K. Georges Bank Winter Flounder by **Lisa Hendrickson**

1.0 Background

The Georges Bank winter flounder stock was last assessed in October 2002 during a Groundfish Assessment Review Meeting (GARM) meeting (NEFSC 2002c). The assessment updated the SAW 34 (NEFSC 2002a) formulation of a biomass dynamics model known as ASPIC Prager 1995) that incorporated landings (1964-2001) and biomass indices from the NEFSC autumn (1963-2001) and spring (1968-2002) bottom trawl surveys. Model results indicated a reasonable fit to the input data with no strong retrospective pattern in the fishing mortality or biomass estimates. Fishing mortality rates were at or below F_{MSY} during 1995-2001. Average total biomass increased during 1994 through 2001 and was slightly above B_{MSY} in 2001. The 2001 estimates of fishing mortality rate (0.25) and total biomass (9,805 mt) indicated that the stock was not overfished and overfishing was not occurring in 2001.

After the 2002 GARM, the biological reference points adopted at SAW34 were re-examined and use of the absolute estimates of F_{MSY} and B_{MSY}, rather than survey-based equivalents, were recommended (NEFSC 2002b). In addition, medium term stochastic projections were generated using ASPIC software for 2002-2008 using bootstrap distributions of stock biomass in 2001 generated from the SAW 34 ASPIC model formulation and assuming F_{2002}=F_{2001} and $F_{2003\text{-}2008}$=F_{MSY}. Projected biomass was maintained at B_{MSY} throughout the projection time series with high probability. Projected catch increased to 3,000 mt and was also maintained throughout the projection time series.

2.0 Assessment Results

Stock status was assessed from the results of an updated run of the SAW 34 formulation of an ASPIC model, but version 5.10 (Prager 2004) of the ASPIC software was used rather than version 3.7.2 which was used in the 2002 assessment. The major software changes in ASPIC version 5.10 are estimation of the *K* parameter instead of *r*, a change in starting biomass parameterization from B_1/B_{MSY} to B_1/K, and model implementation using a continuous time step.

The new version of the ASPIC software was run using the input data input file from the 2002 GARM to determine the effect of the software changes on the assessment results. Similar results were obtained for the two model runs (Table K1), so the new version of the software was then run with the updated time series data that included the NEFSC survey biomass indices for autumn of 2002-2004 and spring of 2003-2005, as well as total landings for 2002-2004. Bias-corrected parameter estimates and 80% confidence intervals were computed from 500 bootstrap trials. Results from the updated model run showed a decrease in the bias-corrected catchabilities (*q*) of both the spring and autumn surveys. Bias-corrected estimates were lower for relative biomass (B_{2004}/B_{MSY}) and higher for relative fishing mortality (F_{2004}/F_{MSY}) in comparison to the 2001 estimates of these parameters.

2.1 <u>The Fishery</u>

Total commercial landings of Georges Bank winter flounder are predominately from U.S. fisheries, but also include landings from Canadian fisheries. Prior to 1978, USSR fleets also landed winter flounder from Georges Bank. After 1993, Canadian landings increased and reached a peak of 500 mt in 2001, comprising 25% of the total landings. Thereafter, Canadian landings declined to 200 mt in 2004.

Total landings peaked at 4,500 mt in 1972 then declined between 1984 and 1995 from 3,900 mt to 800 mt, respectively (Table K2 and Figure K1). Total landings have been increasing since 1995, and during 1999 to 2004, increased sharply from 1,000 to 3,100 mt, respectively.

Discarding of winter flounder occurs in the U.S. multi-species bottom trawl fishery and the scallop dredge fishery. However, data from the Observer Program (1989-2000) and Vessel Trip Report (1994-2000) databases were insufficient to produce reliable estimates of the magnitude or size and age composition of these discards (NEFSC 2002a).

2.2 Research Survey Indices

Relative biomass (stratified mean kg per tow) and abundance (stratified mean number per tow) indices from the NEFSC spring (April, 1968-2005) and autumn (October, 1963-2004) bottom trawl surveys (offshore strata 13-22), as well the Canadian spring bottom trawl surveys (February, 1987-2005), for strata 5Z1-Z4, are presented in Table K3. Biomass indices from all three surveys are presented in Figure K2. Canadian survey indices were not included in the current assessment because some winter flounder habitat on Georges Bank cannot be sampled by the survey gear and the inclusion of these indices in previous ASPIC model runs resulted in poor model fits (NEFSC 2002a). The spring survey indices were lagged back one year and used in the ASPIC model as an end-of-year index.

Despite considerable interannual variability, both series of NEFSC biomass indices indicate a declining trend during the 1980s and an increasing trend during the early 1990s through 2002. Thereafter, the spring biomass indices declined, and in 2004-2005, were at the low levels observed during the early 1990s. The autumn biomass indices also declined, but to a lesser extent. Biomass indices from the Canadian survey showed similar trends.

2.3 Biological Reference Points

ASPIC model estimates of relative total biomass (B_t/B_{MSY}) and fishing mortality rates (F_t/F_{MSY}) are more precisely estimated than the absolute values (Prager 1995). Therefore, bias-corrected estimates of annual total biomass (as of Jan. 1) and fishing mortality rates are presented in relative terms. In order to determine stock status, these ratios are compared to a biomass threshold (50% of B_{MSY}) of 0.5 and a fishing mortality rate threshold (F_{MSY}) of 1.0.

2.4 ASPIC Model Results and Stock Status

Relative fishing mortality rates increased rapidly after 1999 and were above 1.0 (= F_{MSY}) during 2000-2004 (Figure K3). During 2004, the relative fishing mortality rate was 1.86 (80% CL = 1.44, 3.23), nearly double the level of F_{MSY} (Table K4). Relative total biomass (as of January 1) gradually increased from the lowest level on record, in 1994 (0.23), to just above the B_{MSY} threshold in 2003 (0.56), but then declined during 2004 and 2005 (Figure K3). Relative biomass was 0.52 of B_{MSY} in 2004 (80% CL = 0.28, 0.76) then fell below the biomass threshold to 0.46 of

B_{MSY} in 2005 (80% CL = 0.22, 0.76). In 2004, relative biomass was just above the threshold limit and relative fishing mortality was well above $F_{MSY.}$ Therefore, in 2004, the stock was not overfished but overfishing was occurring.

A comparison of relative total biomass and fishing mortality rates from the updated assessment with those from the 2002 GARM indicated why a change in stock status occurred. The increasing biomass trend observed in the 2002 model results shifted to a declining trend after 2003 (Figure K4A) due to a decline in the survey biomass indices after 2002. After 2002, fishing mortality rates continued to increase, reaching levels well-above F_{MSY} (Figure K4B). These changes resulted in a divergence, after 1994, in biomass and fishing mortality rate estimates from the two assessments. Divergence was greatest during 2000-2002 when the 80% confidence intervals of the biomass estimates from the two assessments did not overlap (Figure K4A). Similarly, the confidence intervals for the 2001 and 2002 fishing mortality rate estimates did not overlap for the two times series. Bias-corrected estimates of absolute fishing mortality rates and January 1 total biomass are presented in Table K5.

Based on a comparison of the weighted mean square errors for each of the two survey time series, the fit for the updated model run was slightly poorer than the fit for the 2002 model run. However, in contrast to the 2002 model run, the updated run showed a retrospective pattern. Model runs for terminal years 1998-2004 suggested an underestimation of absolute fishing mortality rates and an overestimation of absolute average biomass during 2002-2004 (Figure K5).

Projections conducted for Amendment 13 included a constant fishing mortality scenario using the F_{MSY} estimate of 0.32 from SAW 34. Absolute total biomass estimates indicate a declining trend during 2002-2005, but are within the 80% confidence limits of the Amendment 13 projections of total biomass (Figure K6A). Unlike the projection scenario, fishing mortality rates increased during 2002-2004 (Figure K6B). During 2003 and 2004, realized landings were at the levels projected for Amendment 13 (Figure K6C).

3.0 Sources of Uncertainty

3.1 Exclusion of the discards from the U.S. otter trawl and scallop dredge fisheries results in an underestimation of fishery removals of the younger age classes (ages 0 to 3).

3.2 Current biomass levels estimated from the ASPIC model may not be reliable because recruitment is implicitly assumed to be a function of stock biomass.

3.3 U.S. landings after 1994 are based on prorations of preliminary logbook data. In 2004, a new method of reporting the landings was implemented whereby dealers rather than NMFS port agents entered the landings directly into the Weighout database.

3.4 There is some uncertainty about the accuracy of the Canadian landings because winter flounder are a bycatch species in the Canadian fisheries and a portion of the landings may be reported as unclassified flounders.

4.0 Research Recommendations

4.1 Include discards in future assessments.

4.2 Ensure that the survey indices and catch are composed of the same size fish.

5.0 Panel Discussion

The Panel discussed the consequence of the re-estimation of reference points in the updated assessment. The model estimates of F_{MSY} and B_{MSY} differ from those reported in SAW 34 and currently adopted. The terms of reference of the 2005 GARM do not include re-estimating reference points. Therefore, the Panel discussed whether it was consistent with the terms of reference to accept the ASPIC estimates of current stock status. However, because the estimation of K and MSY is intrinsic to the model fit, it is impossible to update the stock assessment without re-estimating the reference points. The Panel discussed several alternatives such as an alternative ASPIC run in which K and MSY were fixed at the values estimated from the 2002 GARM, comparing the new reference point estimates to the ASPIC model results from the 2002 GARM, and projecting from the 2002 GARM model using the actual catches. The model where MSY and K were fixed had a slightly poorer fit than the model which freely estimated the parameters. In addition, panelists noted that by imposing a constraint on F_{MSY} and B_{MSY} the model was not the same as that used in the last benchmark assessment. Accepting the results from constrained model would have conflicted with the terms of reference guidance that required the use of the same assessment method approved in the last benchmark assessment. The other two alternatives were considered scientifically invalid because the first method compares unrelated values while the second does not use all the data available. The Panel accepted the freely estimated model which is more pessimistic than the constrained model but has the same trend. The Panel decided to compare the ASPIC model results from the 2002 GARM with the updated model results by using the relative estimates of F and B instead of the absolute values (see comparison with bootstrap CI).

6.0 Literature Cited

NEFSC [Northeast Fisheries Science Center]. 2002a. Report of the 34th Northeast Regional Stock Assessment Workshop (34th SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. *Northeast Fish. Sci. Cent. Ref. Doc.* 02-06; 346 p.

NEFSC [Northeast Fisheries Science Center]. 2002b. Final report of the working group on re-evaluation of biological reference points for New England groundfish. 231 p.

NEFSC [Northeast Fisheries Science Center]. 2002c. Assessment of 20 northeast groundfish stocks through 2001: A report of the Groundfish Assessment Review Meeting (GARM), Northeast Fisheries Science Center, Woods Hole, Massachusetts, October 8-11, 2002. *Northeast Fish. Sci. Cent. Ref. Doc.* 02-16. 511 p.

Prager, M.H. 2004. User's manual for ASPIC: a stock production model incorporating covariates (ver.5). Beaufort Lab. Doc. BL-2004-01. 27 p.

Prager, M.H. 1995. User's manual for ASPIC: a stock production model incorporating covariates, program version 3.6x. Miami Lab. Doc. MIA-92/93-55. 25 p.

Table K1. Summary of results from ASPIC biomass dynamics models (SAW 34 configuration) utilized during the 2002 GARM and for an updated assessment of Georges Bank winter flounder. NA indicates these values are not estimated by the software version. All values are bias-correct using the methods defined by Prager (2004).

	GARM 2002, ASPIC v. 3.7.2 U.S. autumn survey, 1964-2001 U.S. spring survey, 1968-2002 Total landings, 1964-2001	Rerun GARM 2002, ASPIC v. 5.10 U.S. autumn survey, 1964-2001 U.S. spring survey, 1968-2002 Total landings, 1964-2001	Assessment update, ASPIC v. 5.10 U.S. autumn survey, 1964-2004 U.S. spring survey, 1968-2005 Total landings, 1964-2004
Total Objective Function	1.959	1.959	2.448
q (80% C.L.), U.S. Autumn Survey	0.265 (0.183, 0.330)	0.259 (0.184, 0.352)	0.225 (0.156, 0.331)
q (80% C.L.), U.S. Spring Survey	0.342 (0.246, 0.430)	0.329 (0.235, 0.453)	0.266 (0.184, 0.388)
r	0.65	0.67	0.55
K (mt)	18,200	17,491	20,273
$B_{2001\ \mathrm{or}\ 2004}/B_{MSY}$ (as of Jan. 1)	1.06	1.04	0.52
$F_{2001\ \mathrm{or}\ 2004}/F_{MSY}$	0.76	0.76	1.86
B_{2005}/B_{MSY} (as of Jan. 1)			0.46
B_{MSY}[1] (mt)	9,099	8,746	10,136
F_{MSY}	0.33	0.31	0.22
MSY (mt)	3,008	2,950	2,785

[1] GARM 2002 point estimates of F_{MSY}, B_{MSY} and MSY were not bias-corrected.

Table K2. Landings (mt) of Georges Bank winter flounder, by statistical area and country, during 1964-2004.

	522-525 561-562	5Ze[2] (521-526 and 541-562)		5Z (521-562)		
YEAR	USA[1]	CANADA	USSR	CANADA	USSR	TOTAL
1964	1,371			146		1,517
1965	1,176			199	312	1,687
1966	1,877			164	156	2,197
1967	1,917			83	349	2,349
1968	1,570	57	372			1,999
1969	2,167	116	235			2,518
1970	2,615	61	40			2,716
1971	3,092	62	1,029			4,183
1972	2,805	8	1,699			4,512
1973	2,269	14	693			2,976
1974	2,124	12	82			2,218
1975	2,409	13	515			2,937
1976	1,877	15	1			1,893
1977	3,572	15	7			3,594
1978	3,185	65				3,250
1979	3,045	19				3,064
1980	3,931	44				3,975
1981	3,993	19				4,012
1982	2,961	19				2,980
1983	3,894	14				3,908
1984	3,927	4				3,931
1985	2,151	12				2,163
1986	1,762	25				1,787
1987	2,637	32				2,669
1988	2,804	55				2,859
1989	1,880	11				1,891
1990	1,898	55				1,953
1991	1,814	14				1,828
1992	1,822	27				1,849
1993	1,662	21				1,683
1994	907	65				972
1995	706	54				760
1996	1,265	71				1,336

YEAR	522-525 561-562 USA[1]	5Ze[2] (521-526 and 541-562) CANADA	USSR	5Z (521-562) CANADA	USSR	TOTAL
1997	1,287	143				1,430
1998	1,243	93				1,336
1999	938	104				1,042
2000	1,677	161				1,838
2001	1,629	529				2,158
2002	2,110	244				2,354
2003	2,791	310				3,101
2004	2,931	191				3,122

[1] USA landings prior to 1985 include those from Statistical Areas 551 and 552 and landings during 1994-2004 were prorated from Vessel Trip Reports based on gear, month, and state.
[2] Includes landings from statistical areas 521 and 526, outside of the Georges Bank winter flounder stock area.

Table K3. Standardized, stratified relative abundance (mean number per tow) and biomass (mean kg per tow) indices for Georges Bank winter flounder caught in the U.S. spring and autumn and Canada spring research vessel bottom trawl surveys. U.S. offshore survey strata 13-22; Canadian survey strata (5Z1-5Z4). Trawl door standardization coefficients of 1.46 (numbers) and 1.39 (weight) were applied to indices from U.S. survey indices prior to 1985 to account for differences in catchability between different survey doors.

Year	**U.S. Spring Survey**		**U.S. Autumn Survey**		**Canada Spring Survey**	
	Number/tow	kg/tow	Number/tow	kg/tow	Number/tow	kg/tow
1963			1.20	1.82		
1964			1.30	1.82		
1965			2.15	2.05		
1966			5.16	5.66		
1967	*Initiated in 1968*		1.79	2.07		
1968	2.70	3.11	1.31	1.07		
1969	3.14	4.29	2.37	2.39		
1970	1.86	2.29	5.62	6.49		
1971	1.84	2.17	1.32	1.26		
1972	4.95	5.32	1.26	1.58		
1973	2.95	3.51	1.22	1.20		
1974	6.05	5.78	1.19	1.46		
1975	1.96	1.41	3.79	2.06		
1976	4.67	3.01	5.99	3.93		
1977	3.79	1.58	4.86	3.99		
1978	7.07	5.06	4.06	3.10		
1979	1.74	2.21	5.07	3.83		
1980	3.22	2.80	1.66	1.87		
1981	3.73	3.75	3.83	2.43		
1982	2.30	1.52	5.30	2.69		
1983	8.41	7.11	2.73	2.36		
1984	5.53	5.60	3.93	2.45		
1985	3.84	2.65	1.98	1.12		
1986	2.00	1.21	3.58	2.18	*Iinitiated in 1987*	
1987	2.80	1.25	0.76	0.89	1.24	1.74
1988	2.93	1.65	4.08	1.27	4.31	2.75
1989	1.30	0.76	1.56	1.05	4.05	1.95
1990	2.80	1.57	0.50	0.35	4.93	2.64
1991	2.40	1.32	0.27	0.14	1.98	1.38
1992	1.42	0.90	0.68	0.38	0.51	0.59
1993	1.02	0.57	1.17	0.66	3.53	1.76
1994	1.29	0.58	0.87	0.58	5.10	2.01
1995	2.61	1.49	2.36	1.34	5.63	1.96
1996	2.31	1.50	1.54	1.76	4.12	2.30

Year	U.S. Spring Survey		U.S. Autumn Survey		Canada Spring Survey	
	Number/tow	kg/tow	Number/tow	kg/tow	Number/tow	kg/tow
1997	1.61	1.19	1.74	1.53	4.58	3.09
1998	0.76	0.72	1.78	1.57	1.14	1.21
1999	3.83	3.48	1.54	1.76	1.25	1.89
2000	4.42	3.69	2.16	2.66	1.48	2.22
2001	1.29	1.22	2.45	2.51	2.28	2.54
2002	5.05	5.16	2.58	3.15	3.17	3.85
2003	1.22	1.34	1.94	2.24	1.09	1.31
2004	0.39	0.51	2.50	2.04	2.10	1.79
2005	1.09	0.87			1.19	1.23
Mean All Years	2.95	2.48	2.48	2.09	2.82	2.01

Table K4. Bias-corrected estimates of relative fishing mortality rates (F_t/F_{MSY}) and total biomass (B_t/B_{MSY}, as of Jan. 1), derived using an ASPIC biomass dynamics model, for Georges Bank winter flounder during 1964-2005.

Year	F_t/F_{MSY}	B_t/B_{MSY} (as of Jan. 1)
1964	0.85	0.48
1965	0.83	0.56
1966	0.98	0.64
1967	0.98	0.70
1968	0.77	0.75
1969	0.90	0.84
1970	0.94	0.89
1971	1.49	0.92
1972	1.79	0.85
1973	1.26	0.74
1974	0.91	0.74
1975	1.16	0.80
1976	0.71	0.80
1977	1.31	0.89
1978	1.23	0.85
1979	1.17	0.84
1980	1.59	0.84
1981	1.80	0.76
1982	1.44	0.68
1983	2.08	0.66
1984	2.56	0.56
1985	1.61	0.44
1986	1.30	0.44
1987	1.99	0.46
1988	2.47	0.42
1989	1.84	0.34
1990	2.01	0.33
1991	2.02	0.30
1992	2.24	0.28
1993	2.25	0.25
1994	1.28	0.23
1995	0.86	0.25
1996	1.32	0.31
1997	1.29	0.34
1998	1.09	0.37
1999	0.73	0.41
2000	1.13	0.49
2001	1.25	0.53
2002	1.31	0.55
2003	1.76	0.56
2004	1.86	0.52
2005		0.46

Table K5. Bias-corrected estimates of absolute fishing mortality rates and January 1 total biomass (000’s mt), derived using an ASPIC biomass dynamics model, for Georges Bank winter flounder during 1964-2005.

Year	Fishing Mortality Rate	Jan. 1 Total Biomass (000’s mt)
1964	0.19	5.886
1965	0.18	6.994
1966	0.22	8.147
1967	0.22	8.941
1968	0.17	9.659
1969	0.21	10.816
1970	0.21	11.502
1971	0.34	11.992
1972	0.41	10.972
1973	0.29	9.496
1974	0.21	9.485
1975	0.26	10.267
1976	0.16	10.369
1977	0.30	11.570
1978	0.28	11.075
1979	0.27	10.897
1980	0.37	10.881
1981	0.41	9.885
1982	0.33	8.731
1983	0.47	8.502
1984	0.58	7.198
1985	0.36	5.562
1986	0.29	5.500
1987	0.45	5.846
1988	0.56	5.270
1989	0.41	4.286
1990	0.45	4.107
1991	0.45	3.789
1992	0.49	3.498
1993	0.49	3.075
1994	0.27	2.694
1995	0.19	3.033
1996	0.29	3.772
1997	0.28	4.119
1998	0.24	4.490
1999	0.16	5.105
2000	0.26	6.244
2001	0.28	6.791
2002	0.30	7.114
2003	0.40	7.297
2004	0.42	6.692
2005		6.385

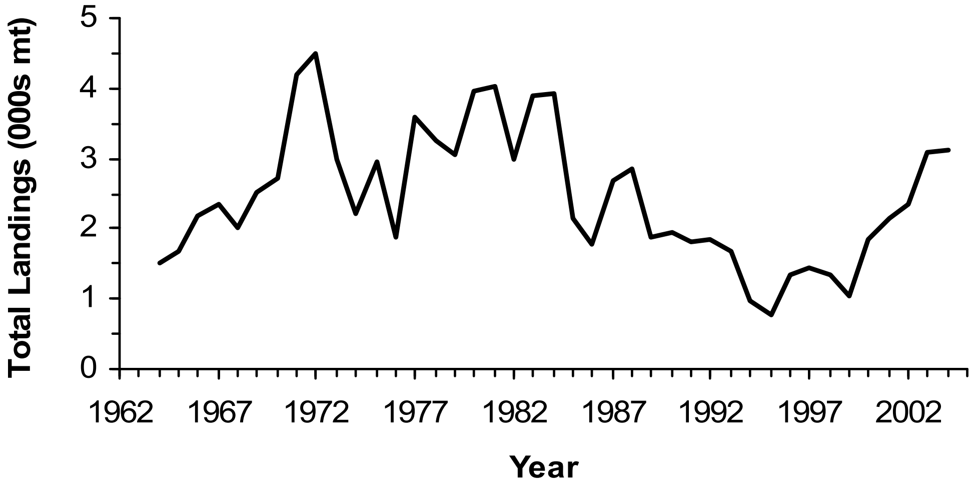

Figure K1. Total commercial landings of Georges Bank winter flounder during 1964-2004.

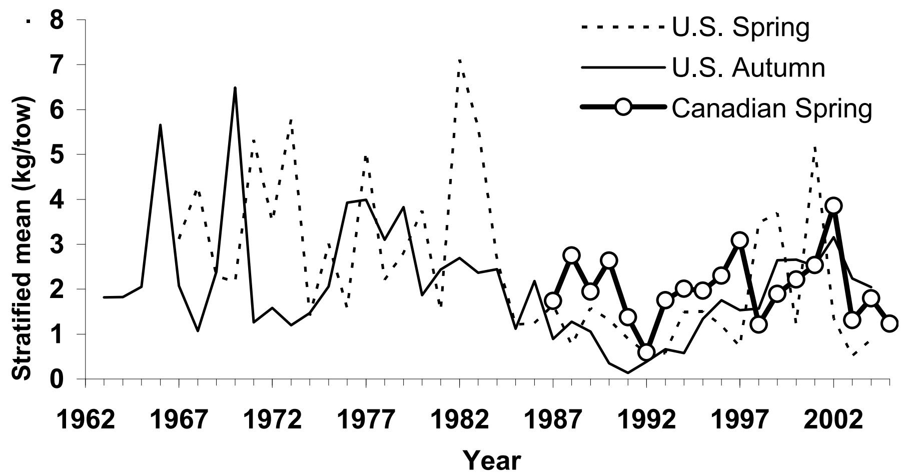

Figure K2. Relative biomass indices (stratified mean kg per tow) of Georges Bank winter flounder from NEFSC spring (1968-2005, lagged back one year) and autumn (1963-2004) bottom trawl surveys and the Canadian spring (1987-2005) bottom trawl survey.

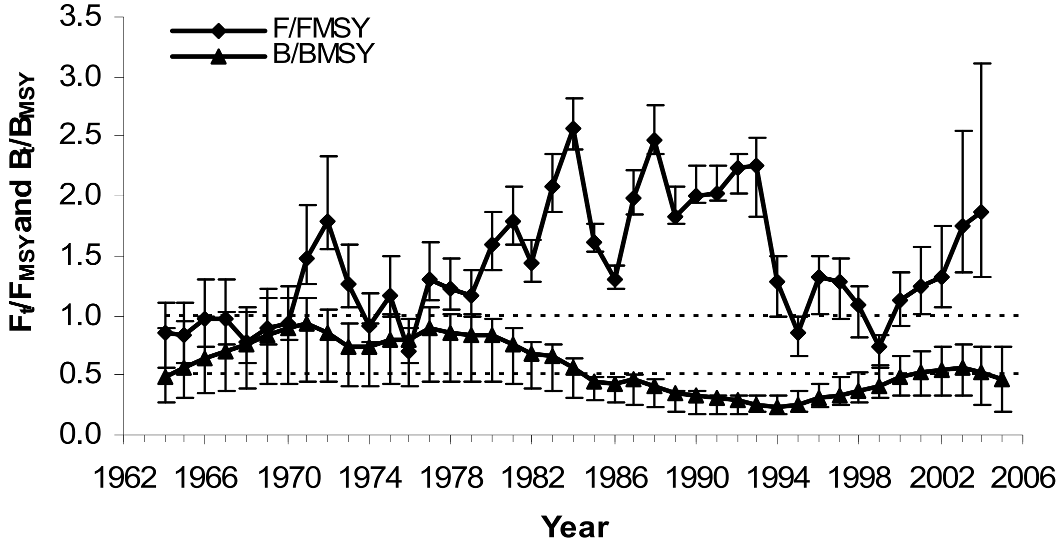

Figure K3. Trends in bias-corrected estimates of relative total biomass (B_t/B_{MSY} on Jan. 1) and relative fishing mortality rates (F_t/F_{MSY}), derived using an ASPIC biomass dynamics model, for Georges Bank winter flounder. Error bars represent bias-corrected 80% confidence intervals.

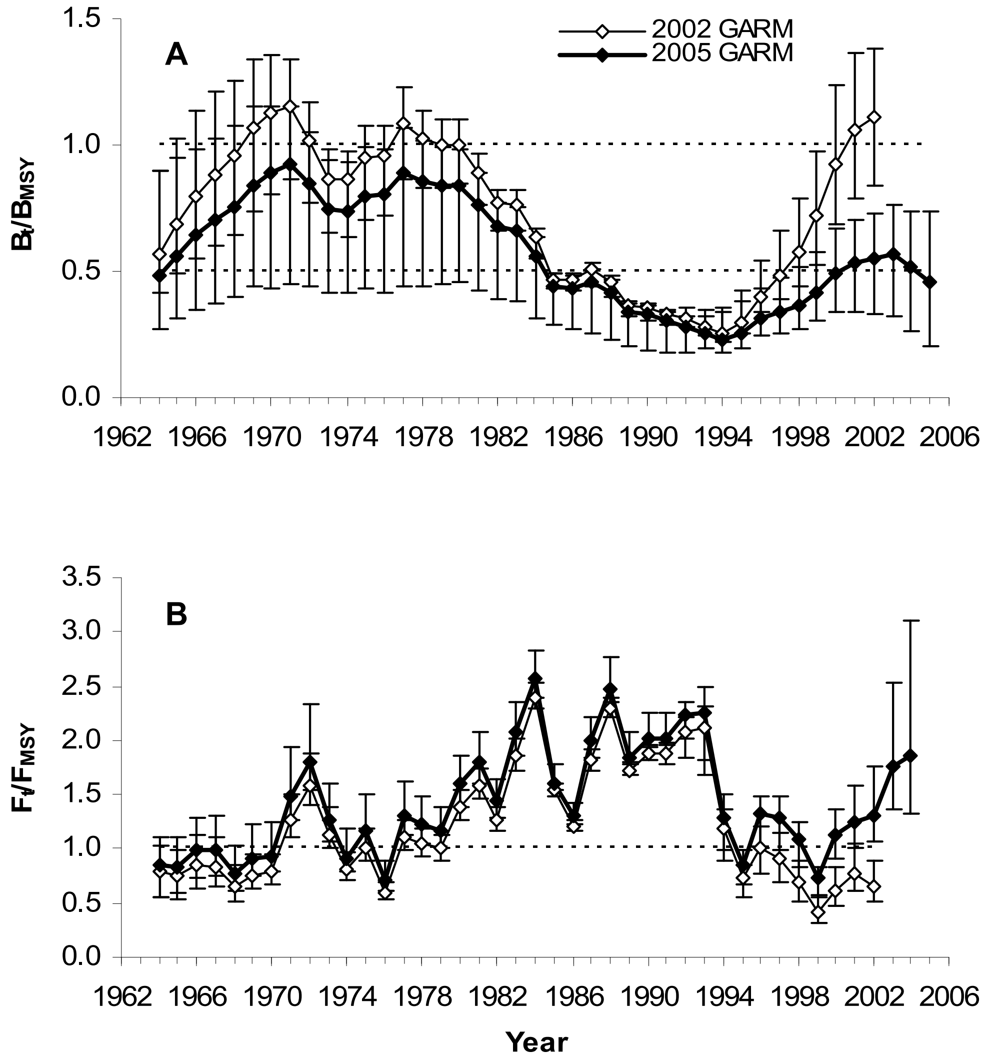

Figure K4. Bias-corrected estimates of (A) relative total biomass (B_t/B_{MSY} on Jan. 1), during 1964-2005, and (B) relative fishing mortality rates (F_t/F_{MSY}), during 1964-2004, for the 2002 and 2005 ASPIC model runs for Georges Bank winter flounder. Error bars represent bias-corrected 80% confidence intervals.

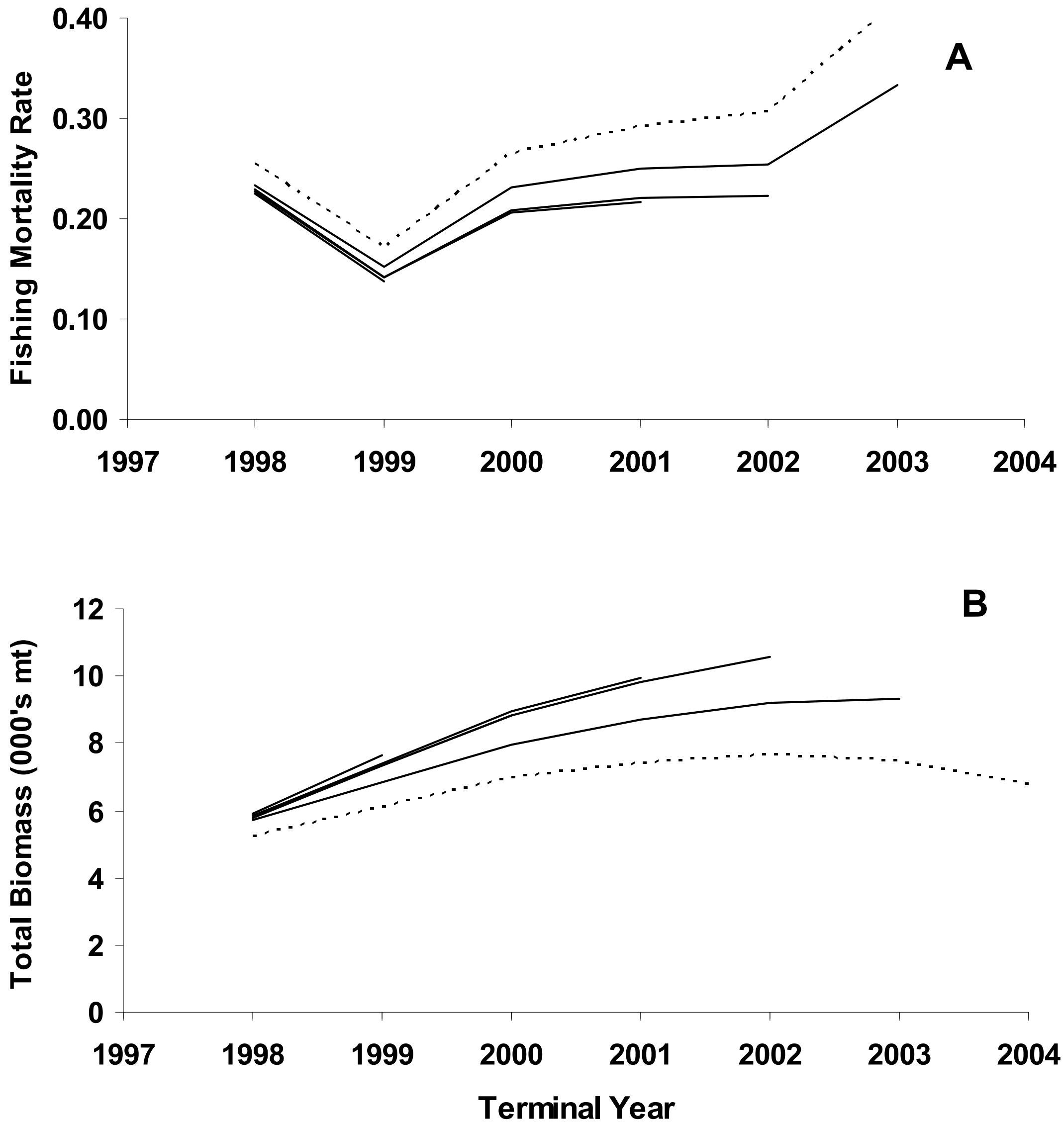

Figure K5. Retrospective patterns in absolute estimates of (A) fishing mortality rates and (B) average biomass, during terminal years 1995-2000, for an updated ASPIC biomass dynamics model for Georges Bank winter flounder, 1964-2004. Estimates of fishing mortality and stock biomass are not bias-corrected.

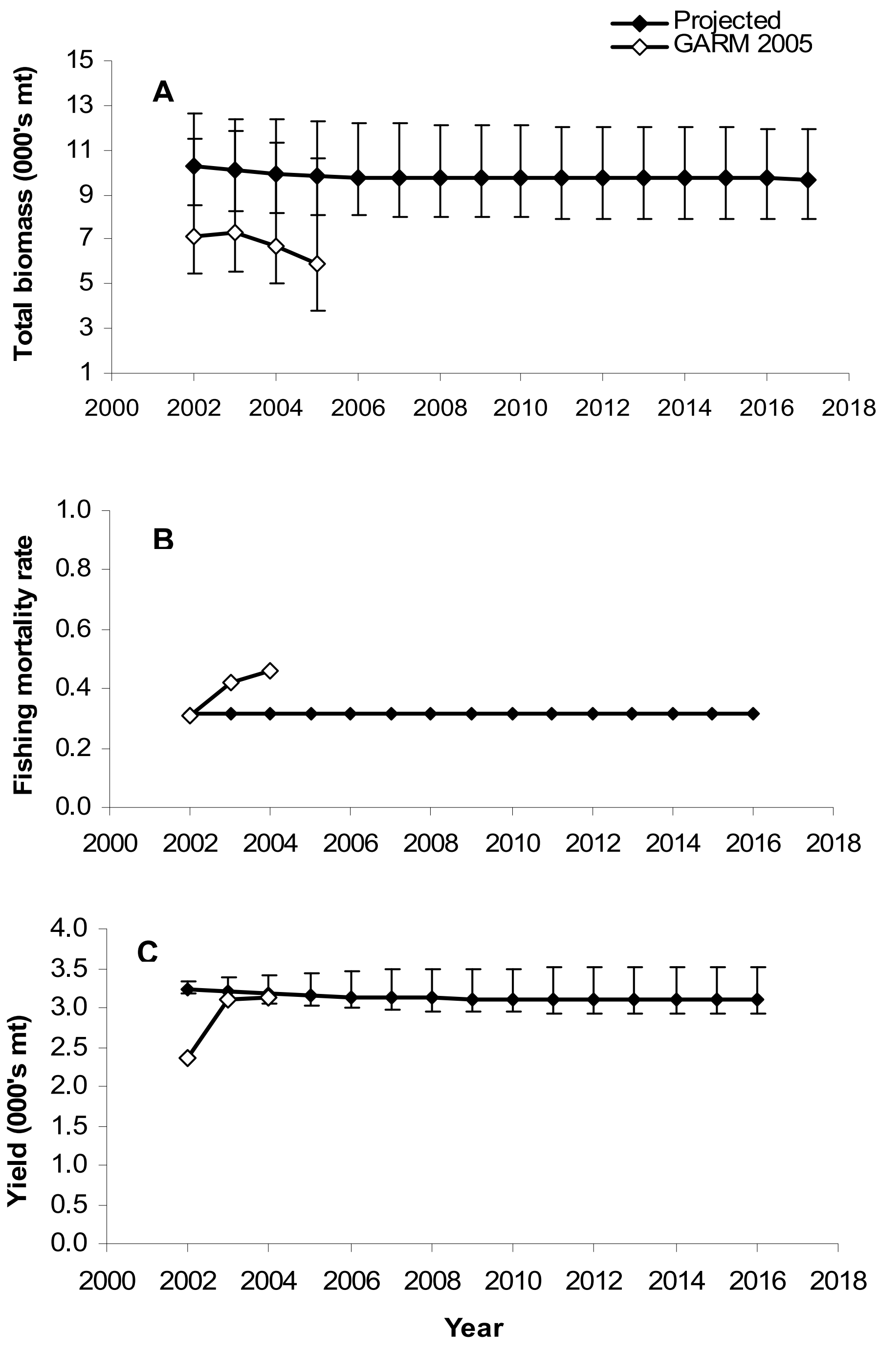

Figure K6. ASPIC-derived absolute estimates of (A) total biomass (as of Jan. 1) and (B) fishing mortality rates, and (C) actual landings, for Georges Bank winter flounder during 2002-2004, versus projected estimates, for Amendment 13, based on a constant F (=0.32) scenario. ASPIC-derived point estimates and 80% confidence limits are bias-corrected.