H. Gulf of Maine-Georges Bank American Plaice by L. O'Brien

1.0 Background

This stock was last assessed in 1998 (O'Brien et al. 1999) and reviewed by the 28th Northeast Regional SAW. Fully recruited F (ages 5-8, u) in 1997 was estimated to be 0.47, an increase of 10% from 1996. Spawning stock biomass was 13,500 mt in 1997, an increase of 11% from 1996. Recruitment since 1993 has been near record low values and the 1997 estimate was the lowest in the time series (1980-1997) with a less than average recruit/SSB survival ratio. The NEFSC spring and autumn bottom trawl survey indices have declined each year since 1995 and the MADMF abundance indices have continued to decline since 1994. Recruitment indices were below average for the 1994-1996 year classes.

2.0 1999 Assessment Update

The Fishery

Total commercial landings of Gulf of Maine-Georges Bank American plaice in 1998 were 3,662 mt, a 7% decline from 1997 (Table H1, Figure H1). Discards were not estimated. Estimates of fishing mortality and spawning stock biomass in 1998 were derived by projection of the 1998 landings and are presented in Figures H4 and H5.

Research Survey Indices

The NEFSC autumn indices of abundance and biomass increased in 1998 and the spring 1999 indices remained stable (Table H2, Figure H2 and H3). Recruitment indices of age 1 fish from the 1998 NEFSC and MADMF autumn survey indicate that the 1997 year class is above average and similar in size to the 1992 year class.

3.0 Forecasts

An analysis of stock-recruit data did not indicate an increase in recruitment with an increase in spawning stock biomass. Parameters estimated by a Beverton-Holt stock recruitment model resulted in statistically infeasible parameters and the model was not accepted. The residuals from the model were lognormal, indicating that a lognormal distribution of the recruitment would provide a model to generate recruitment independent of the spawning stock biomass. This model allows for draws of recruitment over the entire distribution, i.e. between observed values, and also for values greater or less than observed. The lognormal distribution was used to generate stochastic recruitment for forecasts of landings and spawning stock size for 1999-2009. Recruitment in 1998 was not available from the previous assessment and was derived by regression analysis (RCT3) of the 1980-1997 VPA estimates of stock size at age 1 and the age 1 recruits from the NEFSC and MADMF spring and autumn survey from 1980-1998. The predicted stock size of age 1 fish in 1998 was estimated at 32,937 million fish. One thousand estimates of recruits in 1998 were then randomly generated from a normal distribution with a mean of ln(32,937) and SE = 0.45.

A projection over the short term was performed to obtain the fishing mortality in 1998-1999. Fishing mortality in 1998 was estimated as 0.32 from the projection of 1998 landings. F in 1999 was then assumed to be equal to status quo 1998 F. Spawning stock biomass in 1998 was 14,436 mt, and in 1999 declined slightly to 13,755 mt (Figures H4 and H5).

The SFA control rule for Gulf of Maine-Georges Bank American plaice is based on SSB_{MSY} which is currently estimated at 24,200 mt (Figure H6). The rule states that $F_{0.1}$ will be the maximum fishing mortality threshold when the stock is above SSB_{MSY} then decrease linearly to zero at 1/4 SSB_{MSY} (6,050 mt). The target F will be 60% of $F_{0.1}$ when the stock is above SSB_{MSY} and would decrease linearly to zero at ½ of SSB_{MSY} (12,100 mt). Applying the 1999 SSB (13,755 mt) to the control rule dictates that fishing mortality should be no higher than 0.02 (Figure H6).

Long term forecasts from 2000-2009 were performed with an F= 0.02 . Landings and SSB trajectories are presented in Table H3. There is a 50% probability that SSB_{MSY} will be achieved between 2002-2003. The projected biomass in 2009 is just above the maximum (49,000 mt) SSB observed in this stock (Figure H7).

4.0 Sources of Uncertainty

VPA estimates of 1998 calibrated age 1 stock size were not available. The derived estimates may be optimistic.

Projections of SSB are likely to be optimistic if recruits are overestimated.

From the previous assessment (O'Brien et al. 1999):

Sources of uncertainty included:

1 the effect of not including discards from the small-mesh whiting fishery,

2 the effect of using number of trips as an effort multiplier *versus* a more refined measure such as days fished and

3 the effect of expanding discard estimates derived from the small segment covered in the sea sampling program to the whole fleet.

5.0 References

O'Brien, L., R.K. Mayo, and C. Esteves. 1999. Assessment of American plaice in the Gulf of Maine-Georges Bank Region for 1998. NEFSC Ref. Doc. 99-09.

Table H1. Commerical landings (metric tons, live weight) of American plaice from the Gulf of Maine, Georges Bank, Southern New England and the Mid-Atlantic, 1960-1998.

Year	Gulf of Maine			Georges Bank					Southern New England				Mid - Atlantic			Grand Total		
	USA	Can	Total	USA	Can	SSR	Other	Total	USA	USSR	Other	Total	USA	Other	Total	USA	Other	Total
1960	620	1	621	689	-	-	-	689	-	-	-	0	-	-	0	1309	1	1310
1961	692	-	692	830	-	-	-	830	-	-	-	0	-	-	0	1522	0	1522
1962	694	-	694	1233	44	-	-	1277	-	-	-	0	-	-	0	1927	44	1971
1963	693	-	693	1489	127	24	-	1640	-	-	-	0	-	-	0	2182	151	2333
1964	811	-	811	2800	177	-	11	2988	-	-	-	0	-	-	0	3611	188	3799
1965	967	-	967	2376	180	112	-	2668	-	-	-	0	-	-	0	3343	292	3635
1966	955	2	957	2388	242	279	1	2910	-	-	-	0	-	-	0	3343	524	3867
1967	1066	6	1072	2166	203	1018	10	3397	-	-	-	0	4	-	4	3236	1237	4473
1968	904	5	909	1695	173	193	5	2066	637	145	-	782	18	2	20	3254	523	3777
1969	1059	7	1066	1738	71	63	17	1889	505	349	-	854	130	-	130	3432	507	3939
1970	895	-	895	1603	92	927	658	3280	88	18	40	146	8	-	8	2594	1735	4329
1971	648	5	653	1511	36	228	296	2071	11	112	206	329	6	2	8	2176	885	3061
1972	569	-	569	1222	22	358	-	1602	3	71	-	74	-	-	0	1794	451	2245
1973	687	-	687	910	38	289	-	1237	5	158	-	163	-	-	0	1602	485	2087
1974	945	2	947	1039	27	16	2	1084	92	4	-	96	-	-	0	2076	51	2127
1975	1507	-	1507	913	25	148	-	1086	3	-	-	3	-	-	0	2423	173	2596
1976	2550	-	2550	948	24	3	-	975	10	-	-	10	1	-	1	3509	27	3536
1977	5647	-	5647	1408	35	50	-	1493	6	78	-	84	7	-	7	7068	163	7231
1978	7287	30	7317	2193	77	-	-	2270	15	-	-	15	8	-	8	9503	107	9610
1979	8835	-	8835	2478	23	-	-	2501	13	-	7	20	4	-	4	11330	30	11360
1980	11139	-	11139	2399	43	-	5	2447	10	-	-	10	1	-	1	13549	48	13597
1981	10327	1	10328	2482	15	-	2	2499	26	-	2	28	46	-	46	12881	20	12901
1982	11147	-	11147	3935	27	-	1	3963	35	-	2	37	9	-	9	15126	30	15156
1983	9142	7	9149	3955	30	-	-	3985	40	-	-	40	4	-	4	13141	37	13178
1984	6833	2	6835	3277	6	-	-	3283	17	-	-	17	7	-	7	10134	8	10142
1985	4766	1	4767	2249	40	-	-	2289	12	-	-	12	2	-	2	7029	41	7070
1986	3319	-	3319	1146	34	-	-	1180	4	-	-	4	3	-	3	4472	34	4506
1987	2766	-	2766	1032	48	-	-	1080	2	-	-	2	1	-	1	3801	48	3849
1988	2271	-	2271	1097	108	-	-	1205	13	-	-	13	1	-	1	3382	108	3490
1989	1646	-	1646	703	68	-	-	771	1	-	-	1	3	-	3	2353	68	2421
1990	1802	-	1802	639	51	-	-	690	2	-	-	2	2	-	2	2445	51	2496
1991	2936	-	2936	1310	-	-	-	1310	15	-	-	15	0	-	0	4261	0	4261
1992	4564	2	4566	1838	-	-	-	1838	10	-	-	10	4	-	4	6416	2	6418
1993	3865	-	3865	1838	-	-	-	1838	11	-	-	11	4	-	4	5718	0	5718
1994	***3402***	29	3431	***1560***	2	-	-	1562	***21***	-	-	21	***83***	-	83	5066	31	5097
1995	***3123***	3	3126	***1486***	-	-	-	1486	***16***	-	-	16	***20***	-	20	4645	3	4648
1996	***2920***	2	2922	***1423***	-	-	-	1423	***39***	-	-	39	***14***	-	14	4396	2	4398
1997	***2331***	65	2396	***1560***	-	-	-	1560	***22***	-	-	22	***24***	-	24	3937	65	4002
1998		*														3662		

**** 1994-1997 data are spatially distributed based on proportions of landings recorded by area in the VTR database and are considered provisional.**

Table H2. Stratified mean number and mean weight per tow (kg) of American plaice in NEFSC spring and autumn bottom trawl surveys, adjusted for vessel differences, in the Gulf of Maine - Georges Bank area, 1963-1999.

	SPRING		AUTUMN	
	Number	Weight	Number	Weight
1963	---	---	14.17	5.87
1964	---	---	8.20	2.84
1965	---	---	11.95	3.80
1966	---	---	17.78	4.90
1967	---	---	11.05	2.69
1968	11.36	3.40	8.61	2.91
1969	8.59	2.68	7.51	2.36
1970	5.43	1.81	6.46	2.01
1971	3.80	1.26	7.47	1.96
1972	4.28	1.32	7.44	1.60
1973	7.18	1.85	6.19	1.94
1974	8.34	1.94	6.89	1.42
1975	5.78	1.72	8.12	2.43
1976	11.85	3.37	9.98	2.99
1977	14.57	5.11	11.80	3.52
1978	10.61	3.82	15.13	4.66
1979	9.23	3.62	9.96	4.00
1980	18.34	4.78	14.24	5.12
1981	18.75	5.88	13.04	5.62
1982	11.61	3.80	5.88	2.49
1983	16.94	4.60	9.34	3.45
1984	4.10	1.42	7.12	2.02
1985	4.94	1.88	6.95	2.00
1986	3.09	0.92	5.61	1.56
1987	3.50	0.81	4.38	1.09
1988	3.58	0.84	9.69	1.46
1989	4.81	0.75	9.21	1.17
1990	5.09	0.75	15.46	2.90
1991	5.91	1.05	7.71	1.56
1992	4.11	1.36	6.31	1.78
1993	5.29	1.39	11.89	2.39
1994	4.89	0.85	18.07	2.67
1995	9.43	1.94	11.84	2.58
1996	7.83	1.69	7.58	2.23
1997	7.62	1.62	6.27	1.94
1998	4.52	1.11	9.29	2.22
1999	4.18	1.20		

Table H3. Projections of landings, spawning stock biomass, and recruitment with probabilities of exceeding a SSB threshold of 24,200 mt, for American plaice, 1999-2009.

Year	F	Landings 000's mt	SSB 000's mt	P (SSB >24,200 mt)	Recruits 000's
1998	0.32	3.645	14.436	0.000	23655
1999	0.32	3.753	13.755	0.000	23688
2000	0.02	0.254	13.866	0.000	23748
2001	0.02	0.313	18.572	0.011	23650
2002	0.02	0.388	23.106	0.357	23670
2003	0.02	0.466	26.980	0.781	23685
2004	0.02	0.555	31.267	0.959	23709
2005	0.02	0.641	35.312	0.993	23723
2006	0.02	0.744	40.933	1.000	23666
2007	0.02	0.814	44.616	1.000	23653
2008	0.02	0.871	47.638	1.000	23617
2009	0.02	0.917	50.032	1.000	23649

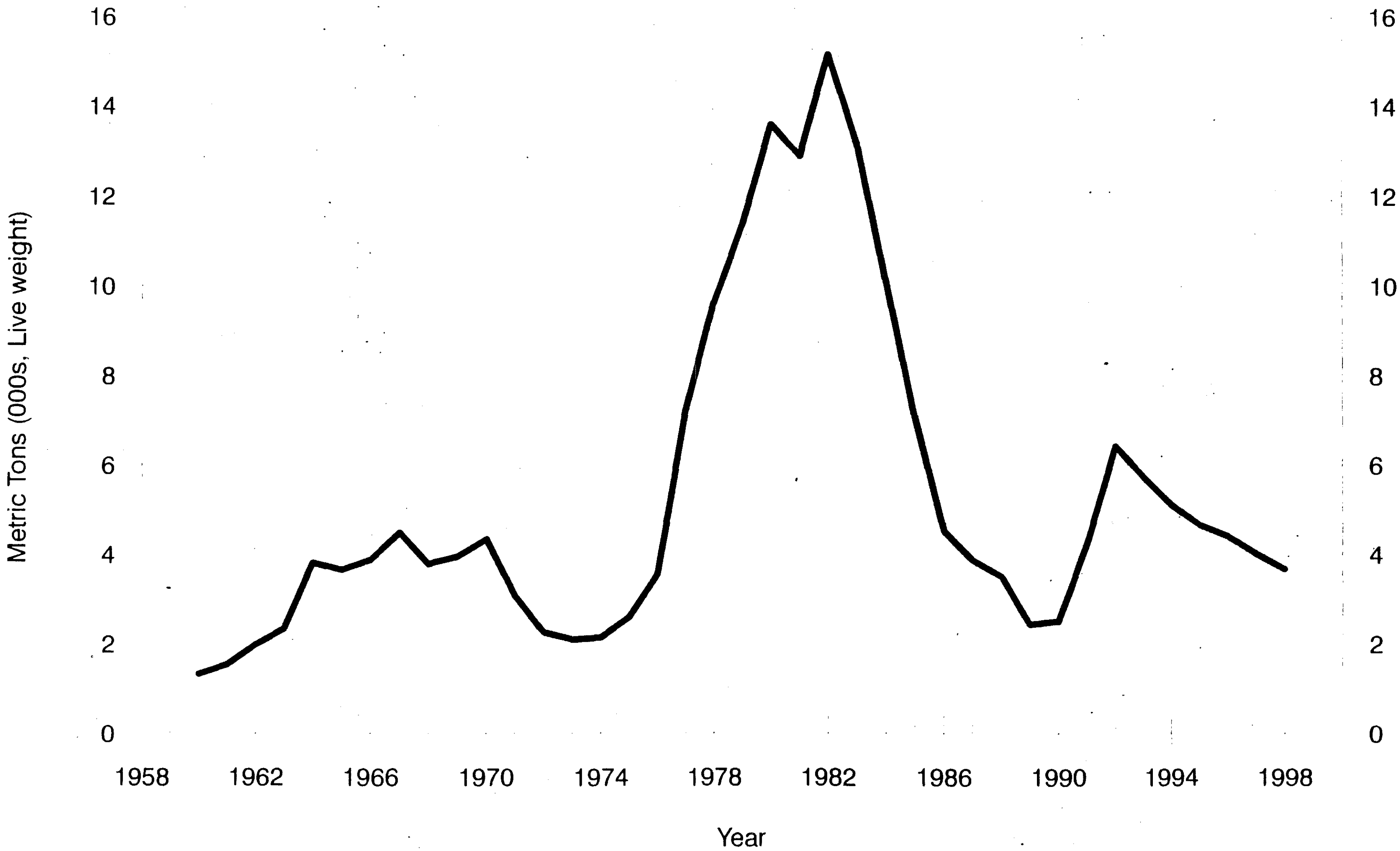

Figure H1. Total commercial landings of Gulf of Maine-Georges Bank American plaice (Division 5Zand 6), 1960-1998.

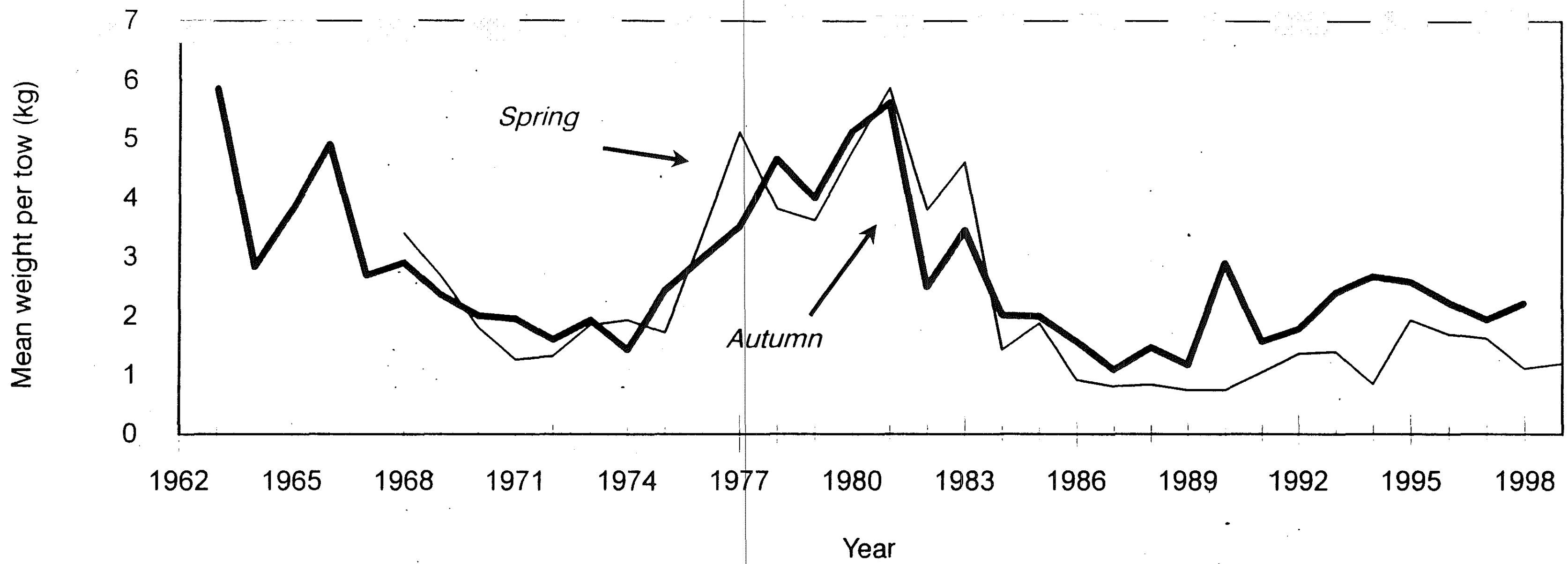

Figure H2. Standardized stratified mean weight per tow (kg) of American plaice in NEFSC spring and autumn research vessel bottom trawl surveys in the Gulf of Maine-Georges Bank region, 1963-1999.

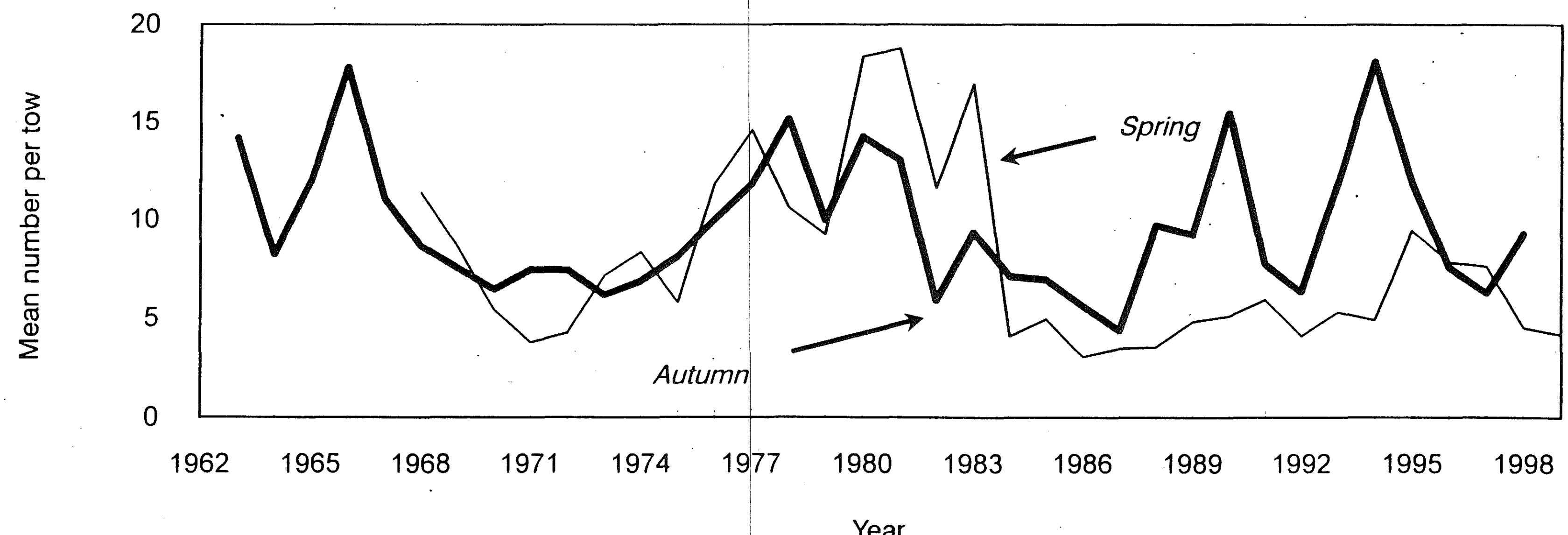

Figure H3. Standardized stratified mean number per tow of American plaice in NEFSC spring and autumn research vessel bottom trawl surveys in the Gulf of Maine-Georges Bank region, 1963 -1999.

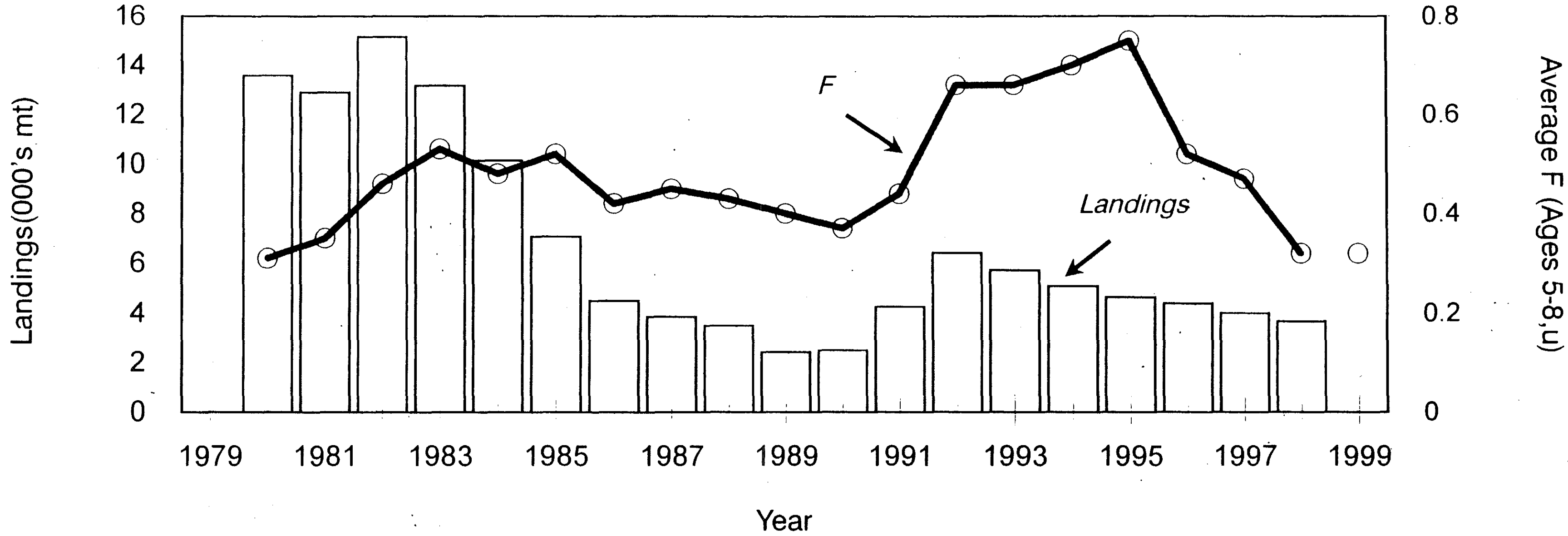

Figure H4. Trends in total commercial landings and fishing mortality for Gulf of Maine-Georges Bank American plaice, 1980 - 1998.

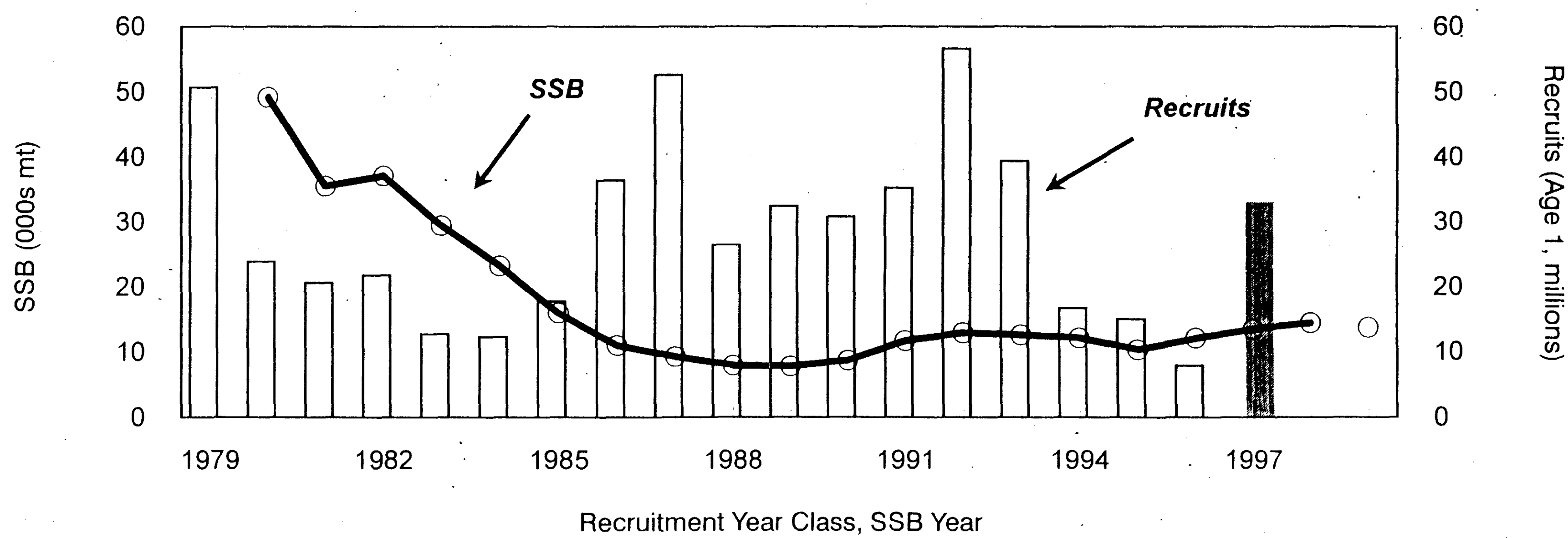

Figure H5. Trends in spawning stock biomass and recruitment for Gulf of Maine-Georges Bank American plaice, 1980-1998.

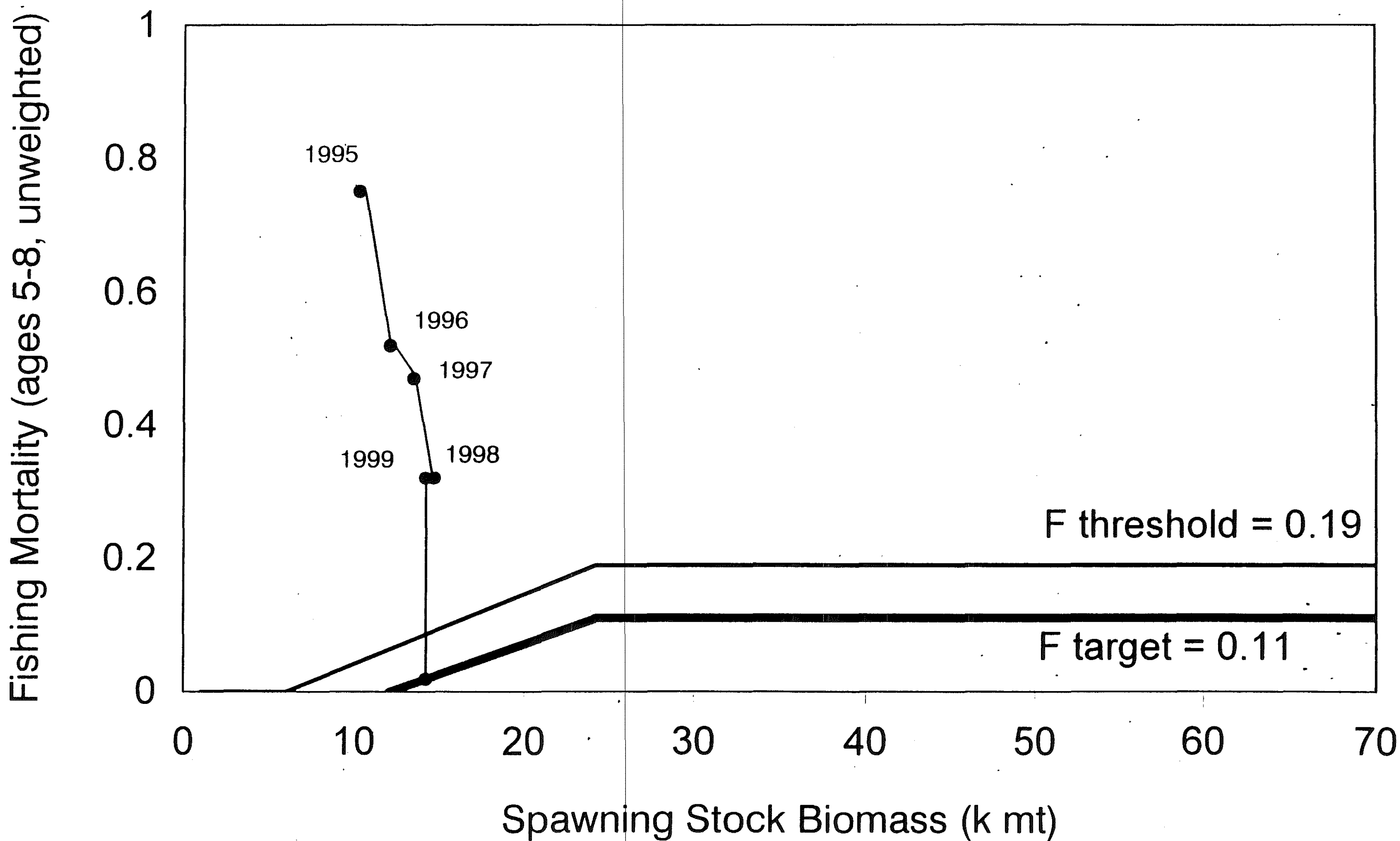

Figure H6. Control rule and recent and projected (1998, 1999) stock status for Gulf of Maine-Georges Bank American plaice.

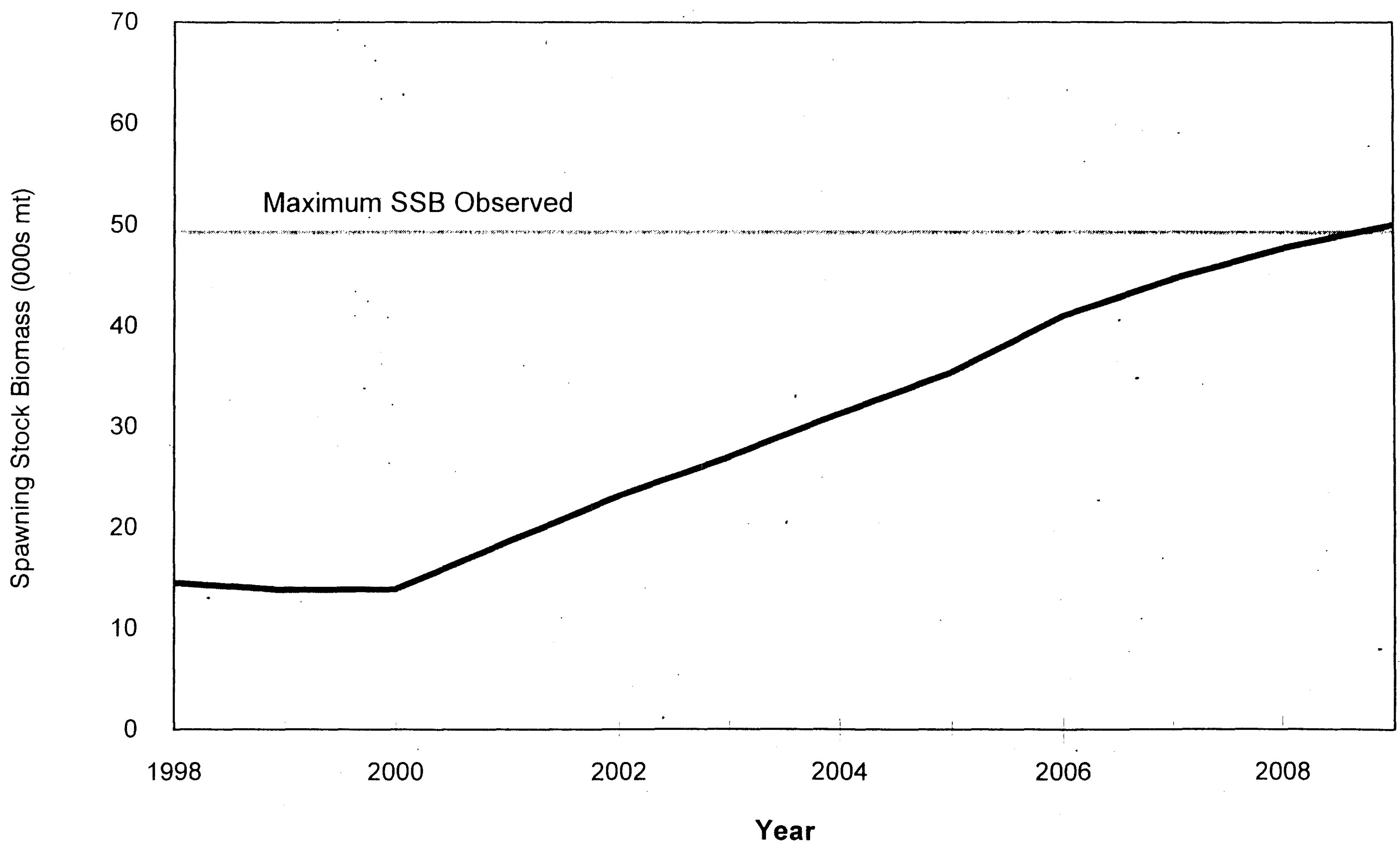

Figure H7. Long-term forecasts of spawning stock biomass (ages 1+) with 80% confidence itervals for Gulf of Maine-Georges Bank American plaice, 1998-2009, and maximum SSB observed.

I. Georges Bank Winter Flounder by R.W. Brown

1.0 Background

The Georges Bank winter flounder stock was last assessed by SAW/SARC 28 in December 1998 (Brown et al. 2000). The 1998 assessment included a catch at age from 1982 - 1997 and research survey indices through the U.S. and Canadian Spring 1998 surveys. It is not possible to update the stock assessment to include the 1998 catch at age or the Autumn 1998 and Spring 1999 survey numerical catch at age indices because age determinations have not been completed for 1998 commercial fishery samples. Medium term stochastic projections were generated and summarized by assuming 1998 and 1999 fishing mortality, and applying the harvest control rule to determine the corresponding level of fishing mortality for 2000 through 2008.

2.0 1998 Assessment

Fishery

Since the late 1960's, U.S. landings have been the dominate component of total commercial landings (Table I1; Figure I1). Canadian landings have averaged 0.1% to 2.7% of total fishery landings since 1970. The Canadian industry's interest in the Georges Bank winter flounder resource is increasing, and reported Canadian landings in 1997 reached their highest reported levels since 1966 (Table I1; Figure I1).

U.S. landings of Georges Bank winter flounder were estimated to be 1,178 mt in 1998 based on prorations performed by the Northeast Regional Office of the National Marine Fisheries Service (Table I1). Canadian landings of Georges Bank winter flounder in 1998 were preliminarily estimated at 151 mt. Discarding of winter flounder occurs at low levels in both the otter trawl and scallop dredge fisheries; however, lack of reliable information to estimate either the magnitude or characterize the size and age distribution of discards precluded the inclusion of discards in the 1998 assessment.

Fishery Independent Information

Two stratified random bottom trawl surveys, the NEFSC Spring survey (April 1968-1998) and the NEFSC Autumn survey (October 1963-1997) were used to estimate changes in abundance (stratified mean number • tow^{-1}) and biomass (stratified mean weight (kg) • tow^{-1}) of winter flounder in the Georges Bank stock area (Table I2; Figure I2). Stratified abundance and biomass indices for Georges Bank winter flounder from the U.S. Spring and Autumn surveys exhibit a considerable amount of variability but generally indicate intermediate levels of abundance from the early 1960s to early 1980s, and declining levels of abundance since the mid-1980s. Stratified mean number at age indices for the NEFSC Spring and Autumn surveys are noisy, but appear to track larger cohorts in the numbers at age matrix for the 1980, 1985, 1987, and 1994 cohorts.

The Department of Fisheries and Oceans, Canada has conducted a stratified random bottom trawl survey on Georges Bank since 1986. Winter flounder captured during the Canadian survey are counted and measured, but no ageing program exists to generate age determinations from this survey. U.S. survey and commercial age keys were used to partition stratified mean numbers at length into stratified mean numbers at age. Sufficient age determinations were available from U.S. Spring survey data to partition stratified mean numbers at length into numbers at age for fish smaller than 40 cm and U.S. commercial age keys from the first quarter of the corresponding year were applied for fish longer than 40 cm. Stratified mean number at age indices from the Canadian survey appear to track larger cohorts corresponding to the 1987, 1992, and 1994 year classes.

Input Data and Analysis

The VPA calibration from the 1998 assessment estimated ages 2 to 6 and included the U.S. Spring indices (ages 1 to 7), the Canadian Spring indices (ages 1 to 7), and the U.S. Autumn indices (ages 1-6, lagged forward one age and one year). Precision of the 1998 stock sizes and 1997 fishing mortality and SSB estimates was derived from 1000 bootstrap simulations of the 1998 VPA formulation. A retrospective analysis of terminal year estimates of stock sizes, fully recruited fishing mortality and SSB was completed back to 1992.

3.0 Assessment Results

The assessment results indicate that stock numbers exceeded 25 million in the early 1980s, gradually declined to reach a low level of approximately 8.8 million in 1993, increased to 13.6 million in 1995, and have again declined to 9.6 million fish in 1997. Age 2 recruitment was relatively stable throughout the time period, but larger 1980, 1985, 1987 and 1994 year classes exceed 5 million fish at age 2 (Figure I3). Recent recruitment, as measured by the 1995 and 1996 year classes, has been among the lowest in the time series (Figure I3). There appears to be little discernable relationship between stock and recruitment over the time period analyzed in this assessment.

Spawning stock biomass declined from levels exceeding 8,000 mt in the early 1980's to less than 2,000 mt in 1994, but increased to almost 3,700 mt in 1996 (Figure I3; Table I3). Spawning stock biomass declined slightly from almost 3,700 mt in 1996 to 3,500 mt in 1997. In the early 1980s, spawning stock biomass consisted of a wide range of ages and the youngest mature ages (2 and 3) comprised less than 40% of the total spawning stock biomass. The age structure of the spawning stock biomass became truncated in the mid 1980s to mid 1990s, when the youngest mature ages (2 and 3) comprised 45% to 75% of the spawning stock biomass. Some broadening of the age structure of spawning stock biomass is evident after 1994, but the age structure remains truncated relative to historical levels.

From the early 1980s to the early 1990s, fully recruited fishing mortality (ages 4-6) ranged from approximately 0.5 to as high as 1.4 (Figure I4; Table I3). Fishing mortality declined sharply after 1993 and has fluctuated between 0.3 and 0.5 from 1994 to 1997.

In the terminal year of the assessment (1997), fully recruited fishing mortality was estimated to be 0.41 (Table I3). Patterns in fishing mortality appear to be reasonably well correlated with reported landings.

VPA Diagnostics

In the 1998 assessment VPA calibration, the coefficient of variation on age 2 was relatively high (0.52), while CV's on older ages were lower (0.41 to 0.47 for ages 3 to 6). The CV's on the survey q's ranged from 0.22 to 0.27. Standardized residuals exhibited no discernable patterns, although 8 of 221 standardized residuals had values exceeding 2.0.

Uncertainty and potential bias estimates were assessed using a bootstrap analysis of the VPA calibration. One thousand bootstrap realizations were produced by randomly resampling survey residuals produced by the final ADAPT calibration. The distribution of bootstrap realizations of spawning stock biomass indicates that there is an 80% chance that the 1997 estimate of SSB is between 3,100 and 4,500 mt. The distribution of bootstrap realizations of fishing mortality suggests that there is an 80% probability that F_{1997} is between 0.26 and 0.45.

Retrospective patterns for fishing mortality indicate a pattern of slightly overestimating average fishing mortality in the terminal year. The retrospective patterns for spawning stock biomass indicate that there is a tendency in the most recent years to slightly overestimate spawning stock biomass in the terminal year.

Evaluation of the Harvest Control Rule

The MSY-based control rule for Georges Bank winter flounder adopted in Amendment 9 was derived from survey-based proxies of biomass and exploitation (Figure I5). The parameters of this control rule were revised during SAW/SARC 28 due to revised estimates of landings and a revision to the strata set used to develop survey indices for the NEFSC Spring and Autumn surveys. The revised control rule defined maximum sustainable yield as 2,700 mt, identified a threshold fishing mortality proxy (F_{MSY}) as a level of an exploitation index (catch • NEFSC Autumn survey biomass^{-1}) of 1.125, and identified a target stock biomass proxy as the NEFSC Autumn survey biomass index value of 2.73 kg•tow^{-1}. Threshold F is defined as the F_{MSY} proxy (F_{MSY} = 1.125) when the NEFSC Autumn survey index is greater than 2.73 kg•tow^{-1} and declines linearly to zero at 50% of the B_{MSY} proxy (NEFSC Autumn survey index less than 1.37 kg•tow^{-1}). The target fishing mortality proxy was estimated to be 75% of the threshold proxy value, and stock biomass proxies were established as 50% of the target B_{MSY} proxy values. Target F is defined as 75% of the F_{MSY} proxy (f_{MSY}=0.74) when the NEFSC Autumn survey index is greater than 2.73 kg•tow^{-1} and declines linearly to zero at 1.37 kg•tow^{-1}.

Using the harvest control rule to evaluate appropriate fishing mortality for 2000-2009 requires evaluation of stock conditions in the 1999 time period. Landings and stock conditions in 1999 were projected by completing a short-term projection with landings from 1998 to produce an estimate of realize F. This F level was then used to complete a two year projection to estimate 1999 landings and 1999 mean biomass. The 1999 estimate of mean biomass (3,409 mt) was multiplied by the U.S. Autumn survey q estimate from the ASPIC surplus production run to translate the measure of mean biomass into 1999 Autumn survey biomass index units. Because the mean biomass was available from the VPA, which incorporates recent survey points into the terminal point estimate of biomass, the point estimate rather than a three year average was used to evaluate the harvest control rule. The 1999 biomass index (0.897) was significantly lower than ½ B_{MSY} (Figure I5). This is consistent with the observation that the 1999 projection of mean biomass (3,409) is less than one-half of the B_{MSY} estimate from surplus production modeling (11,400 mt). Application of the harvest control rule results in a fishing mortality of 0.00 for 2000 - 2008.

The availability of an analytical assessment for this stock provides an opportunity to update the harvest control to incorporate information produced by an analytical assessment. A revised control rule which incorporated estimates of mean biomass and F weighted by biomass would eliminate the necessity of translating between mean biomass and Autumn survey units.

4.0 Forecasts

Medium-term stochastic projections were performed for 1999 - 2008. U.S. landings in 1998 were estimated to be 1,178 mt based on Regional Office prorations and Canadian landings in 1998 were approximately 151 mt. Total 1998 landings were used to complete a short projection to produce an estimate of realized F in 1998. This fully recruited F (0.41) was assumed for 1999, and the fully recruited F resulting from application of the harvest control rule (0.00) was projected for 2000 - 2008.

The projections were based on a partial recruitment vector estimated as the geometric mean of 1994 to 1997 F's at age from the final VPA calibration, 1994 to 1997 arithmetic mean stock and catch weights, and the long-term (1982-1997) maturity schedule for Georges Bank winter flounder. Age 1 recruitment was estimated from the terminal year bootstrap realizations of the VPA in 1998, and recruitment in 1999 - 2008 was resampled from empirical age 1 recruitment estimated by the VPA calibration from 1982 to 1997.

Projections indicate that 1+ biomass of winter flounder will increase from 3,300 mt in 1999 to 17,600 mt in 2008 (Figure I6). The biomass levels indicated in the later years of the projection exceed levels estimated through surplus production modeling. Many of the population compensatory mechanisms that would be expected at these large stock sizes (declining growth rates, delayed maturity) were not explicitly accounted for the projection model. The projection indicates that the probability that 1+ biomass is greater than B_{MSY} exceeds 50% by 2004 (Table I4).

The short time series of stock and recruitment data for this stock over a fairly limited range of stock sizes results in considerable uncertainty about modeling future recruitment. However, the stock projection indicates that even at current recruitment levels, if fishing mortality were reduced to 0.00, stock size would increase at a rapid rate approaching B_{MSY} levels in approximately 5-6 years.

5.0 Sources of Uncertainty

1 Sampling of U.S. commercial landings may be inadequate to characterize the size and age composition, particularly in the years since 1992. This leads to uncertainty in the age composition of landings in the catch at age matrix.

2 The exclusion of U.S. otter trawl and scallop dredge discards most likely results in an underestimation of fishery removals from the younger age classes (ages 0 to 3). Indications from both the sea sample and vessel trip record databases suggests that scallop dredge discards may have increased since the implementation of groundfish retention restrictions resulting in an underestimation of fishery removals of both younger and older age classes.

3 There is some uncertainty about the accuracy of reported Canadian landings because of the non-targeted nature of the Canadian fishery and the tendency to report landings of some flatfish species, including winter flounder, as unclassified flounders.

4 The Canadian fishery has no formal sampling program to estimate the size and age composition of Canadian landings. This assessment assumed that the size and age composition of Canadian landings was identical to the overall size and age composition in the U.S. fishery. This assumption is sensitive to the possibility that selectivity patterns may be different between the fisheries in each country.

6.0 Literature Cited

Brown, R.W., G. Begg, and S.X. Cadrin 2000. Assessment of the Georges Bank Winter Flounder Stock, 1982-1997. Northeast Fisheries Science Center Reference Document 2000 - In Press.

Brown, R.W. and W. Gabriel. Winter Flounder. Pages 81-84, *in* Status of Fishery Resources off the Northeastern United States for 1998. NOAA Technical Memorandum NMFS-NE-115.

Table I1. Landings (mt) of Georges Bank winter flounder from 1962-1998 by statistical area and country.

	522-525 561-562	5Z (521-543)				5ZE (521-526, 541-543)				Included in
	USA	USA	Canada	USSR	Total	USA	Canad	USS	Total	Assessment
1962		6996	26		7022					
1963		6911	120	19	7050					
1964	1371	12656	146		12802					1517
1965	1176	10479	199	312	10990					1687
1966	1877	13807	164	156	14127					2197
1967	1917	10815	83	349	11247					2349
1968	1570		57			4346	59	372	4777	1999
1969	2167		116			6380		235	6615	2518
1970	2615		61			7020	64	40	7124	2716
1971	3092		62			1400	65	1029	15094	4183
1972	2805		8			1026	8	1699	11973	4512
1973	2269		14			4387	14	693	5094	2976
1974	2124		12			4508	12	82	4602	2218
1975	2409		13			4833	13	515	5361	2937
1976	1877		15			3732	11	1	3744	1893
1977	3572		15			5954	15	7	5976	3594
1978	3185		65			6378	65		6443	3250
1979	3045		19			6293	19		6312	3064
1980	3931		44			9941	44		9985	3975
1981	3993		19			9711	19		9730	4012
1982	2961		19			7347	19		7366	2980
1983	3894		14			8014	14		8028	3908
1984	3927		4			7574	4		7578	3931
1985	2151		12			4758	11		4769	2163
1986	1762		25							1787
1987	2637		32							2669
1988	2804		55							2859
1989	1880		11							1891
1990	1898		55							1953
1991	1814		14							1828
1992	1822		27							1849
1993	1662		21							1683
1994	907		65							972
1995	706		54							760
1996	1265		71							1336
1997	1287		143							1430
1998	1178		151							1329

[illegible] flounder from the U.S. NEFSC Spring and Autumn, and Canadian Spring research vessel bottom trawl surveys. U.S. survey strata 01130-01220; Canadian survey strata (5Z1-5Z8). Canadian biomass indices were estimated using the stratified mean number at length and the U.S. survey length-weight regression coefficients. Door standardization coefficients of 1.46 (numbers) and 1.39 (weight) applied to U.S. survey indices before 1985 to account for differences in catchability between survey doors (NEFSC 1991).

	U.S. Spring Survey		**U.S. Autumn Survey**		**Canada Spring Survey**	
	Number•tow^{-1}	Weight (kg)•tow^{-1}	Number•tow^{-1}	Weight (kg)•tow^{-1}	Number•tow^{-1}	Weight (kg)•tow^{-1}
1963			1.200	1.815		
1964			1.298	1.822		
1965			2.152	2.050		
1966			5.163	5.655		
1967	*Spring Survey initiated in 1968*		1.791	2.074		
1968	2.700	3.114	1.308	1.072		
1969	3.136	4.290	2.370	2.385		
1970	1.864	2.294	5.620	6.490		
1971	1.838	2.168	1.324	1.259		
1972	4.946	5.321	1.261	1.580		
1973	2.946	3.507	1.218	1.195		
1974	6.049	5.782	1.193	1.464		
1975	1.955	1.407	3.790	2.061		
1976	4.672	3.012	5.987	3.925		
1977	3.792	1.580	4.862	3.992		
1978	7.068	5.055	4.056	3.100		
1979	1.736	2.206	5.065	3.829		
1980	3.221	2.801	1.661	1.865		
1981	3.727	3.749	3.831	2.434		
1982	2.295	1.523	5.301	2.692		
1983	8.405	7.111	2.726	2.363		
1984	5.529	5.604	3.933	2.445		
1985	3.837	2.650	1.979	1.119		
1986	2.003	1.214	3.575	2.178	*Canadian Survey initiated in 1987*	
1987	2.803	1.247	0.762	0.889	3.73	2.83
1988	2.925	1.648	4.084	1.273	2.70	1.65
1989	1.299	0.757	1.560	1.051	3.48	1.88
1990	2.803	1.573	0.498	0.346	3.29	1.74
1991	2.403	1.319	0.268	0.136	1.43	0.97
1992	1.416	0.898	0.677	0.384	2.25	1.39
1993	1.018	0.570	1.166	0.663	2.78	1.45
1994	1.292	0.578	0.870	0.578	2.45	0.98
1995	2.613	1.489	2.357	1.337	3.10	1.17
1996	2.314	1.504	1.539	1.756	2.20	1.12
1997	1.610	1.192	1.744	1.534	2.80	1.77
1998	0.762	0.722	1.784	1.565	1.42	1.08
1999	3.83	3.479	To be conducted in October 1999		0.98	0.74

Table I3. Stock numbers (thousands), fishing mortality, and spawning stock biomass (mt) at age of Georges Bank winter flounder estimated using an ADAPT calibration.

STOCK NUMBERS

	1982	1983	1984	1985	1986	1987	1988	1989
1	4627	2725	6089	5963	8027	5307	9002	5243
2	8236	3788	2222	4986	4864	6572	4345	7370
3	6532	6424	2389	1564	3354	3381	4210	2802
4	3382	3803	2634	1441	654	1545	1247	937
5	1263	1821	1799	916	445	322	451	258
6	762	572	992	198	306	158	143	191
7	822	1453	1406	175	204	211	146	106
1+	25624	20586	17532	15243	17854	17496	19545	16908

	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	3327	4523	2441	2906	4813	6944	2987	946	00
2	4293	2724	3703	1998	2346	3940	5447	2445	774
3	4785	3248	1694	2311	1364	1439	2611	3793	1568
4	1188	2079	1510	703	858	590	936	1625	2097
5	307	368	842	578	167	480	313	549	797
6	78	84	179	266	184	76	324	114	330
7	28	133	117	75	164	81	258	110	122
1+	14005	13158	10485	8837	9896	13550	12876	9582	

FISHING MORTALITY

	1982	1983	1984	1985	1986	1987	1988	1989
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.05	0.26	0.15	0.20	0.16	0.25	0.24	0.23
3	0.34	0.69	0.31	0.67	0.58	0.80	1.30	0.66
4	0.42	0.55	0.86	0.97	0.51	1.03	1.37	0.92
5	0.59	0.41	2.00	0.90	0.84	0.61	0.66	0.99
6	0.47	0.51	1.23	0.97	0.64	0.97	1.17	0.96
7	0.47	0.51	1.23	0.97	0.64	0.97	1.17	0.96
4-6,u	0.49	0.49	1.36	0.95	0.66	0.87	1.07	0.96

	1990	1991	1992	1993	1994	1995	1996	1997
1	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.00
2	0.08	0.28	0.27	0.18	0.29	0.21	0.16	0.24
3	0.63	0.57	0.68	0.79	0.64	0.23	0.27	0.39
4	0.97	0.70	0.76	1.23	0.38	0.44	0.33	0.51
5	1.09	0.52	0.95	0.94	0.59	0.19	0.81	0.31
6	1.03	0.69	0.84	1.13	0.42	0.32	0.44	0.41
7	1.03	0.69	0.84	1.13	0.42	0.32	0.44	0.41
4-6,u	1.03	0.64	0.85	1.10	0.46	0.32	0.53	0.41

Table I3. (Continued). Stock numbers (thousands), fishing mortality, and spawning stock biomass (mt) at age of Georges Bank winter flounder estimated using an ADAPT calibration.

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

	1982	1983	1984	1985	1986	1987	1988	1989
1	00	00	00	00	00	00	00	00
2	1083	505	295	814	726	1036	654	1127
3	1963	1765	717	471	1313	1192	1273	873
4	2172	1788	1096	688	360	879	589	487
5	1150	1350	816	577	324	254	380	184
6	754	504	667	158	289	140	132	188
7	1162	1689	1339	238	272	289	196	147
1+	8285	7601	4930	2947	3285	3790	3224	3006

	1990	1991	1992	1993	1994	1995	1996	1997
1	00	00	00	00	00	00	00	00
2	760	444	583	318	405	632	1074	373
3	1598	1205	595	797	486	576	1075	1457
4	556	1041	748	323	527	312	618	926
5	214	275	535	385	132	417	218	473
6	74	84	157	221	183	82	343	126
7	45	194	139	109	238	123	393	181
1+	3247	3243	2756	2152	1970	2143	3721	3536

Table I4. Projected mean biomass (mt) of Georges Bank winter flounder and the probability of exceeding the B_{MSY} estimate of 11,400 mt from 1998 to 2009.

Year	Mean Biomass (mt)	Probability of Exceeding B_{MSY}
1998	4,300	0.0%
1999	4,100	0.0%
2000	5,400	0.0%
2001	6,800	0.0%
2002	8,100	3.5%
2003	9,700	37.6%
2004	11,800	68.7%
2005	13,500	91.5%
2006	14,800	97.1%
2007	16,000	99.0%
2008	16,900	99.6%
2009	17,600	99.9%

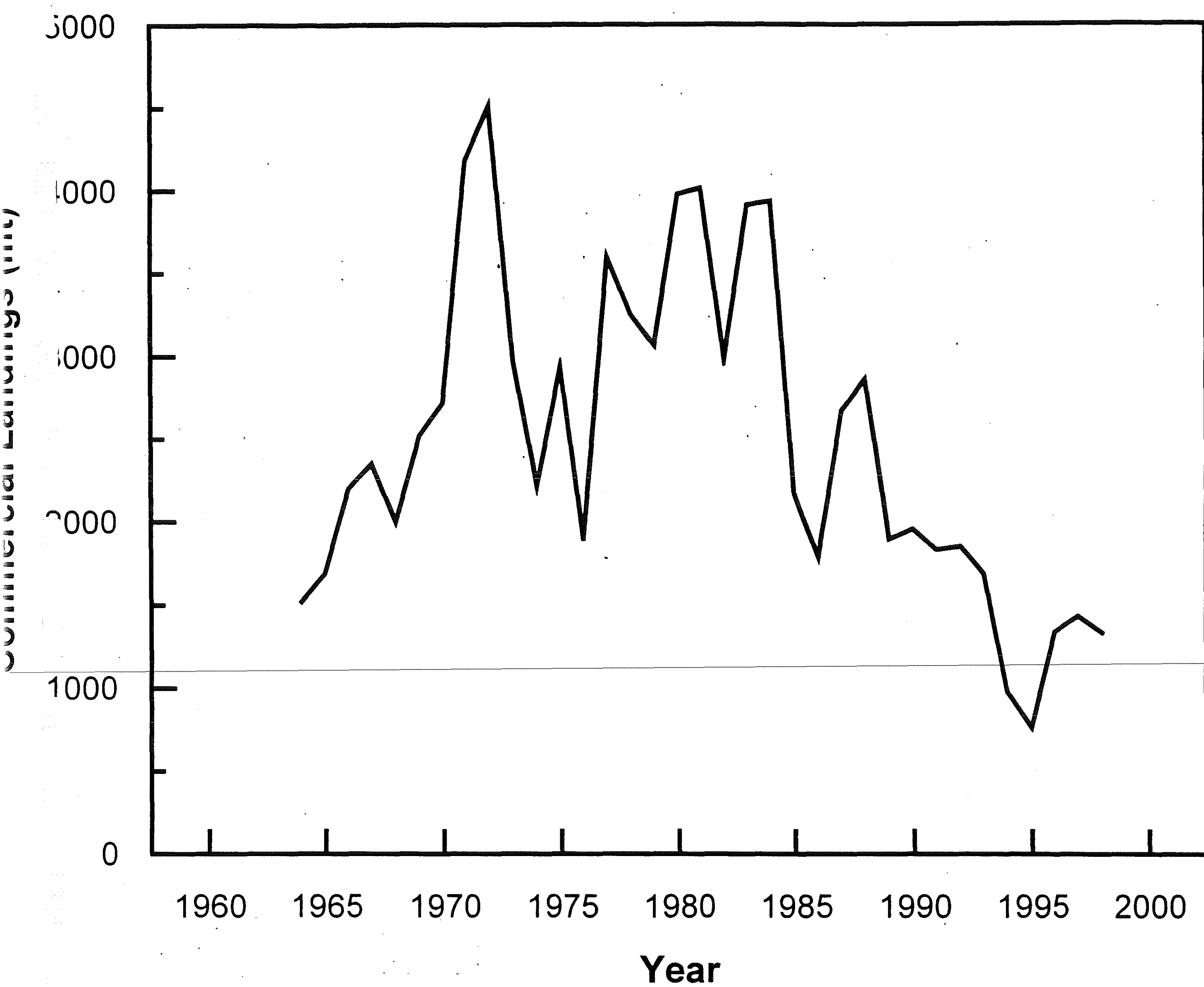

Figure 11. Historical landings of Georges Bank winter flounder from the Georges Bank stock area from 1964 to 1998.

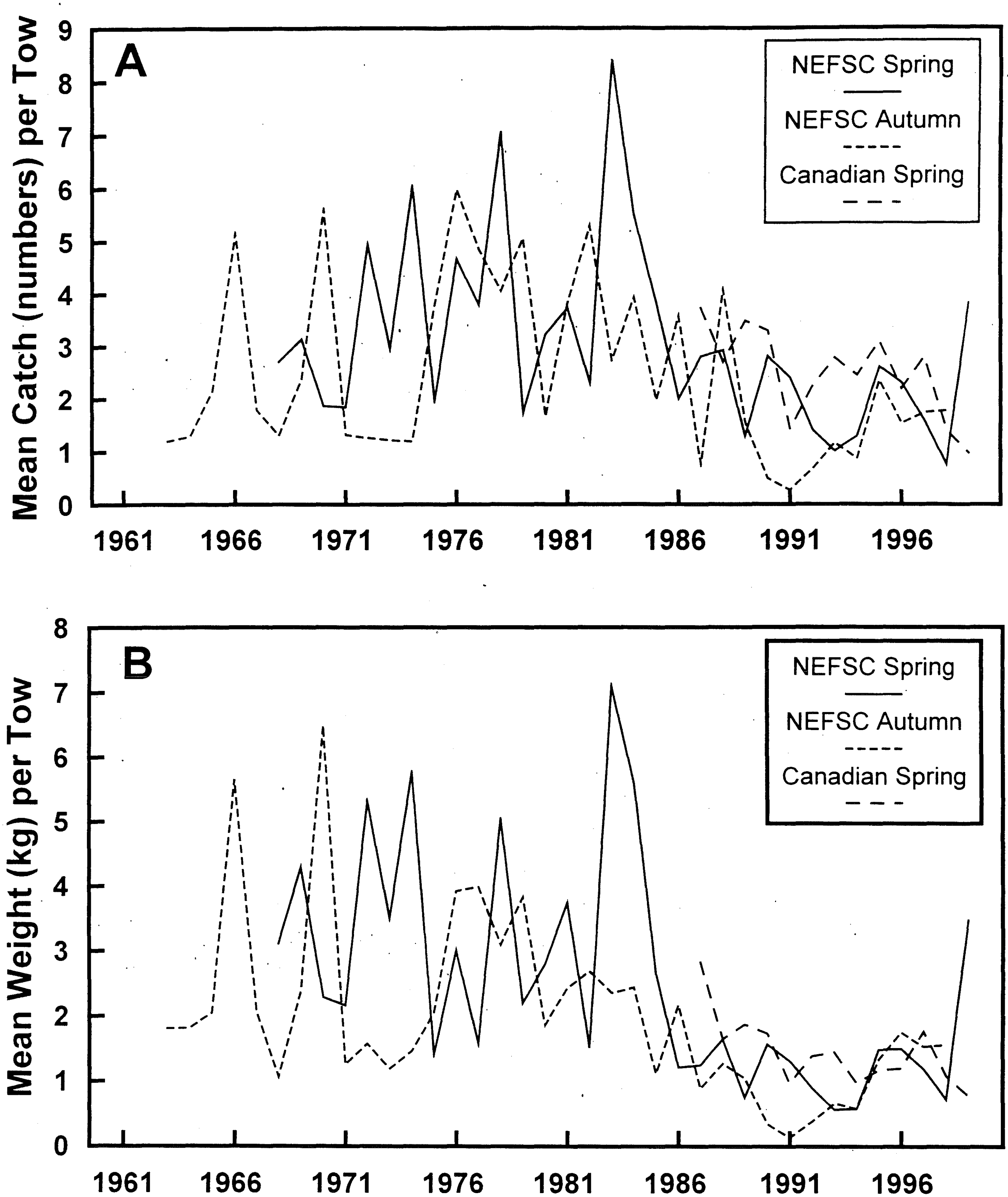

Figure I 2. U.S. and Canadian research vessel bottom trawl survey abundance (number per tow; Panel A) and biomass (kg per tow; Panel B) for Georges Bank winter flounder, 1963-1999. Canadian weight per tow was estimated using the stratified mean number per tow at length and the U.S. survey length-weight regression equation.

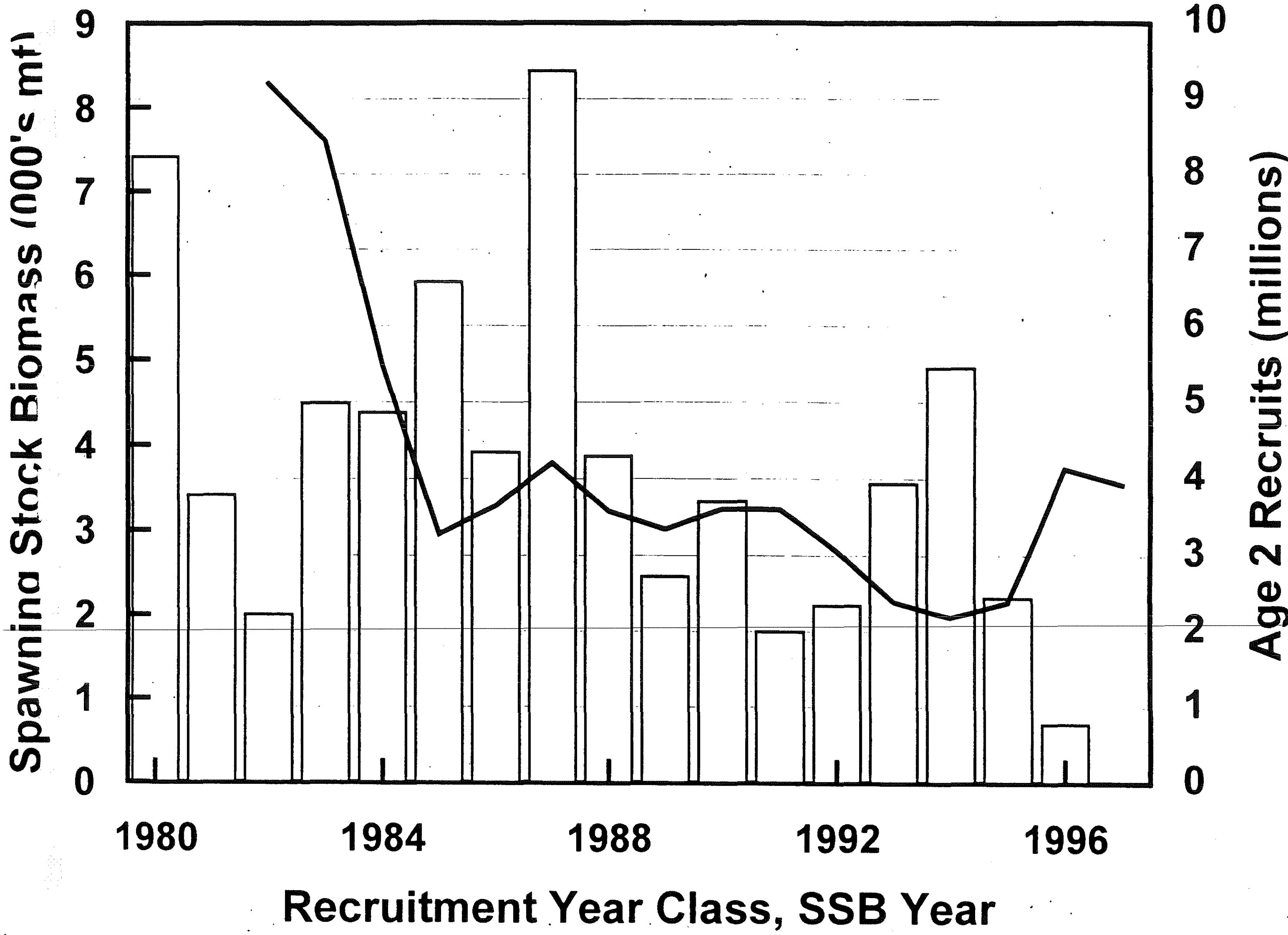

Figure I 3. Trends in spawning stock biomass (line) and age 2 recruitment (bars) estimated from Virtual Population Analysis for Georges Bank winter flounder from 1980 to 1997.

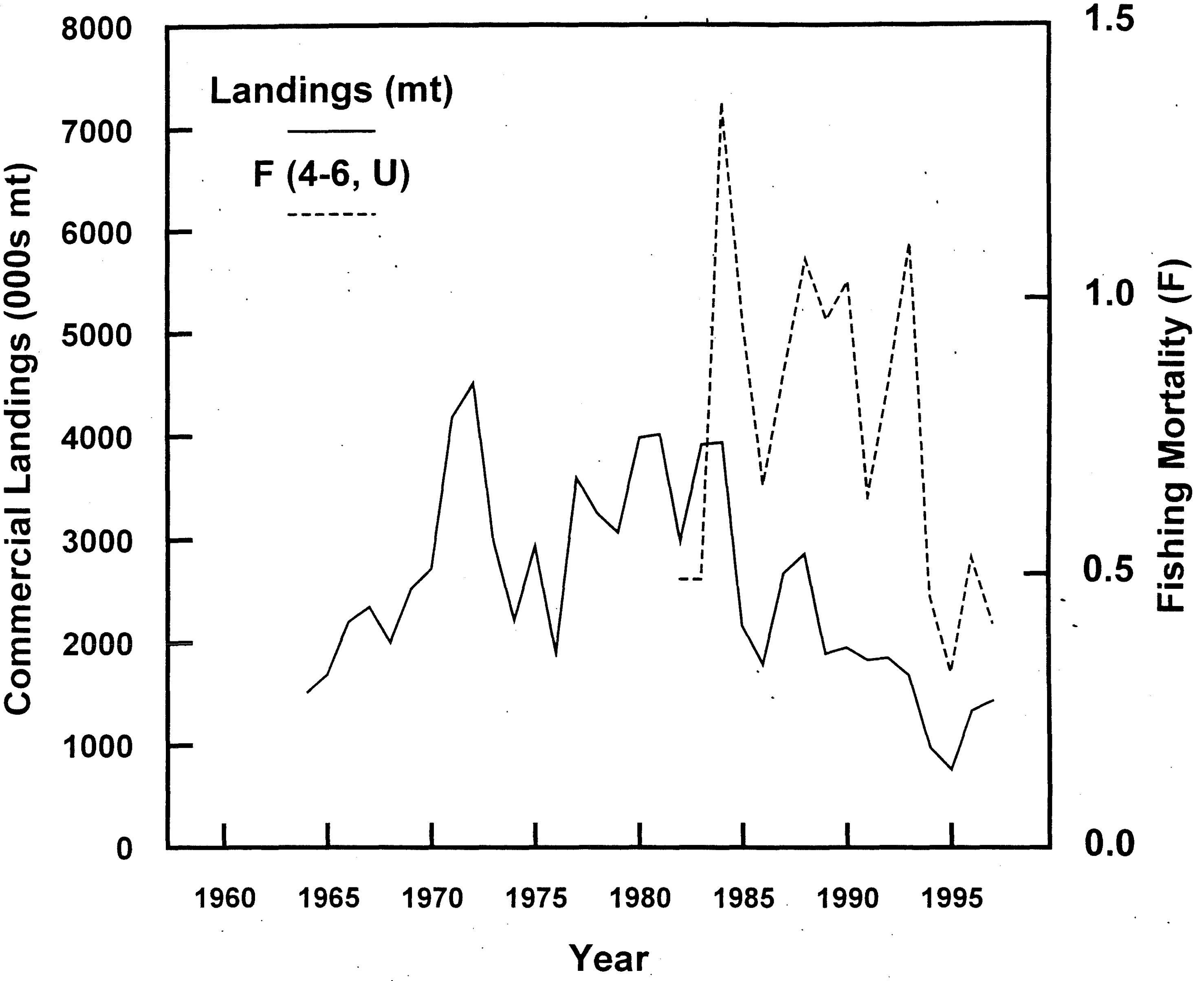

Figure 14. Trends in commercial landings (mt) and fully-recruited fishing mortality (F, ages 4-6, unweighted) estimated from Virtual Population Analysis for Georges Bank winter flounder from 1982 to 1997.

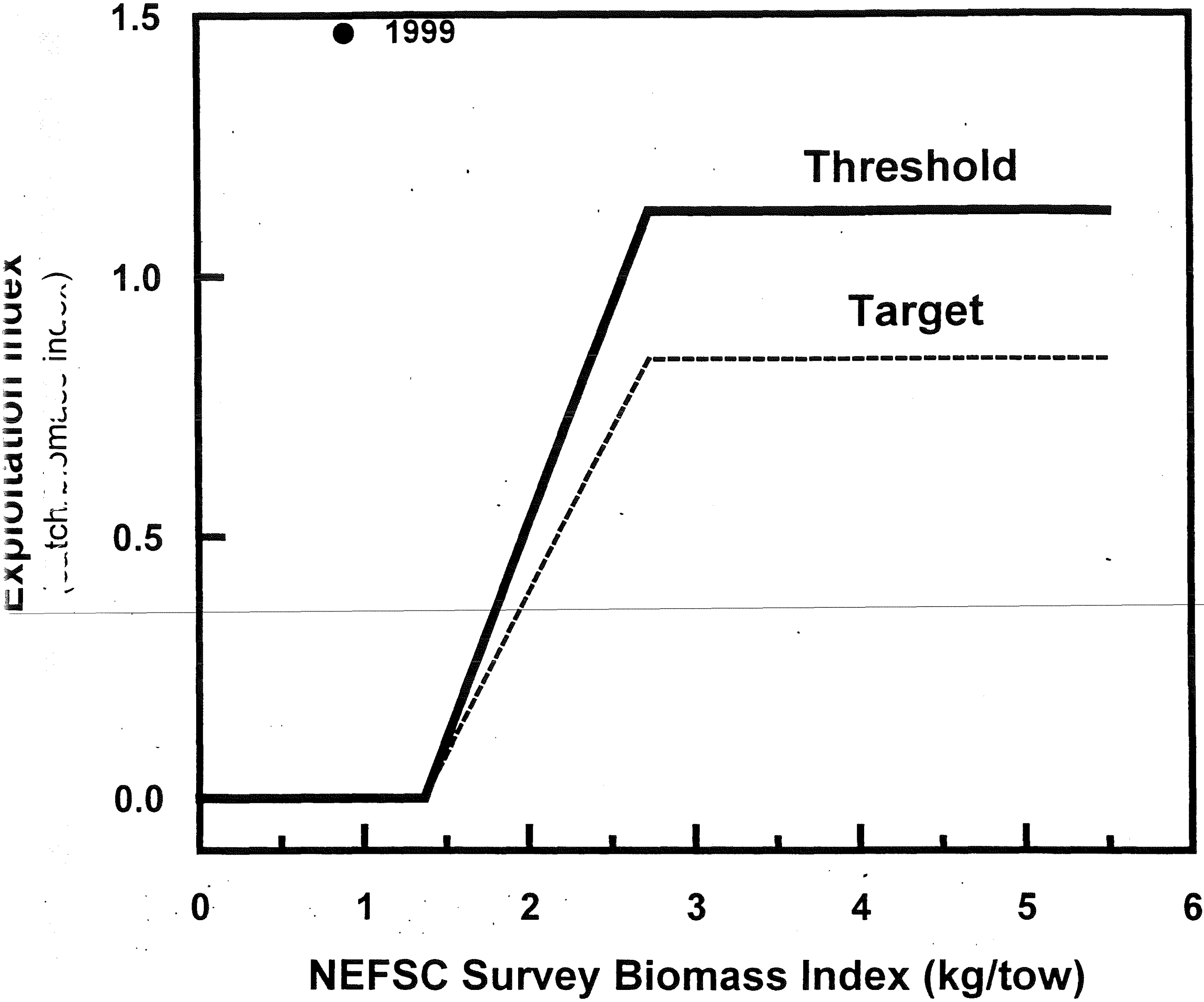

Fig ıre I 5. Harvest control rule for Georges Bank winter flounder based on survey equivalents of MSY-based reference points.

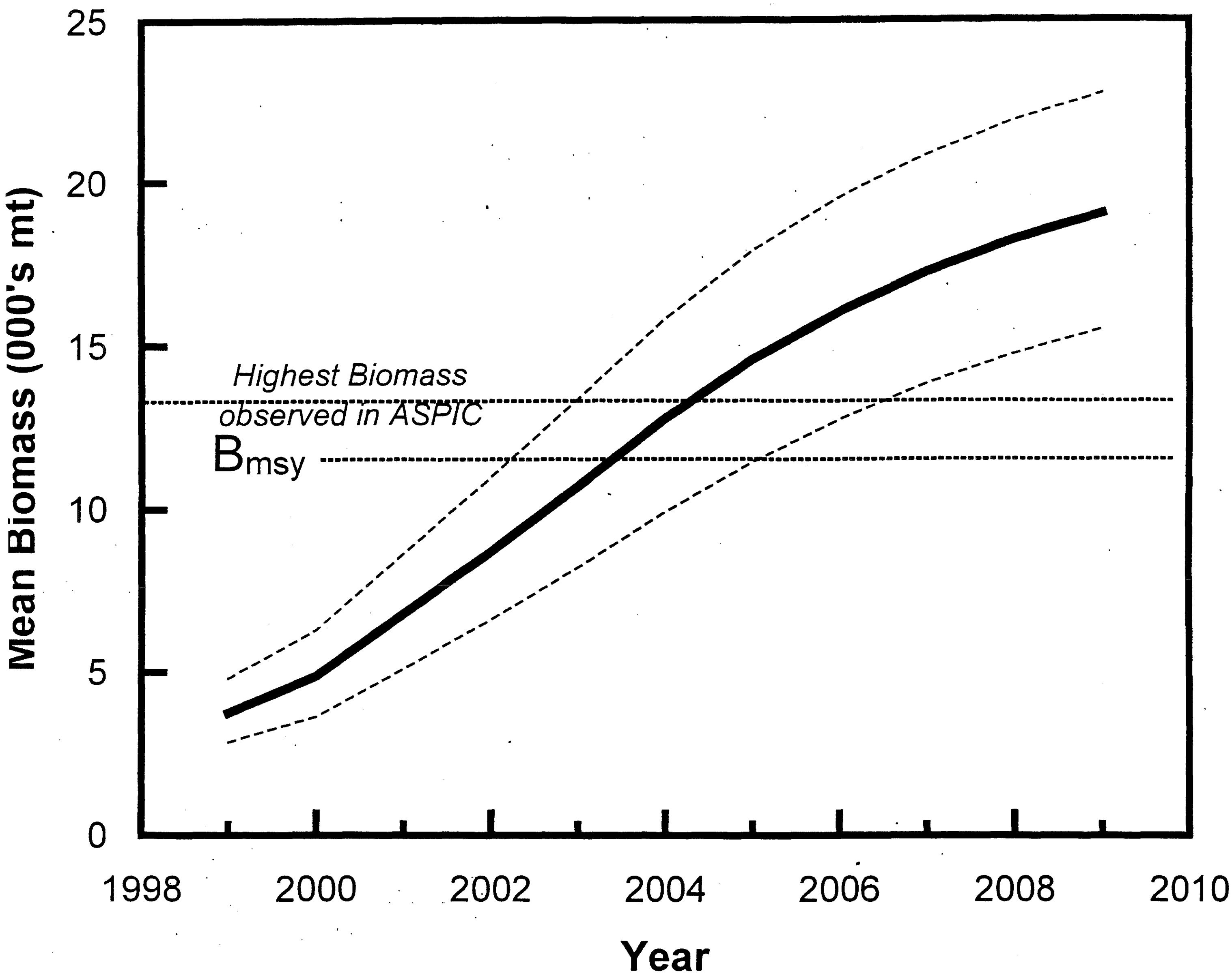

Figure I 6. Medium term projection (10-year) results for Georges Bank winter flounder. Fishing mortality was assumed to be 0.41 in 1998 and 1999 and projected at F=0.00 for 2000-2008. Age 1 recruitment was estimated from the terminal year bootstrap realizations of the VPA in 1998, and 1999-2008 recruitment was resampled from empirical age 1 recruitment estimated by the VPA calibration from 1982-1997.

J. Southern New England/Mid-Atlantic Winter Flounder by Mark Terceiro

1.0 Background

The Southern New England/Mid-Atlantic stock complex of winter flounder was last assessed by SAW 28 in December 1998, with catches through 1997 (NEFSC 1999). The assessment is for the entire stock complex, which includes several inshore spawning aggregations that individually may not demonstrate the same trend in abundance as the complex. Fully recruited (ages 4-6) fishing mortality in 1997 was estimated at 0.31 (Figure J1), corresponding to a biomass weighted F = 0.24 (given current age structure). Mean stock biomass in 1997 was estimated to be 17,900 mt (Figure J2). In the SAW 28 assessment, B_{MSY} was estimated to be 27,810 mt, MSY was estimated to be 10,200 mt, F_{MSY} was estimated to be biomass weighted F = 0.37, and the FMP Amendment 9 ten year rebuilding target biomass weighted fishing mortality was estimated to be $F_{target10}$ = 0.24 (Figure J3).

2.0 Fishery Catches and Research Survey Indices

Commercial and recreational catch was updated through 1998 (Table J1; Figure J1) and NEFSC spring and autumn survey indices were updated though spring 1999 (Table J2; Figure J4). Commercial landings were taken from NMFS NERO prorated landings reports for 1998, and were reported to be 3,240 mt in 1998. Commercial discards were assumed to be 7% of the landings, as in SAW 28 projections, and were calculated to be 231 mt for 1998. Recreational landings were taken from the MRFSS, and were estimated to be 564 mt in 1998. Recreational discards were taken from the MRFSS, using the 1997 mean weight of discards, and estimated to be 16 mt in 1998. Total landings were estimated to be 3,804 mt, total discards were estimated to be 247 mt, and total catch was estimated to be 4,051 mt in 1998.

NEFSC survey indices show an increase in stock biomass since 1993. The NEFSC spring 1999 survey biomass index (1.245 kg/tow) is the highest since 1985 (1.983 kg/tow), and is about 25% of the time series maximum in 1981 (4.762 kg/tow). The NEFSC autumn 1998 survey biomass index (2.232 kg/tow) is about 45% of the time series maximum in 1964 (4.894 kg/tow).

3.0 Forecasts for 1999-2009

Forecasts were started from the January 1, 1998 stock numbers at age estimated by VPA in the SAW 28 assessment. Mean weights at age in the stock biomass, landings and discards, partial recruitment at age, proportion mature at age, and proportion landed at age were as in the SAW 28 assessment. The reported/estimated 1998 catch was input to estimate fully recruited fishing mortality in 1998. Fully recruited fishing mortality in 1999 was assumed to be the same as in 1998. Fishing mortality in 2000 and later years was input as the biomass weighted target F (0.24) according to the FMP Amendment 9 ten year rebuilding control rule (Figure J3). The fully recruited F corresponding to the biomass weighted F control rule value changes over time in the forecast as stock age structure rebuilds.

Recruitment at age 1 in 1999 and later years was generated randomly from the empirical distribution of recruitment estimated by VPA for 1981-1998 (median recruitment of 23.5 million fish), as in the SAW 28 short term forecast. Attempts to model future recruitment using a Beverton-Holt stock-recruitment model provided unrealistic results. Using the parametric model, spawning stock biomass and recruits increased to abundances well above VPA estimates and corresponding historical survey indices, unless model parameters were tightly constrained (R/SSB ratio constrained to less than or equal to the median observed).

Forecasts indicate that fully recruited F (age 4-6) in 1998 and 1999 was 0.33, corresponding to a biomass weighted F (ages 1 and older) of 0.19 in 1998 and 1999. Increasing fishing mortality to the FMP Amendment 9 ten year rebuilding control rule biomass weighted F = 0.24 during 2000-2009 (corresponding to decreasing, fully recruited F from 0.43 to 0.40) indicates that the stock increases to slightly above B_{MSY} (27,810 mt) in 2001 at 29,000 mt, stabilizing at 33,400 mt by 2009, about 20% higher than B_{MSY} (Table J3; Figure J5). Landings increase to 6,100 mt in 2001, stabilizing at 7,300 mt (with 400 mt of discards) by 2009. The projected total yield in 2009 of 7,700 mt is about 75% of MSY (10,200 mt).

4.0 References

NEFSC. 1999. 28th Northeast Regional Stock Assessment Workshop (28th SAW). Stock Assessment Review Committee (SARC) Consensus Summary of Assessment. NMFS/NEFSC, Woods Hole Laboratory Ref. Doc. 99-08.

Table J1. Total winter flounder recreational and commercial catch for the Southern New England/Mid-Atlantic stock complex in weight (mt) and numbers (000s).

Year	Commercial Landings		Commercial Discards		Recreational Landings		Recreational Discards		Total Catch		% Discards/Total	
	mt	000s	mt	000s	mt	000s	mt	000s	mt	000s	mt	000s
1981	11,176	20,705	1,343	5,123	3,050	8,089	88	437	15,657	34,354	9.1	16.2
1982	9,438	19,016	1,149	4,271	2,457	8,392	66	341	13,110	32,020	9.3	14.4
1983	8,659	16,312	1,311	5,251	2,524	8,365	125	399	12,619	30,327	11.4	18.6
1984	8,882	17,116	986	3,936	5,772	12,756	148	745	15,788	34,553	7.2	13.5
1985	7,052	14,211	1,534	4,531	5,198	13,297	230	714	14,014	32,753	12.6	16.0
1986	4,929	9,460	1,273	4,902	2,940	6,994	66	356	9,208	21,712	14.5	24.2
1987	5,172	10,524	950	3,545	3,141	6,899	61	347	9,324	21,315	10.8	18.3
1988	4,312	8,377	904	3,728	3,423	7,359	69	416	8,708	19,880	11.2	20.8
1989	3,670	7,888	1,404	5,761	1,802	3,684	49	335	6,925	17,668	21.0	34.5
1990	4,232	7,202	673	2,567	1,063	2,485	31	201	5,999	12,455	11.7	22.2
1991	4,823	9,063	784	2,701	1,214	2,794	51	230	6,872	14,788	12.2	19.8
1992	3,816	6,759	511	1,811	393	802	15	83	4,735	9,455	11.1	20.0
1993	3,010	5,336	457	1,580	543	1,180	31	155	4,041	8,251	12.1	21.0
1994	2,159	1,948	304	344	598	1,210	34	93	3,095	3,595	10.9	12.2
1995	2,634	2,321	121	107	661	1,390	23	69	3,439	3,887	4.2	4.5
1996	2,781	2,372	173	149	689	1,555	64	168	3,707	4,244	6.4	7.5
1997	3,426	5,834	267	1,200	618	1,204	26	85	4,337	8,323	6.8	15.4
1998	3,240		231		564		16		4,051		6.1	

Table J2. Winter flounder NEFSC survey index stratified mean number and mean weight (kg) per tow for the Southern New England- Mid-Atlantic stock complex. strata set (offshore 1-12. 25. 69-76 ; inshore 1-29. 45-56).

	Spring		Fall	
YEAR	Number	Weight	Number	Weight
1963			8.554	3.283
1964			13.673	4.894
1965			15.537	4.435
1966			9.843	3.275
1967			9.109	2.745
1968	2.444	0.734	8.106	2.191
1969	5.640	3.414	6.842	1.939
1970	2.729	1.326	5.110	2.376
1971	2.035	0.756	3.862	1.232
1972	1.866	0.656	7.687	3.054
1973	7.459	2.013	2.691	0.776
1974	3.362	1.043	2.032	0.821
1975	1.136	0.354	2.358	0.742
1976	3.085	0.805	2.375	1.251
1977	4.186	1.190	4.722	1.735
1978	6.696	1.758	3.743	1.430
1979	2.965	1.069	10.058	2.606
1980	15.250	3.551	9.975	3.216
1981	18.234	4.762	9.899	3.109
1982	6.986	1.918	4.927	1.683
1983	6.262	2.469	8.757	2.691
1984	5.524	2.072	2.681	0.887
1985	5.360	1.983	2.727	0.991
1986	2.266	0.766	1.538	0.487
1987	1.763	0.568	1.167	0.419
1988	2.126	0.730	1.246	0.530
1989	2.485	0.582	1.435	0.341
1990	1.992	0.472	1.979	0.546
1991	2.473	0.692	1.950	0.708
1992	1.579	0.435	2.963	0.829
1993	0.961	0.219	1.382	0.392
1994	1.510	0.329	4.134	1.482
1995	2.097	0.592	2.253	0.626
1996	1.517	0.428	3.186	1.063
1997	1.436	0.399	7.893	2.583
1998	2.774	0.845	6.597	2.232
1999	4.171	1.245		

NOTE: 1968-1972 spring index does not include inshore strata ; 1963-1971 fall index does not include inshore strata. All indices calculated with trawl door conversion factors where appropriate.

Table J3. Ten year stochastic (median recruitment = 23.5 million fish) forecast for SNE/MA winter flounder. Forecasts started from January 1, 1998 stock numbers at age estimated by SAW 28 VPA. Mean weights at age in the stock biomass, landings and discards, partial recruitment at age, proportion mature at age, and proportion landed at age were as in the SAW 28 assessment. The reported/estimated 1998 catch was input to estimate fully recruited fishing mortality in 1998. Fully recruited fishing mortality in 1999 was assumed to be the same as in 1998. Fishing mortality in 2000 and later years was input as the biomass weighted target F (0.24) according to the FMP Amendment 9 ten year rebuilding control rule. Median mean stock biomass in thousands of metric tons. B_{MSY} = 27,810 mt.

Year	Median Mean Stock Biomass	Percent Probability Biomass > B_{MSY}
1998	22.3	5
1999	25.0	30
2000	27.3	48
2001	29.0	57
2002	30.4	64
2003	31.2	68
2004	31.8	71
2005	32.4	74
2006	32.9	76
2007	33.2	77
2008	33.3	77
2009	33.4	78

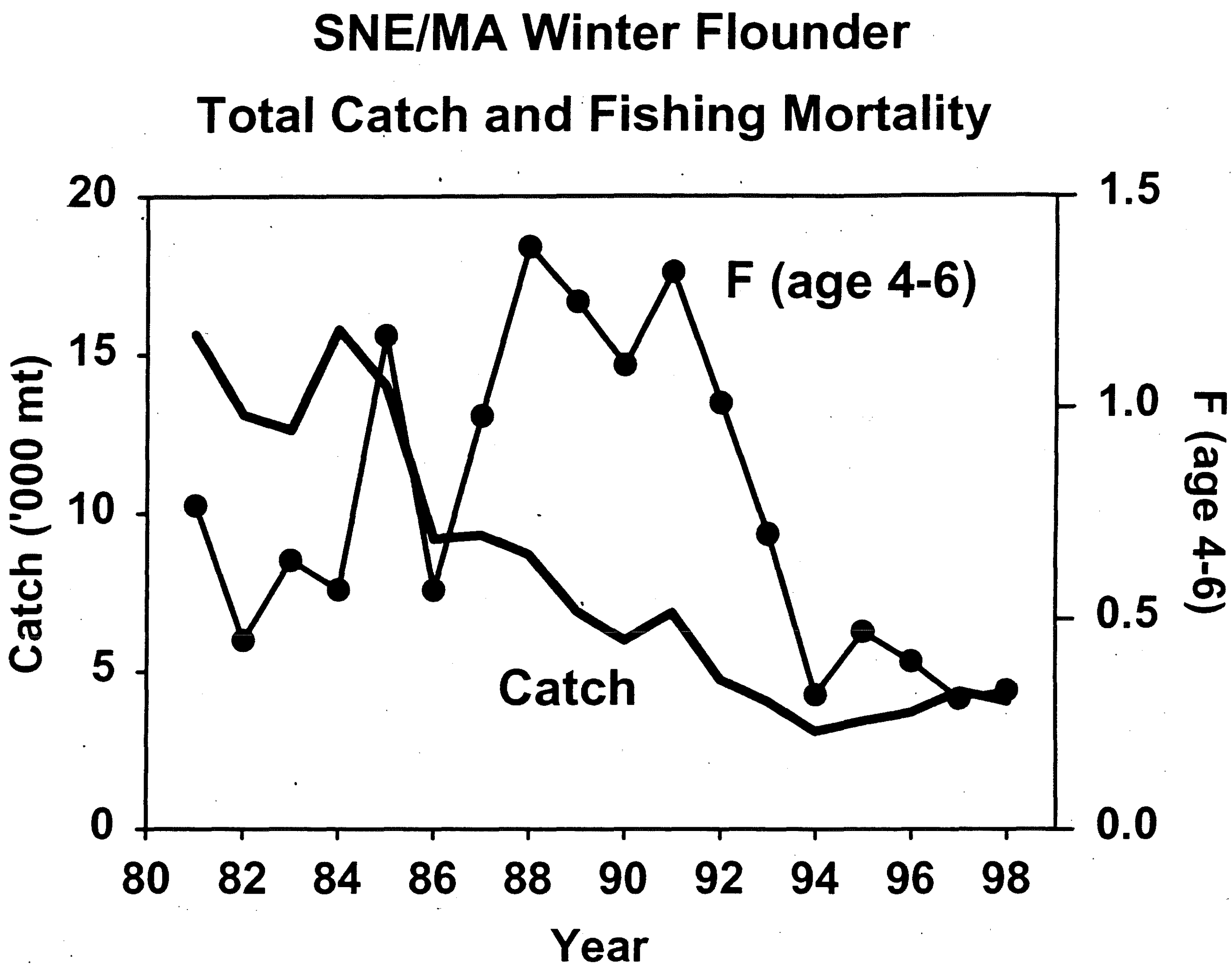

Figure J1. Total catch (landings and discards, thousands of metric tons) and fishing mortality rate (fully recruited F, ages 4-6) for SNE/MA winter flounder.

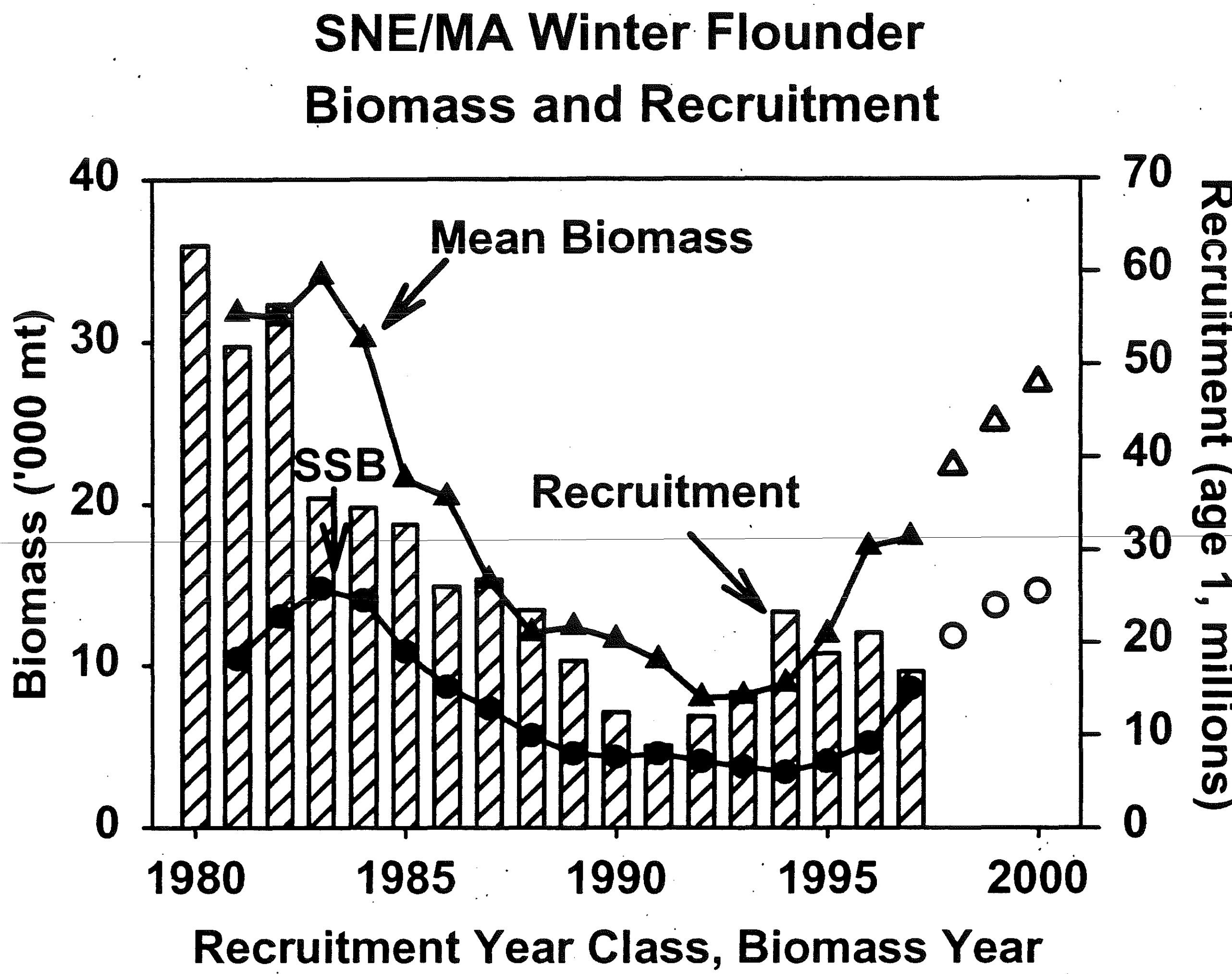

Figure J2. Mean stock biomass (B, ages 1-7+, thousands of metric tons), spawning stock biomass (SSB, ages 3-7+, thousands of metric tons) and recruitment (millions of fish at age 1) for SNE/MA winter flounder.

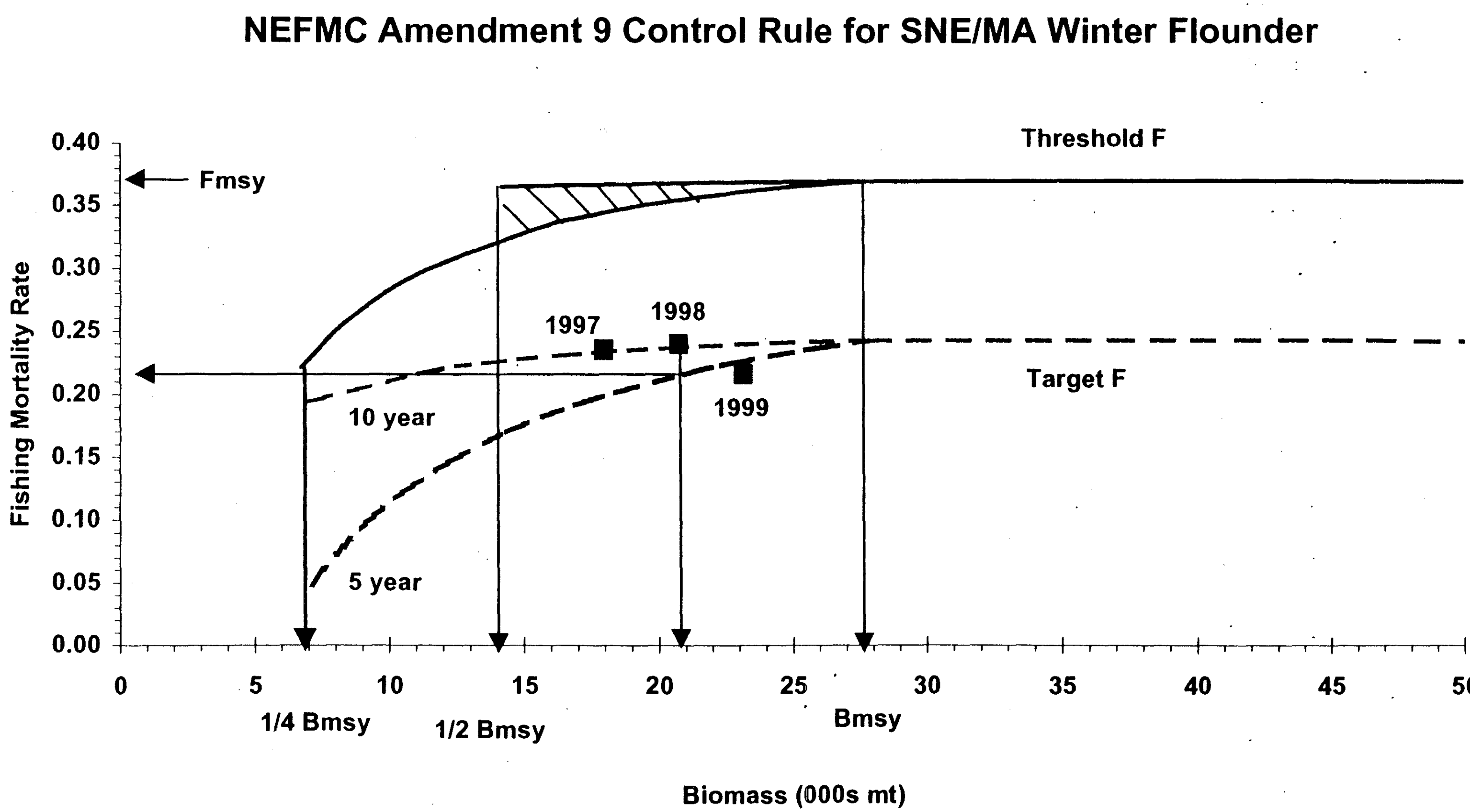

Figure J3. NEFMC FMP Amendment 9 control rule for SNE/MA winter flounder for rebuilding to B_{MSY}, with current 1997-1999 estimates of biomass weighted F and mean stock biomass.

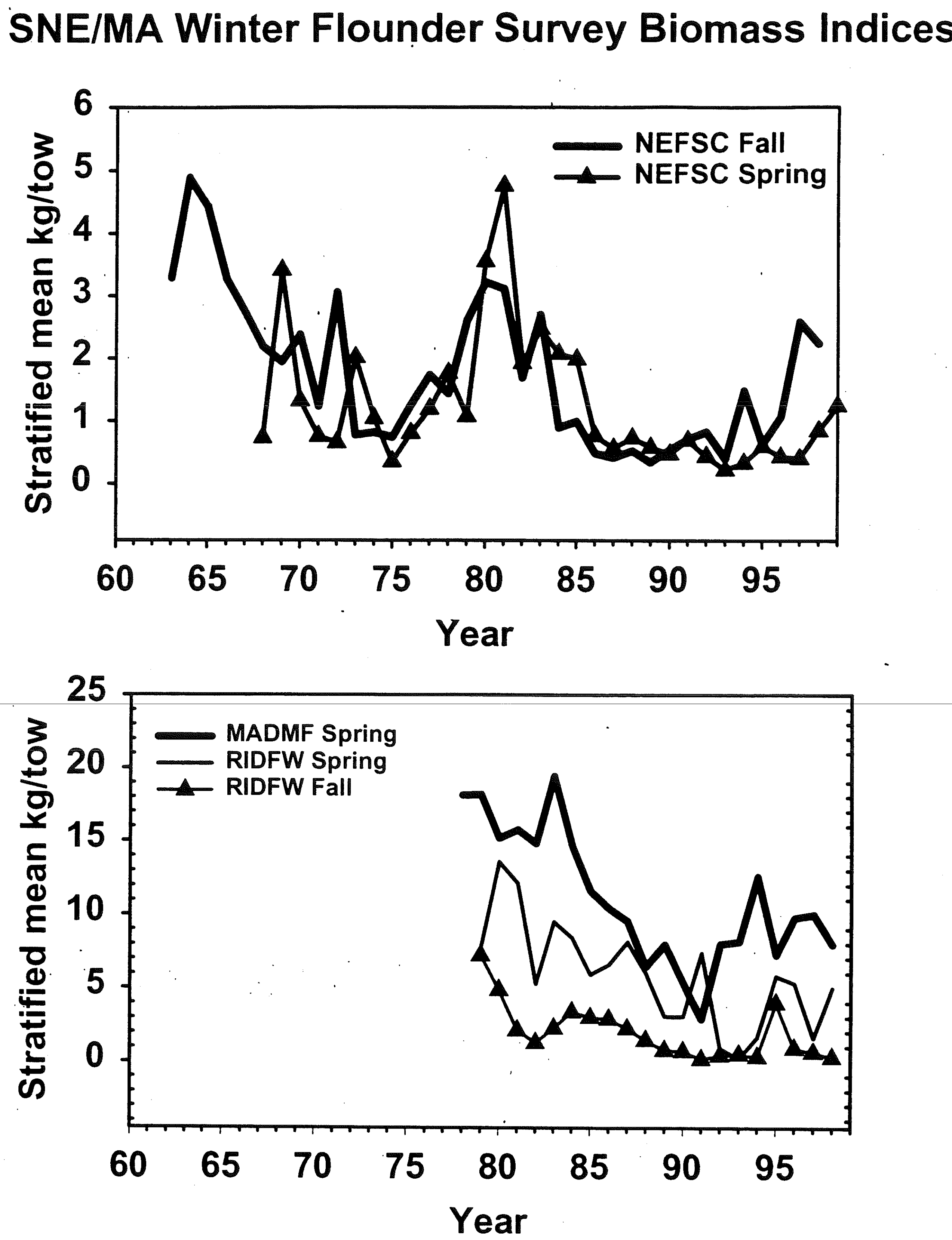

Figure J4. Trends in research survey biomass indices for SNE/MA winter flounder.

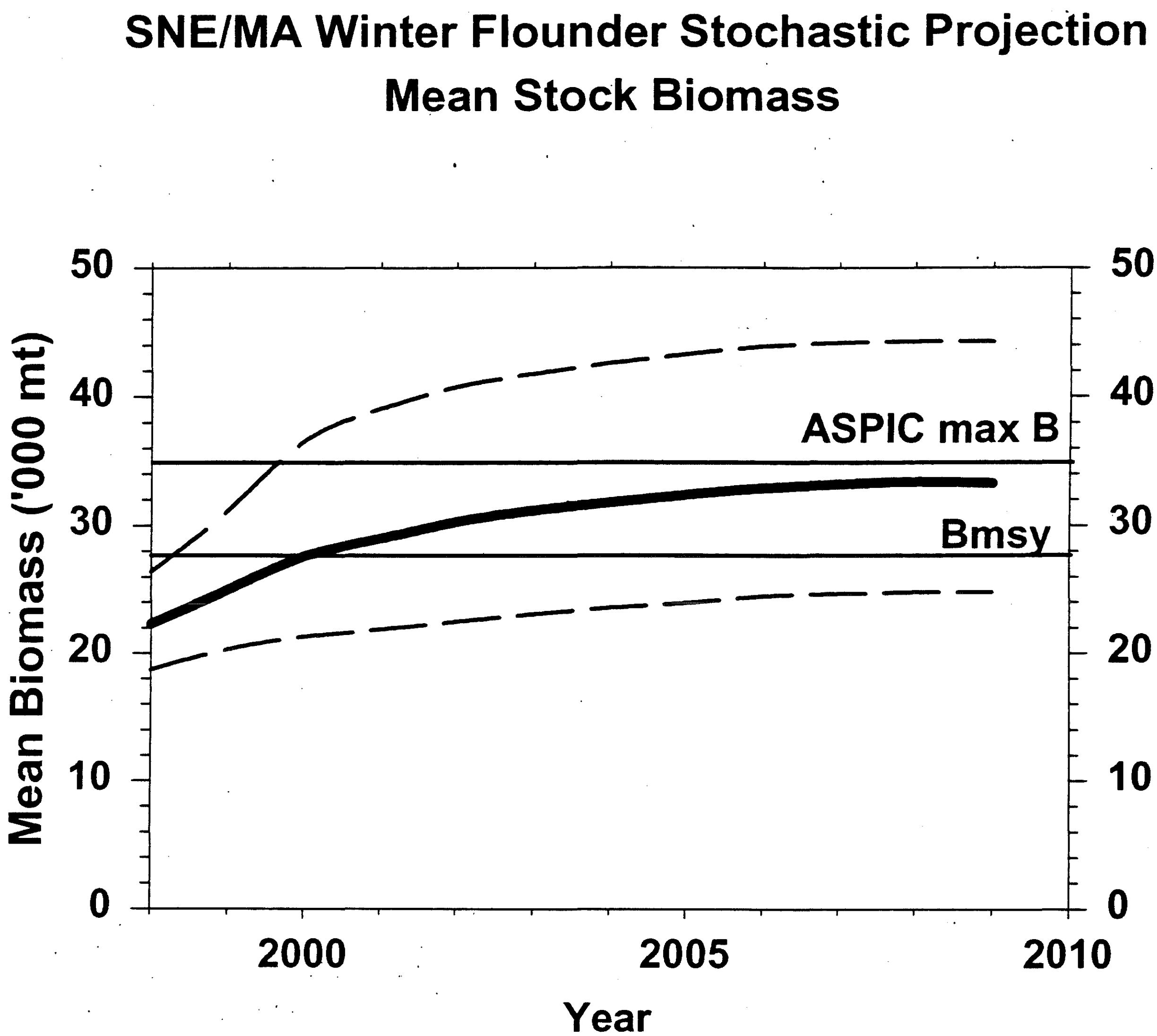

Figure J5. Ten year stochastic forecast of mean stock biomass (median [50^{th} percentile], 10^{th} percentile, and 90^{th} percentile). Horizontal lines are at maximum mean stock biomass estimated from ASPIC (ASPIC max B) and B_{MSY}.

K. Georges Bank/Gulf of Maine White Hake by K.A. Sosebee

1.0 Background

This stock was last assessed in 1998 and reviewed at SAW 28. Fully recruited fishing mortality (ages 4-8) in 1997 was estimated to be 1.15, an increase from an average of 1.0 in 1995 and 1996. Spawning stock biomass was estimated to have declined to 2,900 mt in 1997, a decline from a recent high of 9,600 mt in 1992. The strength of the 1993-1995 recruiting year classes was low. The 1996 year class was estimated to be an average year class over the time series (5.7 million). NEFSC spring and autumn research vessel bottom trawl survey indices had declined to near record low levels in 1997.

2.0 1999 Assessment

Fishery

United States commercial landings of white hake increased to 2,364 metric tons (mt) in 1998, a 6% increase from 1997 (Table 1; Figure 1). Canadian landings declined to 228 mt (21% decline). No discard estimates were derived for 1998.

Input Data and Analyses

The present assessment represents a one-year update to the previous assessment (NEFSC 1999). Stochastic projection software was used to estimate fishing mortality and biomass in 1998. Survivors from 1000 bootstrapped VPA outcomes from the previous assessment were used to start the projections. Survey data from the fall of 1998 and the spring of 1999 was aged using seasonal pooled age-length keys from 1982-1999. The age estimates for fall age-1 and spring age-2 were then used to derive an estimate of recruitment for the 1997 year class using RCT3 . The estimate and the standard error were used to generate 1000 recruitment estimates for age 1 in the projections. The 1998 year class was estimated from resampling of the previous four years (1993-1996 year classes). Reported landings were used to generate fishing mortality in 1998 and 1999 fishing mortality was assumed to be the same as 1998.

3.0 Assessment Results

NEFSC research vessel bottom trawl survey abundance and biomass indices for white hake remained relatively low through autumn 1998 and spring 1999 (Table 2, Figure 2). The autumn 1998 indices declined slightly from the 1997 levels, while the spring 1999 indices increased from the 1998 levels because of the 1996 year class. Recruitment in 1997 was estimated to be 1.9 million fish, the second lowest value in the time series (Figure 4).

Fully recruited fishing mortality (ages 4-8) in 1998 is estimated to be 1.09 (Table 3, Figure 3), a slight decline from 1.15 in 1997, as reported in the previous assessment. Spawning stock biomass is estimated at 2,717 mt in 1998, a decline from 2,945 mt in 1997, as reported in the previous assessment (Table 3, Figure 4). The most recent high level of SSB (9,563 mt) occurred in 1992. Mean biomass increased slightly to 5,471 in 1998 due to the 1996 year class and to 5,498 in 1999 (Tables 3, Figure 4). Biomass weighted fishing mortality (ages 1+) has declined from 0.8 in 1996 to 0.47 in 1998 (Figure 3). Accounting for the precision in the current assessment, there is a 90% probability that fully recruited F in 1998 was greater than 0.8, SSB in 1998 was less than 3,500 mt, and mean biomass was less than 6,800 mt.

4.0 Forecasts

Forecasts of stock size and landings were performed over the medium term (1999-2009) using stochastic projection software. Forecasts continued from the 1998 projection. Fully recruited fishing mortality in 1999 was assumed equal to that in 1998, given the unpredictability of likely 1999 annual landings. A Beverton-Holt stock-recruitment model was attempted for this stock, but gave results that were infeasible (mean biomass of three times the carrying capacity). Recruitment was estimated using a stochastic resampling of the observed recruitment estimates for the 1984-1996 year classes derived from the VPA. The resampling was partitioned into three time periods. For the 1999- 2001 period, recruitment was resampled from only the last four years (1993-1996 year classes: GM recruitment = 2.5 million). The second time period extended the recruitment values sampled to the 1988 year class (1988-1996 year classes: GM recruitment = 4.3 million). This was used for 2002-2005. For the final time period, the whole set of recruitment values from 1984-1996 was used (1984-1996 year classes: GM recruitment = 4.6 million). The concept for this approach is similar to that for Gulf of Maine cod. In the near term, given the low recruitments and R/SSB ratios in three of the last four years, recruitment is more likely to be similar to these values. As the projection moves farther from the present, the likelihood of achieving different levels of recruitment are greater. The partial recruitment vector, maturity ogive, and mean weights at age are the same as those used in the yield per recruit calculation reported in NEFSC, 1999 (Table 3).

Mean biomass in 1999 was estimated at 5,498 mt. According to the SFA control rule, when mean biomass declines below 6,900 mt, fishing mortality should be zero (Figure 5). Thus, the projections were run with a fishing mortality of zero for 2000-2009. Biomass trajectories with 80% confidence limits are given in Figure 6. At a fishing mortality of zero, B_{msy} can be achieved with a greater than 50% probability by 2004 (Table 5, Figure 6).

5.0 Sources of Uncertainty

*1998 fishing mortality may be uncertain if landings are not complete and if the PR has changed.

* The time series of recruitment values is short and may not reflect the entire range of values.

From SARC 28:

* Discards are not incorporated into the VPA catch at age.

* Red hake may be mis-identified as white hake and vice versa.

* Missing ages in the survey age/length keys were interpolated.

* White hake may move seasonally into and out of the defined stock area.

6.0 References

NEFSC. 1999. 28th Northeast Regional Stock Assessment Workshop (28th SAW). Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NMFS/NEFSC, Woods Hole Laboratory Ref. Doc. 99-08.

Table K1. Total Landings (mt.live) of white hake by country from the Gulf of Maine to Cape Hatteras (NAFO Subareas 5 and 6), 1964-1998.

	Canada	USA	Other	Grand Total
1964	29	3016	0	3045
1965	0	2617	0	2617
1966	0	1563	0	1563
1967	16	1126	0	1142
1968	85	1210	0	1295
1969	34	1343	6	1383
1970	46	1807	280	2133
1971	100	2583	214	2897
1972	40	2946	159	3145
1973	117	3279	5	3401
1974	232	3773	0	4005
1975	146	3672	0	3818
1976	195	4104	0	4299
1977	170	4976	338	5484
1978	155	4869	29	5053
1979	251	4044	4	4299
1980	305	4746	2	5053
1981	454	5969	0	6423
1982	764	6179	2	6945
1983	810	6408	0	7218
1984	1013	6757	0	7770
1985	953	7353	0	8306
1986	956	6109	0	7065
1987	555	5818	0	6373
1988	534	4783	0	5317
1989	583	4548	0	5131
1990	547	4927	0	5474
1991	552	5607	0	6159
1992	1138	8444	0	9582
1993	1681	7466	0	9147
1994	955	4737	0	5692
1995	481	4333	0	4814
1996	372	3287	0	3659
1997	290	2225	0	2515
1998	228	2364	0	2592

Table K2 Stratified mean catch per tow in numbers and weight (kg) for white hake from NEFSC offshore spring and autumn research vessel bottom trawl surveys (strata 21-30,33-40), 1963-1999.

	Spring			Autumn		
Year	No/Tow	Wt/Tow	Length	No/Tow	Wt/Tow	Length
1963				5.00	6.31	46.2
1964				1.77	4.14	56.3
1965				4.39	6.86	50.4
1966				6.79	7.67	45.1
1967				3.92	3.64	42.6
1968	1.60	1.74	44.1	4.24	4.54	44.9
1969	3.76	5.09	46.3	9.24	13.09	46.8
1970	5.84	11.86	52.9	8.05	12.82	51.3
1971	3.31	5.14	51.3	10.38	12.10	43.6
1972	10.18	12.66	47.3	12.52	13.10	45.2
1973	9.24	12.22	49.9	9.05	13.46	51.7
1974	8.08	13.99	55.0	5.35	11.00	54.5
1975	9.32	11.22	44.7	5.28	7.23	48.5
1976	9.98	17.01	52.7	6.04	10.56	54.7
1977	6.13	11.01	55.5	9.78	13.74	47.8
1978	3.22	6.14	51.8	7.87	12.54	50.2
1979	5.26	4.97	43.0	5.62	10.31	53.1
1980	10.38	13.96	49.7	10.86	16.66	48.8
1981	17.09	19.92	45.9	8.70	12.16	49.9
1982	6.06	8.91	51.0	1.96	2.11	46.7
1983	3.23	3.12	43.7	8.22	10.79	48.8
1984	2.75	4.17	51.4	5.32	8.23	51.9
1985	4.33	5.38	48.5	9.37	9.74	42.9
1986	8.24	5.61	40.0	14.42	11.56	41.9
1987	7.15	6.44	45.3	7.59	9.62	49.2
1988	4.52	3.69	41.9	8.12	9.88	46.1
1989	3.65	3.22	43.0	11.76	9.23	40.5
1990	11.11	18.37	53.3	13.09	10.58	41.5
1991	8.42	6.14	41.6	13.22	12.20	44.6
1992	7.59	7.11	45.1	10.16	11.24	47.7
1993	7.93	6.84	45.1	11.35	11.66	45.2
1994	4.59	3.17	40.1	8.44	7.02	42.3
1995	4.38	4.02	44.1	9.54	8.20	40.8
1996	2.87	3.07	45.9	4.52	6.35	51.2
1997	1.88	0.89	38.4	4.69	4.55	41.5
1998	2.25	1.09	37.7	4.41	4.27	44.5
1999	3.32	2.97	44.6			

Table K3. Input data and results from stochastic projections at fishing mortality of zero.

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
1	0.0000	1.0000	0.0400	0.199	0.124
2	0.0399	1.0000	0.2600	0.544	0.340
3	0.5191	1.0000	0.7000	1.066	0.756
4	1.0000	1.0000	0.8900	1.910	1.437
5	1.0000	1.0000	0.9800	3.069	2.416
6	1.0000	1.0000	0.9800	4.393	3.681
7	1.0000	1.0000	1.0000	6.040	5.175
8	1.0000	1.0000	1.0000	7.886	6.910
9+	1.0000	1.0000	1.0000	13.200	13.200

Year	Mean Biomass Median	Prob. of Exceeding Bmsy
1998	5.471	0.000
1999	5.498	0.000
2000	6.761	0.000
2001	10.231	0.003
2002	14.286	0.029
2003	19.297	0.254
2004	25.132	0.716
2005	33.252	0.985
2006	40.014	1.000
2007	47.189	1.000
2008	54.347	1.000
2009	61.199	1.000

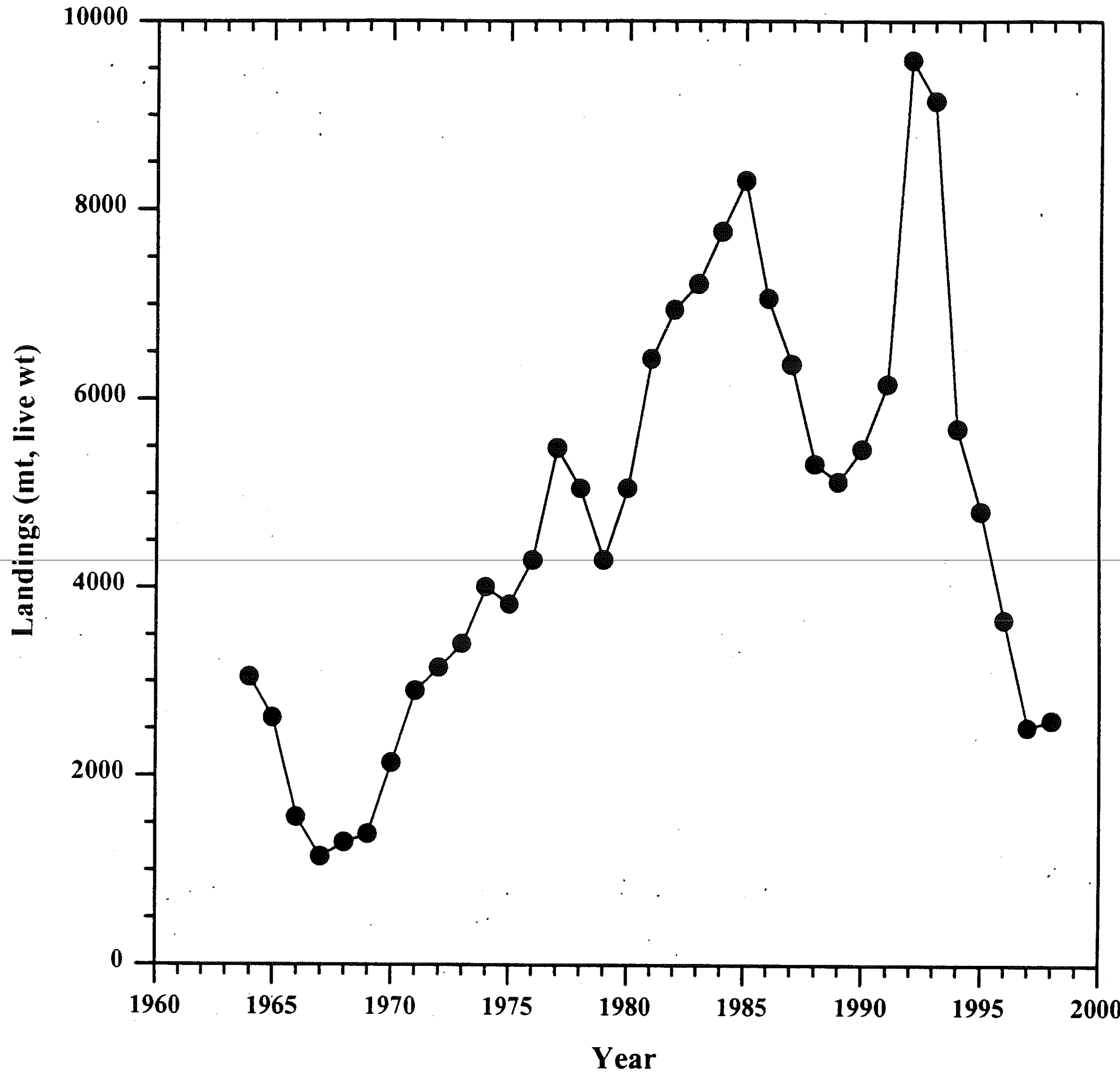

Figure K1. Total landings of white hake from the Gulf of Maine to Mid-Atlantic region, 1964-1998.

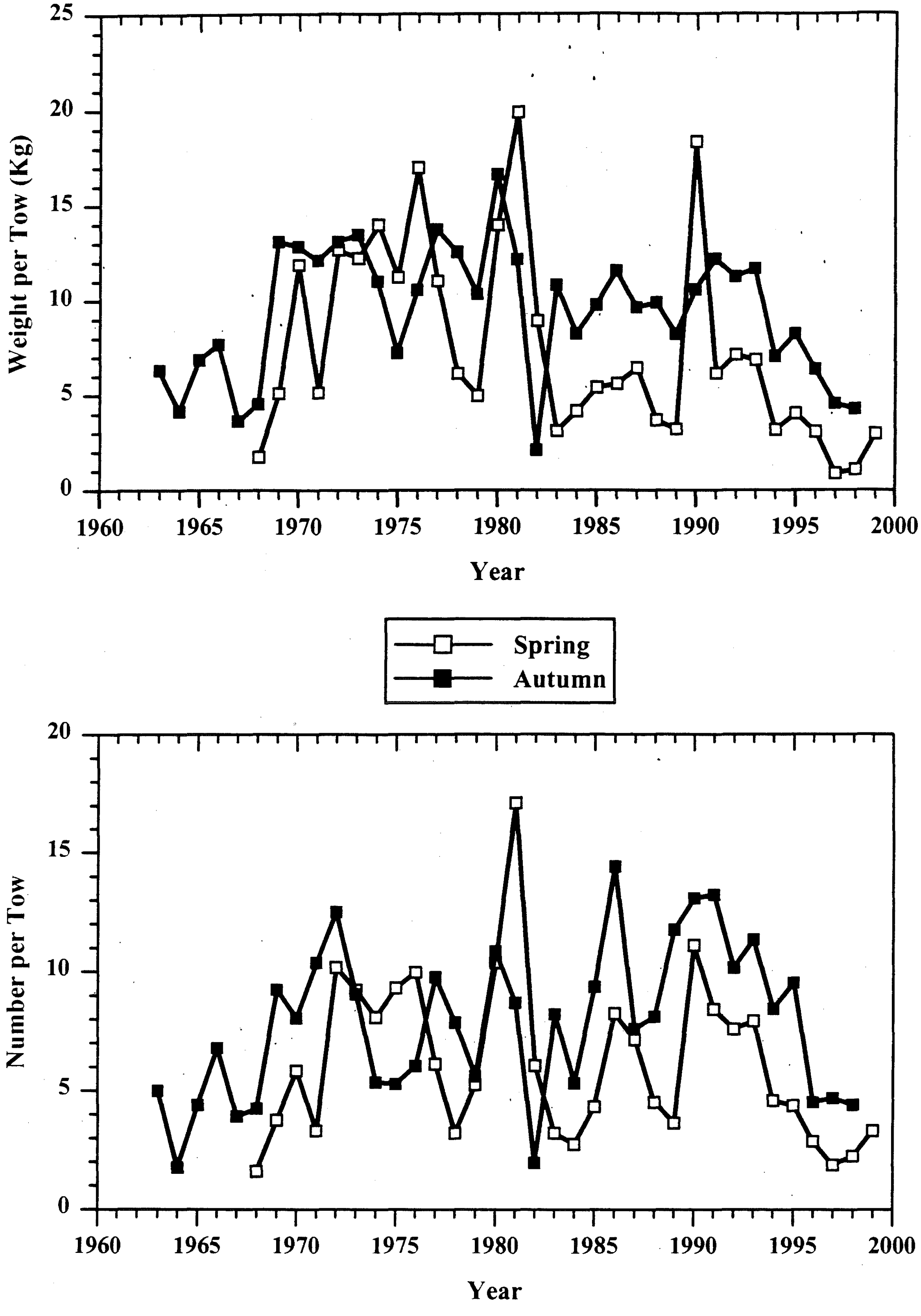

Figure K2. White hake indices of biomass (top panel) and abundance (bottom panel) from the NEFSC bottom trawl spring (open squares) and autumn (solid squares) surveys in the Gulf of Maine to Northern Georges Bank region (offshore strata 21-30, 33-40).

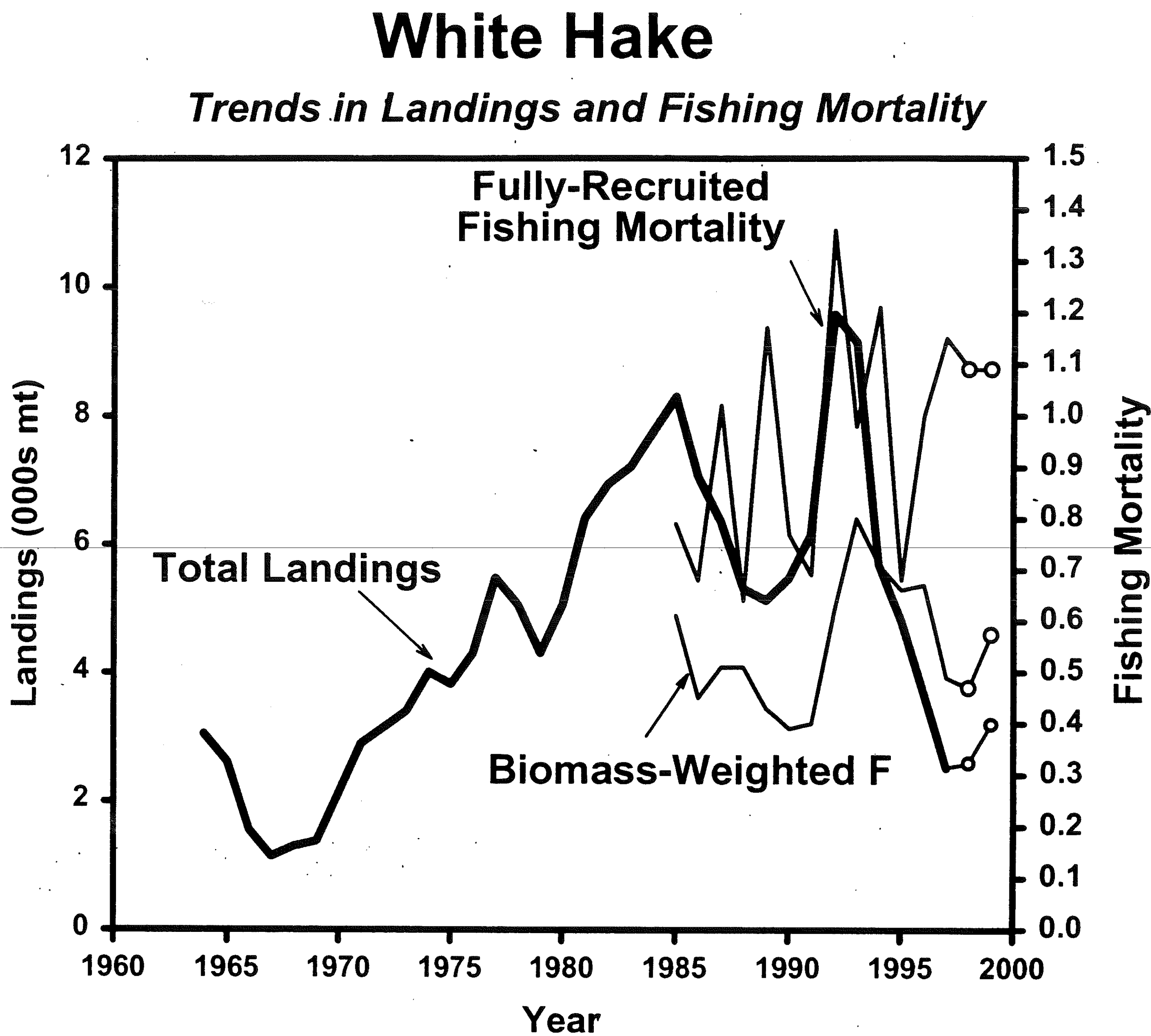

Figure K3. Total commercial landings and fishing mortality from the VPA calibration (solid thick lines) and the projection (open circle).

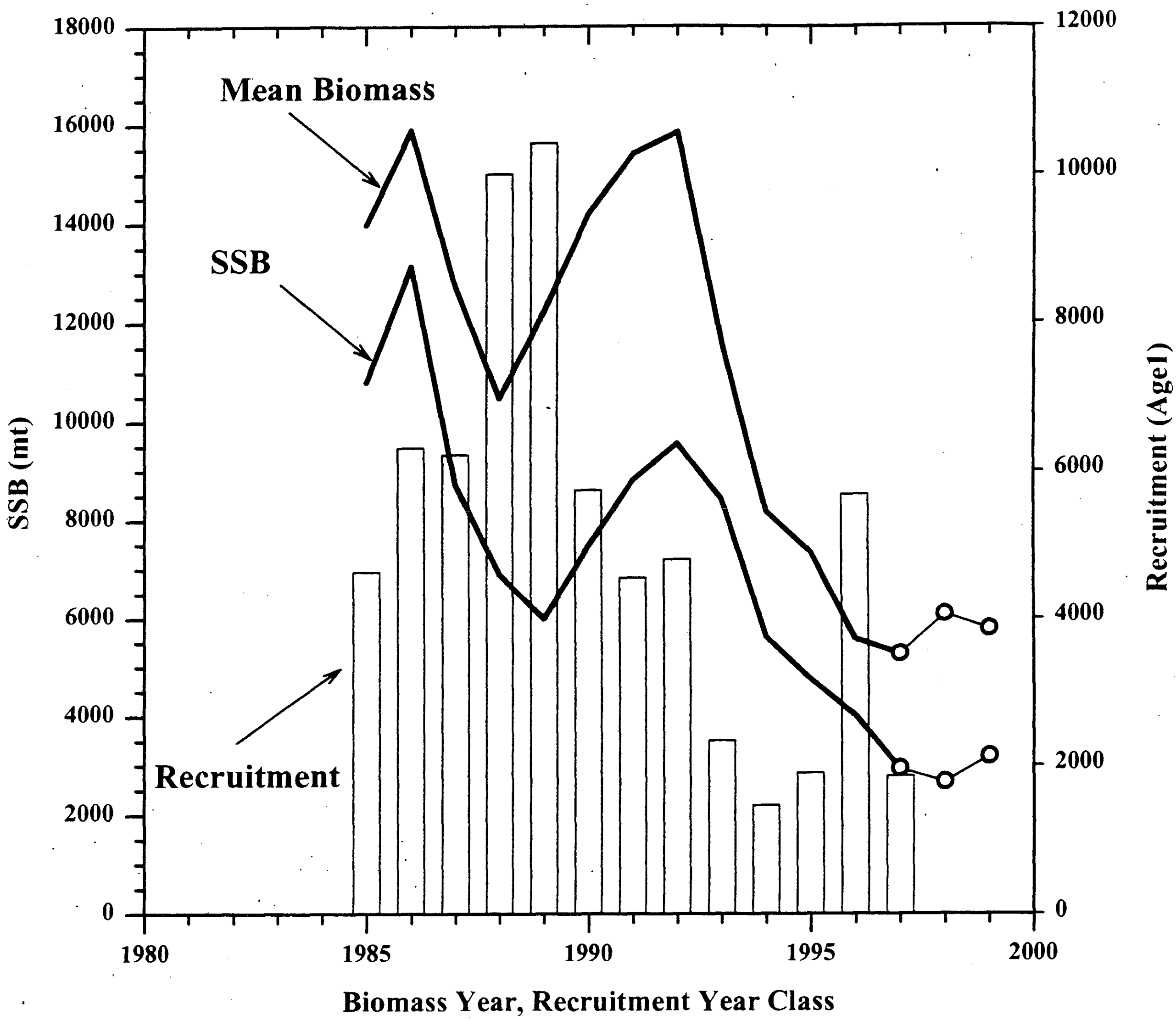

Figure K4. Mean biomass, spawning stock biomass and recuitment of white hake from the Gulf of Maine to Mid-Atlantic region. (Solid lines are VPA estimates. Circles are projection estimates.)

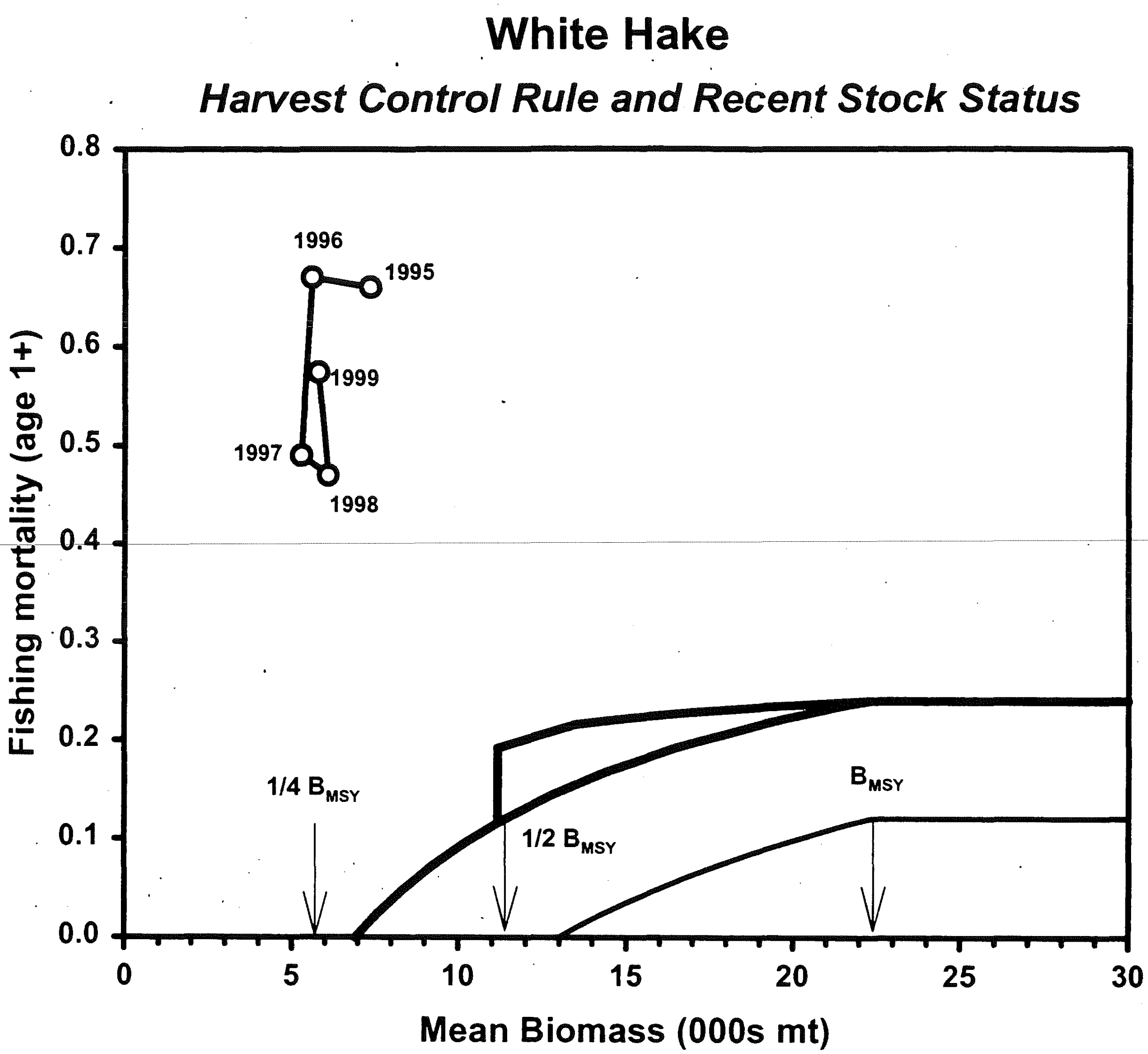

Figure K5. Harvest control rule for white hake.

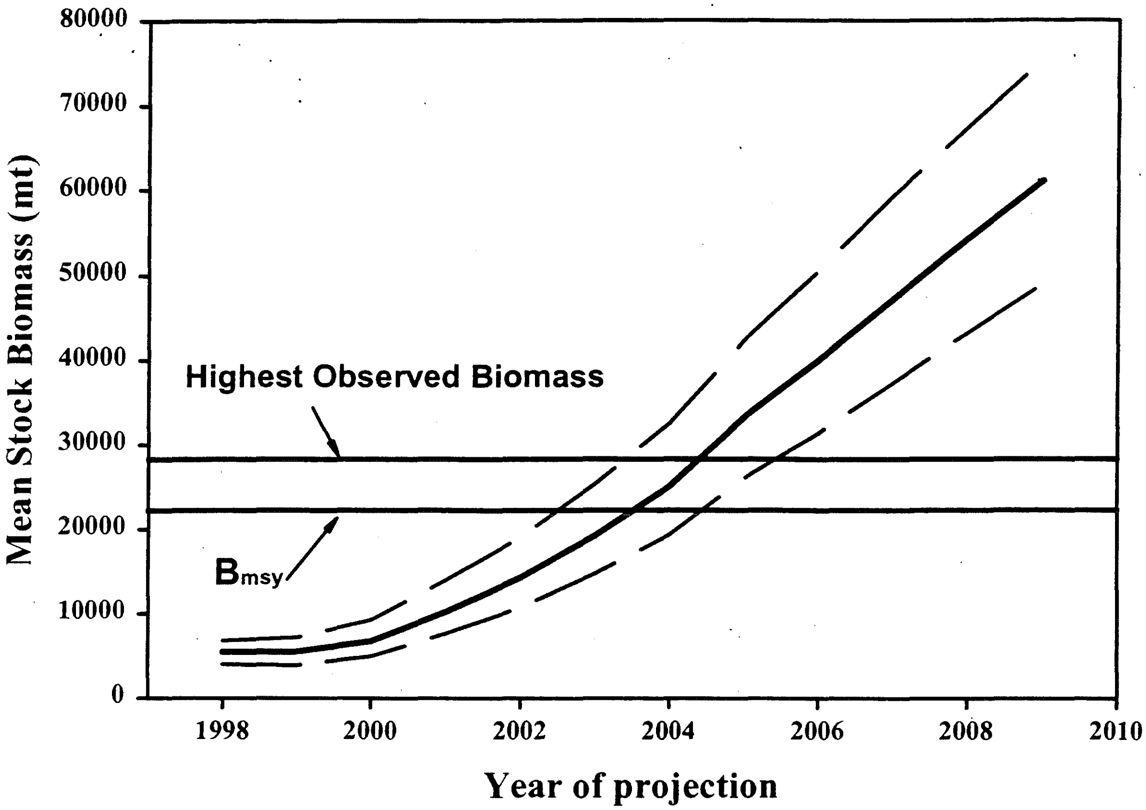

Figure K6. Results from stochastic projections at fishing mortality of 0. The dashed lines represent the 10th and 90th percentiles.

Section 4. Working Group Comments and Recommendations

1. Survivorship is increasing for Georges Bank haddock, Georges Bank yellowtail and witch flounder and decreasing for cod stocks. Possible patterns seen in year of maximum recruitment and minimum recruitment among stocks may reflect the impact of environmental factors on recruitment. A suggestion was made to expand research to include more stocks and to begin a collaborative research effort with Canadian scientists.

2. Some stocks such as witch flounder and American plaice do not show a relationship between stock and recruitment, but these stocks have short time-series that do not contain sufficient contrast for these methods. Analyses were done to determine how to incorporate recruitment in the out-years of the projections. Some assessments will use a Beverton-Holt S/R model while others will re-sample observed recruitments from the empirical data.

3. The assessments for some stocks including Gulf of Maine cod and Georges Bank cod have displayed a retrospective pattern in recent years. In particular, for both cod stocks, fishing mortality on the fully recruited ages in the last year of the assessment has been underestimated since 1995. This may result from an overestimation of the stock sizes of these ages. In addition, recruitment has been underestimated somewhat, although the converged estimates still indicate very low recruitment in recent years.

4. Truncated age distributions can have a negative effect on spawning success which in turn, can have an impact on the variability of recruitment, especially the frequency of large year classes. Georges Bank haddock was cited as an example.