C. Georges Bank yellowtail flounder

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Additional details and supporting information can be found in the Appendix of the GARM-III Report (NEFSC 2008).

1.0 Background

The Georges Bank yellowtail flounder stock is jointly managed by the US and Canada through the Transboundary Management Guidance Committee (TMGC). Stock assessments are conducted annually by the Transboundary Resources Assessment Committee (TRAC). A benchmark assessment completed in 2005 (TRAC 2005) focused on the issue of the strong retrospective pattern. Based on this benchmark assessment and subsequent assessments (Legault et al. 2006, Legault et al. 2007), the so-called "Major Change" model has been utilized to provide stock management advice. This model splits the survey time series between 1994 and 1995 to reduce the retrospective pattern. This split is most appropriately thought of as "aliasing of an unknown mechanism that produces a better fitting model" (Legault et al. 2007). Although the TMGC does not have explicit biomass reference points, these were calculated previously and have been used in US management decisions (NEFSC 2002a). Based on the current biological reference points, the stock is currently overfished and overfishing is occurring. This report revises and updates the 1994-2007 US catch to reflect the Groundfish Assessment Review Meeting (GARM) III Data meeting recommendations (GARM 2007) and updates the research survey abundance indices and analytical models though 2007/2008 as recommended in the TRAC benchmark assessment and at the GARM III Methods meeting (GARM 2008a) and the GARM III Biological Reference Points meeting (GARM 2008b). Finally, biological reference points for this stock were calculated using the VPA results and a two-stanza recruitment approach (i.e. recruitment associated with SSB either greater than or less than 5000 mt) as recommended in the GARM III Biological Reference Points meeting (GARM2008b) to determine the current status of the stock.

2.0 Fishery

US Landings

U.S. landings of yellowtail flounder from Georges Bank (Figure C1) during 1994-2007 were derived from the new trip-based allocation described in the GARM III Data meeting (GARM 2007, Palmer 2008, Wigley et al. 2007a, Table C1, Figure C2). Changes to previous estimates were minimal and uncertainty in the landings due to the random component of the allocation was insignificant (Legault et al. 2008). US landings have been limited by quotas in recent years. Landings at age and mean weight at age are determined by port sampling of small, medium, large, and unclassified market categories and pooled age-length keys by half year. Sampling intensity has increased in recent years (Table C2) resulting in lower variability in landings at age estimates (Table C3).

US Discards

US discarded catch for years 1994-2007 was estimated using the Standardized Bycatch Reporting Methodology recommended in the GARM III Data meeting (GARM 2007, Wigley et al. 2007b). Observed ratios of discards of yellowtail flounder to kept of all species for large mesh otter trawl, small mesh otter trawl, and scallop dredge were applied to the total landings by these gears by half-year. Uncertainty in the discard estimates was estimated based on the SBRM approach detailed in the GARM III Data meeting (GARM 2007, Wigely at al. 2007b, Table C4). US discards were approximately 13% of the US catch in years 1994-2007 (Table C1; Figure C2). Discards at age and associated mean weights at age were estimated from sea sampled lengths and pooled observer and survey age-length keys.

Canadian Landings

Canadian landings since 2004 have been well below previous levels and the allowed quota for that fishery (Table C1; Figure C2). Since 2003, scale samples from Canadian landings were aged by the US readers and these age-length keys used directly for these landings. Previously, US age-length keys had been applied to Canadian length frequency distributions. In 2008, Canadian landings were so low (17 mt) that no port samples were collected. These landings were assumed to follow the same age distribution as the US landings in 2008.

Canadian Discards

During the 2005 benchmark assessment, yellowtail flounder discards from the Canadian scallop fleet were estimated for the entire time series and used in the stock assessment for the first time (Stone and Legault 2005). Inclusion of this catch did not cause a large change in the assessment results because the magnitude is relatively constant throughout the time series used in the assessment, 1973 onward (Table C1; Figure C2). Discards at length were estimated from ogives of relative selectivity compared to research survey catches at length and converted to ages using age-length keys from US and Canada commercial landings and observers by quarter.

Total Catch at Age

Total catch at age was formed by adding the US landings, US discards, Canadian landings, and Canadian discards (Table C5a-c). Average catch weight at age was computed as the catch numbers weighted average of the weights at age from these four sources (Table C6a). Beginning of year weights at age were calculated using the Rivard weights approach (Table C6b). Spawning stock biomass weights at age were set equal to the catch weights at age.

3.0 Research Surveys

Survey abundance and biomass indices are reported in Table C7a-d. Estimates from research vessel surveys are from valid tows on Georges Bank (NEFSC offshore strata 13-21; Canadian strata 5Z1-5Z4; NEFSC scallop strata 54, 55, 58-72, 74) standardized according to net, vessel, and door changes. The three bottom trawl surveys are presented as minimum swept area estimates to allow direct interpretation of the catchability estimates associated with each survey and age combination. The three surveys of biomass show a similar pattern of rapid increase from lows in the early to mid 1990s to highs in the early 2000s followed by a decline in the most recent years (Figure C3).

The 2008 DFO survey had one tow with over 7.5 mt of yellowtail. This catch is well above any previous single catch in the survey time series (<1 mt) and the total catch summed from the remaining 56 stations in the 2008 survey (~0.5 mt). The estimated population abundance at ages 2-4 and the total biomass from the survey varied by an order of magnitude depending on whether this one tow was included or not (Table C.7c). During the TRAC meeting of June 2008, it was agreed that the 2008 DFO survey would not be included as an index of abundance, although the rest of the time series would be used in assessment, for the reference case. Two sensitivity runs of the VPA were conducted which included the 2008 DFO survey: one with the large tow and one which dropped the large tow.

4.0 Assessment

Input Data and Model Formulation

The 2005 benchmark assessment could not select a single formulation for Georges Bank yellowtail flounder VPA stock assessment. Instead, the previously used "Base Case VPA" (same formulation as GARM I, NEFSC 2002b and GARM II, Mayo and Terceiro 2005) was used along with a "Major Change VPA" which extended the ages from 6+ to 12, split the survey time series in 1995, and allowed for power functions relating survey abundance at age to model estimates. Assessments since the benchmark have modified the Major Change model to only differ from the Base Case by splitting the survey series between 1994 and 1995.

Model Selection Process

Since the Base Case and Major Change formulations were both recommended at the last benchmark assessment, and even though only the Major Change model has been used for management advice in recent years, both were updated with 2007 catch and 2008 NEFSC Spring survey values. Results were not noticeably different from the 2007 TRAC or GARM III Biological Reference Point meeting assessments with the Base Case VPA exhibiting a strong retrospective pattern while the Major Change VPA does not (Table C8; Figures C4a-c). Thus, the Base Case formulation was dropped from further consideration and only the Major Change formulation considered.

Assessment Results

The VPA estimates when the 2008 DFO survey were not included, the reference case, were estimated relatively precisely, CVs 25-46% for N and 9-66% for q (Table C9). Population abundance is increased in 2007 due to the strong 2005 year class (Table C10) as well as reduced fishing mortality on all ages. The fishing mortality rate on ages 4-5 has been trending down for the past 4 years and is now approaching the TRAC reference level of 0.25 (Table C11; Figure C5). Spawning stock biomass more than doubled from 2006 to 2007 and Jan-1 biomass more than tripled from 2007 to 2008 due mainly to the strength of the 2005 year class (Tables C12a-b; Figure C6). The 2007 estimates of F, SSB, and Jan-1 biomass were well estimated as seen in the relatively tight 80% confidence intervals derived from bootstrapping (Table C13).

Diagnostics

Residuals for indices of abundance do not show strong patterns, although occasional year effects are apparent in some surveys (Figure C7). The estimated catchability coefficients increase between the early and recent period for all indices, but show reasonable patterns at age and magnitudes with only the recent DFO values above one (Figure C8). These q values above one could be due to herding of yellowtail by the doors combined with the high selectivity of the DFO net for yellowtail. Back-calculated partial recruitment patterns from the fishery are flat-topped due to the formulation of the VPA, but also show a decrease in selectivity of age 2 yellowtail in recent years most likely due to increased mesh size regulations (Figure C9).

Sensitivity Analyses

The two sensitivity analyses, including the 2008 DFO survey with and without the big tow, had similar precision in the estimates but quite different estimates 2007 F and SSB (Table C8). Both sensitivity runs resulted in higher estimates of 2007 F. While this was expected for the run without the big tow, the increase in F when the big tow was included is due to the lack of age 6+ fish in the big tow requiring a high F. The SSB increased when the big tow was included and decreased when in was not, due mainly to the change in strength of the 2005 year class, as seen in the estimates of age 1 recruitment in 2006. Both sensitivity runs had relatively large residuals for the 2008 DFO survey and so were not pursued further.

5.0 Biological Reference Points

Method and Special Considerations

As in previous assessments, the estimated stock and recruitment values did not follow a parametric relationship (Figure C10) and so the non-parametric approach was undertaken. Hindcast recruitment estimates were derived by regressing the estimated numbers of recruits from the stock assessments on the NEFSC Fall survey index at age 1 (Figure C11). Following the recommendation of the GARM III Biological Reference Points review (GARM 2008b), recruitment values were split into two groups based on the associated spawning stock biomass levels being above or below 5000 mt and used to estimate the SSB_{MSY} and MSY proxies.

Use of historical hindcast recruitment implies that the productivity conditions have not changed over the long term. The GARM III Biological Reference Points Panel recommended that the hindcast recruitment values be checked for consistency with the catch which occurred during those years. This check was done by averaging the recruitment and catch values for years 1963-1972, averaging the first five years of partial recruitment and weight at age in the VPA, and solving for the resulting full F. The full F estimated was 0.78, quite similar to the level in the earliest years of the VPA, thus confirming that the hindcast estimates of recruitment are reasonable.

Recent five year averages of partial recruitment, maturity, and weight at age were used in yield per recruit analysis to estimate $F_{40\%MSP}$ as a proxy for F_{MSY} (Table C14). Applying F_{MSY} for 100 years in stochastic projections, while sampling recruitment from the empirical distribution described above, allowed estimation of SSB_{MSY} and MSY as the median values at the end of the 100 year projections (see Legault 2008).

Final Values: F_{MSY}, SB_{MSY}, and MSY

The estimated values of F_{MSY} (0.254), SSB_{MSY} (43200 mt), and MSY (9400 mt) are quite similar those from the GARM III Biological Reference Points meeting and slightly different from the GARM II meeting (Table C15). The change in SSB_{MSY} and MSY from GARM II to GARM III is due to the change from the Base Case formulation to the Major Change formulation resulting in lower recruitments in recent years. Dividing the 2007 values of F and SSB by F_{MSY} and SSB_{MSY}, respectively, results in a current status of overfishing ($F2007/F_{MSY} > 1.0$) and overfished ($SSB2007/SSB_{MSY} < 0.5$) (Figure C12).

6.0 Projections

Initial Conditions

The recent five year average of partial recruitment, maturity, and weight at age used in the yield per recruit analysis were also used in projections (Table C14). The population abundance at age at the start of 2008 was derived from the bootstrap results, with the recruitment estimate generated as the geometric mean of the estimated recruitments during 1973-2007 from each bootstrap solution. Catch in 2008 was assumed equal to the catch in 2007 (1686 mt).

$F_{REBUILD}$

Georges Bank yellowtail flounder is currently in a rebuilding plan with end date of 2014. The $F_{REBUILD}$ was found by iteratively solving for the F which applied in years 2009-2014 resulted in median 2014 SSB equal to SSB_{MSY}.

Projected Catch in 2009 for GARM III

Median catch in 2009 was estimated under three scenarios for F in 2009: 1) $F_{STATUS\ QUO}$, meaning the F2009 is set equal to F2007, 2) F_{MSY}, and 3) $F_{REBUILD}$ (Table C16). All three scenarios estimated catch much higher than the 2007 catch while still allowing SSB to more than double relative to the 2007 value due to the progression of the 2005 year class through the fishery. Note that neither the $F_{STATUS\ QUO}$ nor the F_{MSY} projections would result in rebuilding to SSB_{MSY} with at least 50% probability by 2014.

TRAC and NEFMC Projections

The Transboundary Resource Assessment Committee (TRAC) met via conference call the week after the GARM III Stock Assessment meeting to review the Georges Bank yellowtail flounder assessment. At this meeting, some variations on the projections were requested to conform to standard procedures in the TRAC and the 75% probability level or rebuilding agreed to by the New England Fishery Management Council. Specifically, the 2008 recruitment values in the bootstrapped VPA were filled by the geometric mean for years 1998-2007 instead of the GARM III approach of using the geometric mean of the entire time series. This resulted in only a minor change to the point estimate (19.002 million using 1998-2007, 19.120 million using 1973-2007) but the 80% confidence interval was much wider using the shorter time series (17.630-20.632 million using 1998-2007, 18.715-19.575 using 1973-2007) due to the convergence properties of VPA. Additionally, the 2008 catch was set equal to the quota for that year (2,500 mt) instead of set equal to the 2007 catch as in the GARM III projections.

Two projections were conducted: 1) F_{ref} where F in years 2009-2014 is set equal to the TRAC F_{ref} of 0.25 and 2) F_{reb75} where a constant F in years 2009-2014 is calculated to achieve SSB_{MSY} in 2014 with 75% probability (the probability level agreed to by the New England Fishery Management Council) (Table C17). The median catch in 2009 is quite different in these two projections, 4648 mt using Fref and 2114 mt using Freb75. The median SSB in 2014 also differs in these two projections, 39,000 mt using Fref and 53,200 mt using F_{reb75}. Catches lower than those associated with fishing at Fref are required to meet the USA rebuilding plan.

Additionally, a risk plot was created for the TRAC projections by setting catch in 2009 to different levels and determining the probability of F in 2009 exceeding Fref = 0.25 (Table C18; Figure C13). In these same projections, the percent change in median adult biomass (age 3+) from 2009 to 2010 was calculated as a proxy for the risk of a biomass change under different catch levels (Table C18). These results confirm that a catch of about 4600 mt in 2009 is risk neutral and is expected to be associated with an increase in adult biomass from 2009 to 2010 of about 9%.

Finally, due to the changes observed in age 3 partial recruitment in the fishery in recent years and the important of the 2005 year class at age 3 in 2008, a sensitivity analysis was conducted that examined the impact of different age 3 PR in the projections. The age 3 PR was 64.9% based on the average of the last five years. Projections were conducted which set the age 3 PR to 40% and 90% (Table C19). The changes in 2009 catch, 2008 F and 2009 SSB were not great and changed in the direction expected. Lower age 3 PR meant that the 2005 year class was less heavily fished in 2008 forcing a higher fishing mortality rate on ages 4+ (but still below Fref). This higher fishing mortality rate reduced the adult population and the lower PR at age 3 caused 2009 catches to be lower. However, the slight protection of the 2005 year class in 2008, due to the lower PR at age 3, caused the 2009 SSB to be larger.

7.0 Summary

Georges Bank yellowtail flounder continues to be overfished ($SSB2007/SSB_{MSY} = 0.22$) and overfishing is continuing ($F2007/ F_{MSY} = 1.14$). However, the trend in F is down and SSB is should continue to increase as the strong 2005 year class progresses through the fishery. The Major Change formulation continues to be recommended as the basis for management because of the strong retrospective pattern in the Base Case formulation. The 2008 DFO survey was not included in the reference case due to a single large tow of yellowtail which resulted in substantial increase of abundance for all ages from 2 to 5, inconsistent with stock dynamics and indicative that the tow results were outliers. The major source of uncertainty in this assessment continues to be the inability of the Base Case formulation to produce consistent results as exhibited by the retrospective pattern. Although the Major Change formulation reduces the retrospective pattern, the three bottom trawl surveys have not changed operating procedures and are not expected to have a change in catchability. Thus, the change in q is aliasing some other mechanism, such as changes in catch estimation or natural mortality rate.

8.0 Panel Discussion/Comments

Conclusions

The Panel accepted the split survey VPA formulation ,after exclusion of the 2008 Canadian survey, as Final and the best available estimate of stock status and a sufficient basis for management advice. It noted, however, that while this split reduced the retrospective pattern, it did not address the underlying cause. The exclusion of the 2008 Canadian survey estimate from the assessment was due to the presence of one tow over 7.5 mt. This exclusion was consistent with the recent TRAC advice.

Hindcast recruitment estimates were accepted for 1963 – 72 when the US fall survey index was available but VPA estimates were not. An analysis, as recommended by the GARM III ‘models’ review, confirmed that the estimated year-classes could support the observed catch during this period at a moderate F of 0.78.

The Panel recommended that the $F_{REBUILD}$ forecast use the same recruitment assumptions as for the BRP estimation but also sample from recruitment estimates below the SSB breakpoint of 5,000t. It was noted that the reduction of B_{MSY} and MSY estimates between GARM II and GARM III was due to reduced recruitment estimates in the current assessment, this due to splitting the survey time series.

It was also noted that using the split formulation still resulted in a small retrospective pattern in the estimates of recent SSB; suggesting that SSB may still be overestimated.

Research Recommendations

The Panel had no specific research recommendations for this stock.

9.0 References

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Table C1. Landings, discards, total catch (metric tons), and proportion of total catch which is discards for Georges Bank yellowtail flounder.

Year	US Landings	US Discards	Canada Landings	Canada Discards	Other Landings	Total Catch	% discards
1935	300	100	0	0	0	400	25%
1936	300	100	0	0	0	400	25%
1937	300	100	0	0	0	400	25%
1938	300	100	0	0	0	400	25%
1939	375	125	0	0	0	500	25%
1940	600	200	0	0	0	800	25%
1941	900	300	0	0	0	1200	25%
1942	1575	525	0	0	0	2100	25%
1943	1275	425	0	0	0	1700	25%
1944	1725	575	0	0	0	2300	25%
1945	1425	475	0	0	0	1900	25%
1946	900	300	0	0	0	1200	25%
1947	2325	775	0	0	0	3100	25%
1948	5775	1925	0	0	0	7700	25%
1949	7350	2450	0	0	0	9800	25%
1950	3975	1325	0	0	0	5300	25%
1951	4350	1450	0	0	0	5800	25%
1952	3750	1250	0	0	0	5000	25%
1953	2925	975	0	0	0	3900	25%
1954	2925	975	0	0	0	3900	25%
1955	2925	975	0	0	0	3900	25%
1956	1650	550	0	0	0	2200	25%
1957	2325	775	0	0	0	3100	25%
1958	4575	1525	0	0	0	6100	25%
1959	4125	1375	0	0	0	5500	25%
1960	4425	1475	0	0	0	5900	25%
1961	4275	1425	0	0	0	5700	25%
1962	5775	1925	0	0	0	7700	25%
1963	10990	5600	0	0	100	16690	34%
1964	14914	4900	0	0	0	19814	25%
1965	14248	4400	0	0	800	19448	23%
1966	11341	2100	0	0	300	13741	15%
1967	8407	5500	0	0	1400	15307	36%
1968	12799	3600	122	0	1800	18321	20%
1969	15944	2600	327	0	2400	21271	12%
1970	15506	5533	71	0	300	21410	26%
1971	11878	3127	105	0	500	15610	20%
1972	14157	1159	8	515	2200	18039	9%
1973	15899	364	12	378	300	16953	4%
1974	14607	980	5	619	1000	17211	9%
1975	13205	2715	8	722	100	16750	21%
1976	11336	3021	12	619	0	14988	24%
1977	9444	567	44	584	0	10639	11%
1978	4519	1669	69	687	0	6944	34%
1979	5475	720	19	722	0	6935	21%
1980	6481	382	92	584	0	7539	13%
1981	6182	95	15	687	0	6979	11%
1982	10621	1376	22	502	0	12520	15%
1983	11350	72	106	460	0	11989	4%
1984	5763	28	8	481	0	6280	8%
1985	2477	43	25	722	0	3267	23%
1986	3041	19	57	357	0	3474	11%
1987	2742	233	69	536	0	3580	21%
1988	1866	252	56	584	0	2759	30%
1989	1134	73	40	536	0	1783	34%
1990	2751	818	25	495	0	4089	32%
1991	1784	246	81	454	0	2564	27%
1992	2859	1873	65	502	0	5299	45%
1993	2089	1089	682	440	0	4300	36%
1994	1431	158	2139	440	0	4167	14%
1995	360	38	464	268	0	1130	27%
1996	743	71	472	388	0	1675	27%
1997	888	58	810	438	0	2194	23%
1998	1619	116	1175	708	0	3619	23%
1999	1818	484	1971	597	0	4870	22%
2000	3373	408	2859	415	0	7055	12%
2001	3613	337	2913	815	0	7677	15%
2002	2476	248	2642	493	0	5859	13%
2003	3236	373	2107	809	0	6525	18%
2004	5837	549	96	422	0	6905	14%
2005	3161	476	30	255	0	3922	19%
2006	1196	377	25	565	0	2162	44%
2007	1061	503	17	105	0	1686	36%

Table C2. Georges Bank US landings (metric tons) and number of lengths available from port samples by half year and market category along with number of ages available for age-length key and number of lengths sampled per 100 metric tons.

		Landings (metric tons)					Number of Lengths					Number	Lengths /
Year	half	unclass	large	small	medium	Total	unclass	large	small	medium	Total	of Ages	100 mt
1994	1	5	109	58		172							
	2	1	664	593		1258		517	724		1241		
	Total	7	773	650		1431		517	724		1241	302	87
1995	1	1	114	76		191		411	475		886		
	2	2	80	87		169		92	131		223		
	Total	3	195	162		360		503	606		1109	284	308
1996	1	1	382	161		544		254	250		504		
	2	2	102	95	0	199		192	268		460		
	Total	3	485	256	0	743		446	518		964	260	130
1997	1	10	428	169	0	607		628	1072		1700		
	2	3	179	99		281		91	121		212		
	Total	14	607	268	0	888		719	1193		1912	508	215
1998	1	43	383	141		567		555	490		1045		
	2	26	448	577		1052		199	85		284		
	Total	69	832	718		1619		754	575		1329	293	82
1999	1	39	679	296		1014		435	451		886		
	2	25	536	243	0	804		137	125		262		
	Total	63	1215	539	0	1818		572	576		1148	213	63
2000	1	55	1454	520	0	2029	114	526	260		900		
	2	38	885	420		1344	300	543	595		1438		
	Total	94	2339	941	0	3373	414	1069	855		2338	529	69
2001	1	98	1887	585		2570		1015	592		1607		
	2	31	777	235		1043		459	958		1417		
	Total	128	2664	820		3613		1474	1550		3024	702	84
2002	1	45	1679	356	0	2080		780	357		1137		
	2	10	271	115	0	396		680	327		1007		
	Total	55	1950	471	0	2476		1460	684		2144	543	87
2003	1	31	1586	457		2074		1276	994		2270		
	2	7	897	258		1162		1244	1028		2272		
	Total	37	2483	715		3236		2520	2022		4542	1144	140
2004	1	52	2477	439	4	2972		3249	2314		5563		
	2	29	2132	684	20	2865		1565	1362		2927		
	Total	81	4609	1123	24	5837		4814	3676		8490	1699	145
2005	1	17	851	497	9	1374		2351	1282		3633		
	2	21	1114	639	12	1787	93	2636	1686		4415		
	Total	38	1965	1136	22	3161	93	4987	2968		8048	1798	255
2006	1	24	580	170	7	781	128	3183	2447		5758		
	2	6	248	155	7	415		2147	1600		3747		
	Total	29	827	325	14	1196	128	5330	4047		9505	2248	795
2007	1	25	470	240	14	749		2844	2025		4869		
	2	5	159	144	5	312		1221	732		1953		
	Total	30	628	384	19	1061		4065	2757		6822	1457	643
Grand Total		652	21573	8509	79	30812	635	29230	22751		52616	11980	171

Table C3. Georges Bank yellowtail flounder coefficient of variation for US landings at age by year.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1994		57%	6%	14%	27%	41%
1995		27%	11%	13%	22%	40%
1996		23%	7%	15%	26%	60%
1997		17%	11%	8%	30%	35%
1998		64%	31%	16%	36%	30%
1999	97%	21%	9%	25%	33%	34%
2000		11%	9%	11%	20%	32%
2001		17%	11%	10%	22%	48%
2002	76%	15%	11%	11%	15%	22%
2003		16%	8%	9%	11%	16%
2004		53%	8%	6%	9%	11%
2005		11%	4%	6%	12%	16%
2006		10%	5%	6%	6%	13%
2007		12%	5%	6%	14%	18%

Table C4. Georges Bank yellowtail flounder US discards (metric tons) and coefficient of variation by gear and year.

	Otter Trawl Large Mesh		Otter Trawl Small Mesh		Scallop Dredge	
Year	D (mt)	CV	D (mt)	CV	D (mt)	CV
1994	138	150%	0	0%	10	6%
1995	36	70%	0	0%	7	20%
1996	51	30%	0	0%	45	0%
1997	211	22%	0	0%	117	74%
1998	185	66%	0	0%	297	46%
1999	11	67%	0	0%	566	13%
2000	25	71%	0	90%	669	12%
2001	50	51%	0	105%	28	7%
2002	24	42%	0	79%	29	27%
2003	115	39%	1	95%	293	0%
2004	324	20%	55	62%	81	21%
2005	177	12%	52	28%	186	20%
2006	107	14%	26	95%	251	19%
2007	270	12%	111	107%	121	25%

Table C5a. Georges Bank yellowtail flounder landings at age (thousands of fish).

Year	age1	age2	age3	age4	age5	age6+
1973	0	3840	13086	9281	3746	1618
1974	180	6299	7821	7400	3545	1478
1975	427	16861	6947	3393	2085	1150
1976	43	19341	5091	1348	533	869
1977	31	6647	9851	1729	396	477
1978	0	2172	4030	1685	466	176
1979	17	6827	3408	1246	552	273
1980	0	2405	8819	1439	326	100
1981	6	480	5279	4566	798	126
1982	217	13159	7075	3252	1033	84
1983	241	7739	16166	2338	631	128
1984	244	1916	4272	4741	1594	321
1985	375	3369	824	659	414	66
1986	92	5841	996	354	164	77
1987	15	1865	2798	780	135	114
1988	0	1700	1217	643	170	39
1989	0	1385	688	271	70	20
1990	0	742	4624	745	106	20
1991	0	28	906	2358	302	63
1992	0	3256	1934	1203	513	28
1993	5	655	2398	1889	342	79
1994	44	936	5971	1715	435	136
1995	6	183	1020	646	119	26
1996	2	368	1513	604	133	19
1997	35	399	1188	1456	268	70
1998	23	784	2402	1452	938	67
1999	17	1562	3347	1282	644	230
2000	63	3213	4952	2703	697	387
2001	111	2434	6093	2587	894	458
2002	169	3845	3041	1728	604	430
2003	85	2897	3638	1950	660	607
2004	0	380	2474	3454	1842	1355
2005	0	932	3319	1501	336	158
2006	0	336	796	628	277	169
2007	3	332	1143	565	121	49

Table C5b. Georges Bank yellowtail flounder discards at age (thousands of fish).

Year	age1	age2	age3	age4	age5	age6+
1973	359	1335	479	192	69	31
1974	2187	3201	473	258	97	42
1975	4209	9533	428	147	90	58
1976	592	12597	411	77	42	49
1977	347	2447	716	117	23	18
1978	9962	1370	549	229	74	34
1979	304	3689	382	186	71	52
1980	318	1590	866	99	26	12
1981	101	617	684	354	57	19
1982	1946	4933	405	149	62	12
1983	462	259	495	138	49	26
1984	270	102	263	302	202	58
1985	596	1004	233	160	102	15
1986	87	562	131	35	40	36
1987	141	1420	338	203	57	23
1988	499	1303	327	203	57	14
1989	190	791	433	157	40	11
1990	231	1373	2372	234	34	6
1991	663	119	585	653	81	8
1992	2414	5912	1037	270	90	14
1993	5229	731	928	436	69	11
1994	27	401	331	104	41	7
1995	41	130	416	232	51	11
1996	99	313	551	281	68	9
1997	47	733	645	400	111	20
1998	146	1207	986	433	183	79
1999	43	1191	848	266	149	72
2000	68	650	762	470	130	141
2001	65	449	863	306	109	67
2002	42	324	406	188	79	55
2003	75	1022	1072	370	123	86
2004	64	821	697	349	128	95
2005	60	597	767	211	76	20
2006	154	965	902	375	96	45
2007	50	1131	622	135	22	8

Table C5c. Georges Bank yellowtail flounder catch at age (thousands of fish).

Year	age1	age2	age3	age4	age5	age6+
1973	359	5175	13565	9473	3815	1650
1974	2368	9500	8294	7658	3643	1520
1975	4636	26394	7375	3540	2175	1207
1976	635	31938	5502	1426	574	918
1977	378	9094	10567	1846	419	495
1978	9962	3542	4580	1914	540	211
1979	321	10517	3789	1432	623	325
1980	318	3994	9685	1538	352	113
1981	107	1097	5963	4920	854	145
1982	2164	18091	7480	3401	1095	96
1983	703	7998	16661	2476	680	155
1984	514	2018	4535	5043	1796	379
1985	970	4374	1058	818	517	81
1986	179	6402	1127	389	204	113
1987	156	3284	3137	983	192	137
1988	499	3003	1544	846	227	53
1989	190	2175	1121	428	110	30
1990	231	2114	6996	978	140	26
1991	663	147	1491	3011	383	71
1992	2414	9167	2971	1473	603	42
1993	5233	1386	3327	2326	411	91
1994	71	1336	6302	1819	477	144
1995	47	313	1435	879	170	37
1996	101	681	2064	885	201	28
1997	82	1132	1832	1857	378	90
1998	169	1991	3388	1885	1121	146
1999	60	2753	4195	1548	794	301
2000	132	3864	5714	3173	826	528
2001	176	2884	6956	2893	1004	525
2002	212	4169	3446	1916	683	485
2003	160	3919	4710	2320	782	693
2004	64	1201	3171	3804	1970	1451
2005	60	1529	4086	1712	411	178
2006	154	1300	1698	1003	373	214
2007	53	1464	1765	700	142	58

Table C6a. Georges Bank yellowtail flounder catch weight at age (kg).

Year	age1	age2	age3	age4	age5	age6+
1973	0.101	0.348	0.462	0.527	0.603	0.778
1974	0.115	0.344	0.496	0.607	0.678	0.832
1975	0.113	0.316	0.489	0.554	0.619	0.695
1976	0.108	0.312	0.544	0.635	0.744	0.861
1977	0.116	0.342	0.524	0.633	0.780	0.931
1978	0.102	0.314	0.510	0.690	0.803	0.970
1979	0.114	0.329	0.462	0.656	0.736	0.950
1980	0.101	0.322	0.493	0.656	0.816	1.072
1981	0.122	0.335	0.489	0.604	0.707	0.840
1982	0.115	0.301	0.485	0.650	0.754	1.082
1983	0.140	0.296	0.441	0.607	0.740	1.010
1984	0.162	0.239	0.379	0.500	0.647	0.797
1985	0.181	0.361	0.505	0.642	0.729	0.800
1986	0.181	0.341	0.540	0.674	0.854	1.015
1987	0.121	0.324	0.524	0.680	0.784	0.875
1988	0.103	0.328	0.557	0.696	0.844	0.975
1989	0.100	0.327	0.520	0.720	0.866	1.053
1990	0.105	0.290	0.395	0.585	0.693	0.845
1991	0.121	0.237	0.369	0.486	0.723	0.877
1992	0.101	0.293	0.365	0.526	0.651	1.110
1993	0.100	0.285	0.379	0.501	0.564	0.863
1994	0.193	0.260	0.353	0.472	0.621	0.775
1995	0.174	0.275	0.347	0.465	0.607	0.768
1996	0.119	0.276	0.407	0.552	0.707	1.012
1997	0.214	0.302	0.408	0.538	0.718	0.947
1998	0.178	0.305	0.428	0.546	0.649	0.966
1999	0.202	0.368	0.495	0.640	0.755	0.901
2000	0.229	0.383	0.480	0.615	0.766	0.954
2001	0.251	0.362	0.460	0.612	0.812	1.027
2002	0.282	0.381	0.480	0.665	0.833	1.068
2003	0.228	0.359	0.474	0.653	0.824	1.048
2004	0.211	0.296	0.440	0.586	0.728	0.956
2005	0.119	0.341	0.445	0.594	0.767	0.997
2006	0.100	0.309	0.411	0.555	0.760	0.998
2007	0.148	0.288	0.406	0.536	0.764	1.002

Table C6b. Georges Bank yellowtail flounder beginning of year weight at age (kg).

Year	age1	age2	age3	age4	age5	age6+
1973	0.055	0.292	0.403	0.465	0.564	0.778
1974	0.069	0.186	0.416	0.530	0.598	0.832
1975	0.068	0.191	0.410	0.524	0.613	0.695
1976	0.061	0.188	0.415	0.557	0.642	0.861
1977	0.071	0.192	0.404	0.587	0.704	0.931
1978	0.057	0.191	0.418	0.601	0.713	0.970
1979	0.068	0.183	0.381	0.578	0.713	0.950
1980	0.056	0.192	0.403	0.551	0.732	1.072
1981	0.078	0.184	0.397	0.546	0.681	0.840
1982	0.072	0.192	0.403	0.564	0.675	1.082
1983	0.107	0.185	0.364	0.543	0.694	1.010
1984	0.109	0.183	0.335	0.470	0.627	0.797
1985	0.132	0.242	0.347	0.493	0.604	0.800
1986	0.135	0.248	0.442	0.583	0.741	1.015
1987	0.074	0.242	0.423	0.606	0.727	0.875
1988	0.058	0.199	0.425	0.604	0.758	0.975
1989	0.059	0.184	0.413	0.633	0.776	1.053
1990	0.070	0.170	0.359	0.552	0.706	0.845
1991	0.078	0.158	0.327	0.438	0.650	0.877
1992	0.060	0.188	0.294	0.441	0.563	1.110
1993	0.062	0.170	0.333	0.428	0.545	0.863
1994	0.162	0.161	0.317	0.423	0.558	0.775
1995	0.138	0.230	0.300	0.405	0.535	0.768
1996	0.075	0.219	0.335	0.438	0.573	1.012
1997	0.179	0.190	0.336	0.468	0.630	0.947
1998	0.124	0.256	0.360	0.472	0.591	0.966
1999	0.147	0.256	0.389	0.523	0.642	0.901
2000	0.182	0.278	0.420	0.552	0.700	0.954
2001	0.204	0.288	0.420	0.542	0.707	1.027
2002	0.250	0.309	0.417	0.553	0.714	1.068
2003	0.200	0.318	0.425	0.560	0.740	1.048
2004	0.166	0.260	0.397	0.527	0.690	0.956
2005	0.074	0.268	0.363	0.511	0.670	0.997
2006	0.059	0.192	0.374	0.497	0.672	0.998
2007	0.129	0.170	0.354	0.469	0.651	1.002
2008	0.087	0.210	0.364	0.493	0.665	0.999

Table C7a. NEFSC Spring survey indices of minimum swept area abundance for Georges Bank yellowtail flounder in 000s of fish and metric tons.

Year	age1	age2	age3	age4	age5	age6+	B (mt)
1973	1882.9	3184.3	2309.4	1036.7	399.4	210.2	2852.2
1974	308.2	2168.5	1795.5	1225.0	336.9	273.8	2639.6
1975	409.2	2918.0	809.1	262.6	201.5	86.3	1626.4
1976	1008.4	4259.0	1216.0	302.4	191.2	108.4	2205.8
1977	0.0	654.0	1097.7	363.7	81.9	12.8	969.8
1978	912.2	778.4	494.4	213.9	25.7	7.7	719.8
1979	394.0	1956.8	395.2	328.3	58.7	88.7	1233.8
1980	55.3	4528.6	5617.2	460.6	55.0	35.3	4325.1
1981	11.4	995.9	1724.2	698.9	206.9	56.9	1902.8
1982	44.1	3656.5	1096.5	992.5	444.5	88.3	2426.3
1983	0.0	1810.0	2647.8	514.4	119.6	237.3	2564.2
1984	0.0	90.3	806.0	837.9	810.4	236.5	1597.6
1985	106.4	2134.2	254.4	273.4	143.4	0.0	959.0
1986	26.6	1753.0	282.6	54.6	132.9	53.2	822.5
1987	26.6	73.3	133.0	129.3	51.0	53.2	319.2
1988	75.5	266.9	355.2	234.7	193.2	26.6	549.1
1989	45.2	391.3	737.7	281.0	59.3	43.5	707.7
1990	0.0	63.7	1074.7	358.4	112.2	100.8	678.3
1991	422.5	0.0	246.9	665.1	255.5	20.0	612.5
1992	0.0	1987.7	1840.7	621.8	160.0	16.7	1520.1
1993	44.7	281.1	485.8	307.9	26.0	0.0	467.9
1994	0.0	602.3	614.7	343.6	140.4	38.7	641.1
1995	39.0	1144.6	4670.4	1441.7	621.5	9.5	2503.6
1996	24.4	958.1	2548.6	2621.8	591.6	56.2	2769.3
1997	18.2	1134.5	3623.1	3960.7	682.3	129.7	4230.6
1998	0.0	2020.1	1022.2	1123.4	737.1	339.6	2255.8
1999	48.7	4606.3	10501.7	2640.5	1575.2	756.3	9033.4
2000	177.3	4677.6	7440.5	2828.5	789.2	508.4	6498.9
2001	0.0	2246.7	6370.5	2340.0	469.2	439.7	4858.8
2002	182.4	2341.5	11971.1	3958.4	1690.3	845.4	9281.7
2003	196.1	4241.4	6564.9	2791.9	428.6	836.9	6524.2
2004	47.1	957.3	2114.4	659.9	247.7	263.8	1835.3
2005	0.0	1953.5	4931.0	2332.7	261.8	111.4	3307.2
2006	493.5	907.8	3419.2	2112.7	307.7	79.8	2349.3
2007	87.1	4899.7	6079.1	2762.3	540.0	125.2	4563.3
2008	0.0	2206.7	4921.5	1681.1	300.3	26.6	3151.6

Table C7b. NEFSC Fall survey indices of minimum swept area abundance for Georges Bank yellowtail flounder in 000s of fish and metric tons.

Year	age1	age2	age3	age4	age5	age6+	B (mt)
1973.5	2420.4	5336.0	4954.5	2857.4	1181.2	599.9	6299.2
1974.5	4486.7	2779.5	1471.6	1029.1	444.3	368.1	3560.7
1975.5	4548.6	2437.3	851.7	555.2	324.4	61.1	2257.4
1976.5	333.5	1863.9	460.3	113.6	118.5	97.3	1463.3
1977.5	906.7	2147.1	1572.8	615.4	102.3	105.7	2699.0
1978.5	4620.6	1243.3	757.2	399.2	131.6	34.9	2274.3
1979.5	1282.0	2008.5	253.7	116.7	134.3	108.6	1450.4
1980.5	743.6	4970.0	5912.0	662.0	212.3	250.9	6412.4
1981.5	1548.2	2279.4	1592.8	570.5	76.4	52.8	2500.1
1982.5	2353.3	2120.3	1543.4	410.4	86.6	0.0	2203.3
1983.5	105.7	2216.4	1858.5	495.7	29.9	47.7	2068.5
1984.5	641.6	388.1	296.7	236.0	72.7	60.7	575.8
1985.5	1310.2	527.5	165.9	49.1	78.3	0.0	688.4
1986.5	273.4	1075.1	338.7	71.9	0.0	0.0	795.5
1987.5	98.7	388.8	384.6	51.4	77.1	0.0	493.9
1988.5	18.2	206.7	104.0	26.6	0.0	0.0	165.5
1989.5	241.0	1934.1	750.4	76.6	54.0	0.0	948.1
1990.5	0.0	359.2	1429.9	285.8	0.0	0.0	703.2
1991.5	2038.8	267.0	426.2	347.2	0.0	0.0	708.4
1992.5	146.8	383.9	691.0	157.1	139.4	26.6	559.2
1993.5	814.6	135.2	568.8	520.4	0.0	21.4	529.5
1994.5	1159.8	214.6	954.1	692.2	254.9	54.8	870.7
1995.5	267.7	115.4	335.2	267.2	44.6	12.1	343.7
1996.5	144.3	341.3	1813.8	433.5	72.7	0.0	1264.6
1997.5	1351.8	517.7	3341.0	2028.5	1039.8	79.8	3669.7
1998.5	1844.4	4675.3	4078.9	1154.6	289.5	71.7	4219.7
1999.5	2998.7	8175.9	5558.9	1390.3	1394.2	252.8	7738.3
2000.5	610.8	1647.5	4672.5	2350.3	919.7	802.6	5666.1
2001.5	3414.2	6083.6	7853.7	2524.8	1667.8	1988.2	11213.4
2002.5	2031.4	5581.8	2064.5	576.1	295.6	26.6	3643.9
2003.5	1045.3	4882.8	2725.9	548.0	97.0	185.7	3919.2
2004.5	850.3	5346.1	4862.4	2044.4	897.1	170.7	4966.4
2005.5	304.0	2033.6	3652.1	595.9	179.3	0.0	2390.6
2006.5	6012.1	6067.2	3556.7	1132.9	247.7	44.4	4388.4
2007.5	1026.5	11110.9	7634.7	1939.6	371.3	90.9	7911.6

Table C7c. DFO Spring survey indices of minimum swept area abundance for Georges Bank yellowtail flounder in 000s of fish and metric tons. Note that two vectors are presented for 2008: 2008a includes the large tow while 2008b does not.

Year	age1	age2	age3	age4	age5	age6+	B (mt)
1987	75.2	751.1	1238.5	309.7	54.9	30.9	785.9
1988	0.0	1116.5	801.9	383.6	174.9	14.8	776.7
1989	71.8	645.8	383.2	185.2	41.8	14.1	295.9
1990	0.0	1500.9	2281.1	575.0	131.3	8.6	951.2
1991	15.4	539.6	745.8	2364.1	330.3	9.1	1105.6
1992	34.8	6942.1	2312.0	622.4	219.8	18.8	1556.7
1993	49.4	1528.8	2568.8	2562.9	557.5	81.8	1661.3
1994	0.0	3808.4	2178.6	1890.1	491.4	130.0	1731.4
1995	132.0	786.5	2737.4	1600.8	406.6	63.6	1274.6
1996	280.5	4491.0	5769.2	3399.8	726.5	77.2	3334.9
1997	13.6	7849.2	8742.1	10293.6	2543.2	421.5	8359.0
1998	561.7	2094.3	3085.9	2725.6	1250.4	351.2	2699.4
1999	99.8	13118.5	13101.2	4822.9	3364.5	1383.5	11109.4
2000	6.8	8655.8	17256.5	12100.9	3187.6	2319.8	12544.7
2001	183.3	12511.6	26489.4	8368.0	2881.0	1507.2	13933.8
2002	55.5	7522.3	19503.3	7693.6	3491.7	1781.4	13016.4
2003	56.3	7476.4	15480.7	6971.1	2151.0	1249.9	10217.8
2004	20.6	2263.5	10225.3	5788.7	1429.2	890.5	5693.4
2005	377.3	1007.5	17581.9	12931.4	3581.9	983.8	8399.2
2006	391.5	3076.8	11696.4	4132.7	515.4	149.4	4137.0
2007	108.9	7646.4	17423.7	8048.5	1439.1	156.2	8391.2
2008a	0.0	30382.5	107131.7	35919.3	5067.8	34.5	42333.4
2008b	0.0	2907.3	6882.8	1964.6	367.1	35.9	4104.4

Table C7d. NEFSC Scallop survey index of abundance (stratified mean catch/tow) for Georges Bank yellowtail flounder.

Year	age 1	Year	age 1
1982.5	0.313	1995.5	0.609
1983.5	0.140	1996.5	0.508
1984.5	0.233	1997.5	1.062
1985.5	0.549	1998.5	1.872
1986.5	0.103	1999.5	1.038
1987.5	0.047	2000.5	0.912
1988.5	0.116	2001.5	0.789
1989.5	0.195	2002.5	1.005
1990.5	0.100	2003.5	0.880
1991.5	2.117	2004.5	0.330
1992.5	0.167	2005.5	0.573
1993.5	1.129	2006.5	2.422
1994.5	1.503		

Table C8. Mohn's rho retrospective statistic for F, SSB, and R.

	Major Change				Base Case	
Peel	**F**	**SSB**	**R**	**F**	**SSB**	**R**
2000	-37%	89%	90%	-80%	312%	146%
2001	-57%	115%	68%	-88%	416%	162%
2002	13%	23%	143%	-80%	266%	253%
2003	136%	-25%	35%	-45%	110%	90%
2004	4%	57%	-4%	-41%	168%	-16%
2005	5%	36%	-40%	-52%	101%	-45%
2006	-5%	13%	22%	-32%	21%	9%
Average	**8%**	**44%**	**45%**	**-60%**	**199%**	**86%**

Table C9. Diagnostics for VPA estimates.

Stock Numbers Predicted in Terminal Year Plus One (2008)

	No 2008 DFO			With Big Tow			Without Big Tow		
Age	N	Std. Error	CV	N	Std. Error	CV	N	Std. Error	CV
2	14994	6927	0.46	24272	9838	0.41	12568	5109	0.41
3	31704	9893	0.31	36110	10611	0.29	23866	7114	0.30
4	5339	1845	0.35	6462	2014	0.31	3969	1350	0.34
5	1875	476	0.25	1496	374	0.25	1097	293	0.27

Catchabiility Values for Each Survey Used in Estimate

	No 2008 DFO			With Big Tow			Without Big Tow		
Index	Catchability	Std. Error	CV	Catchability	Std. Error	CV	Catchability	Std. Error	CV
USsearly 1	0.007	0.005	0.66	0.007	0.005	0.66	0.007	0.005	0.66
USsearly 2	0.076	0.014	0.19	0.076	0.014	0.19	0.076	0.014	0.19
USsearly 3	0.096	0.017	0.18	0.096	0.017	0.18	0.096	0.017	0.18
USsearly 4	0.093	0.012	0.12	0.093	0.012	0.12	0.093	0.012	0.12
USsearly 5	0.076	0.015	0.20	0.076	0.015	0.20	0.076	0.015	0.20
USsearly 6	0.072	0.023	0.31	0.072	0.023	0.31	0.072	0.023	0.31
USspr 1	0.004	0.001	0.25	0.004	0.001	0.25	0.004	0.001	0.25
USspr 2	0.046	0.014	0.32	0.046	0.014	0.32	0.046	0.014	0.32
USspr 3	0.095	0.015	0.16	0.095	0.015	0.16	0.095	0.015	0.16
USspr 4	0.152	0.020	0.13	0.152	0.020	0.13	0.152	0.020	0.13
USspr 5	0.229	0.046	0.20	0.229	0.046	0.20	0.229	0.046	0.20
USspr 6	0.423	0.093	0.22	0.423	0.093	0.22	0.423	0.093	0.22
USspr95 1	0.005	0.001	0.30	0.004	0.001	0.30	0.005	0.002	0.31
USspr95 2	0.144	0.017	0.11	0.137	0.017	0.13	0.153	0.017	0.11
USspr95 3	0.500	0.088	0.18	0.495	0.090	0.18	0.529	0.092	0.17
USspr95 4	0.593	0.099	0.17	0.596	0.104	0.18	0.631	0.109	0.17
USspr95 5	0.481	0.109	0.23	0.498	0.111	0.22	0.520	0.115	0.22
USspr95 6	0.391	0.092	0.24	0.405	0.091	0.23	0.423	0.090	0.21
USfall 1	0.040	0.010	0.25	0.040	0.010	0.25	0.040	0.010	0.25
USfall 2	0.088	0.014	0.16	0.088	0.014	0.16	0.088	0.014	0.16
USfall 3	0.150	0.016	0.11	0.150	0.016	0.11	0.150	0.016	0.11
USfall 4	0.156	0.022	0.14	0.156	0.022	0.14	0.156	0.022	0.14
USfall 5	0.205	0.041	0.20	0.205	0.041	0.20	0.205	0.041	0.20
USfall 6	0.306	0.065	0.21	0.306	0.065	0.21	0.306	0.065	0.21
USfall95 1	0.065	0.015	0.23	0.062	0.015	0.24	0.070	0.016	0.23
USfall95 2	0.212	0.074	0.35	0.210	0.072	0.35	0.225	0.080	0.36
USfall95 3	0.556	0.108	0.19	0.557	0.108	0.19	0.586	0.122	0.21
USfall95 4	0.471	0.083	0.18	0.484	0.088	0.18	0.501	0.097	0.19
USfall95 5	0.490	0.128	0.26	0.504	0.133	0.26	0.521	0.140	0.27
USfall95 6	0.362	0.131	0.36	0.372	0.135	0.36	0.386	0.140	0.36
Canada 2	0.145	0.046	0.32	0.145	0.046	0.32	0.145	0.046	0.32
Canada 3	0.232	0.034	0.14	0.232	0.034	0.14	0.232	0.034	0.14
Canada 4	0.389	0.072	0.19	0.389	0.072	0.19	0.389	0.072	0.19
Canada 5	0.436	0.097	0.22	0.436	0.097	0.22	0.436	0.097	0.22
Canada 6	0.253	0.064	0.25	0.253	0.064	0.25	0.253	0.064	0.25
Can95 2	0.312	0.067	0.21	0.341	0.076	0.22	0.321	0.062	0.19
Can95 3	1.297	0.200	0.15	1.375	0.213	0.15	1.210	0.229	0.19
Can95 4	1.660	0.227	0.14	1.843	0.289	0.16	1.586	0.263	0.17
Can95 5	1.512	0.277	0.18	1.632	0.294	0.18	1.414	0.293	0.21
Can95 6	1.170	0.213	0.18	0.984	0.249	0.25	1.032	0.240	0.23
Scall 1	2.33E-05	6.87E-06	0.29	2.33E-05	6.87E-06	0.29	2.33E-05	6.87E-06	0.29
Scall95 1	5.39E-05	4.69E-06	0.09	5.33E-05	4.73E-06	0.09	5.72E-05	4.74E-06	0.08

	No 2008 DFO	With Big Tow	Without Big Tow
F2007	0.2892	0.3505	0.4523
SSB2007	9527	10351	7053
R2006	49437	56011	37743
MSR	0.582	0.600	0.603

Table C10. Estimated population abundance at age (000s).

Year	age 1	age 2	age 3	age 4	age 5	age 6+	sum
1973	29384	24172	29516	17300	6966	3013	110351
1974	52184	23733	15136	12051	5732	2391	111229
1975	70632	40588	10930	5010	3079	1709	131948
1976	24731	53646	9852	2425	977	1562	93193
1977	17283	19674	15554	3171	719	850	57252
1978	54437	13809	7987	3390	956	373	80953
1979	25508	35604	8124	2468	1073	559	73336
1980	24034	20595	19711	3268	747	239	68594
1981	62997	19390	13268	7499	1302	221	104677
1982	22846	51480	14885	5535	1783	156	96685
1983	6581	16754	25937	5517	1514	345	56648
1984	10843	4755	6579	6472	2305	487	31441
1985	16749	8414	2089	1379	870	136	29636
1986	8473	12837	2991	767	402	224	25695
1987	9193	6776	4801	1440	282	201	22692
1988	22841	7386	2617	1153	309	73	34379
1989	9661	18250	3361	771	198	55	32296
1990	11217	7738	12981	1747	250	47	33980
1991	22557	8975	4437	4399	560	104	41032
1992	17518	17869	7215	2296	940	65	45904
1993	13938	12168	6459	3250	574	126	36516
1994	13180	6725	8713	2323	609	184	31734
1995	11672	10726	4304	1576	305	66	28650
1996	13470	9514	8500	2237	509	70	34299
1997	19801	10938	7175	5104	1040	246	44303
1998	22402	16138	7934	4228	2515	328	53545
1999	24564	18189	11418	3467	1778	675	60091
2000	19880	20057	12412	5591	1456	931	60327
2001	22331	16157	12945	5060	1756	918	59167
2002	15547	18124	10633	4404	1570	1116	51394
2003	11770	12537	11091	5615	1894	1678	44585
2004	10472	9492	6749	4870	2522	1857	35962
2005	14435	8516	6689	2695	647	280	33263
2006	49437	11764	5596	1850	688	395	69731
2007	18373	40337	8460	3058	622	252	71101
2008	19120	14994	31704	5339	1875	536	73568

Table C11. Estimated fishing mortality rate at age.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1973	0.01	0.27	0.70	0.90	0.90	0.90
1974	0.05	0.58	0.91	1.16	1.16	1.16
1975	0.08	1.22	1.31	1.43	1.43	1.43
1976	0.03	1.04	0.93	1.02	1.02	1.02
1977	0.02	0.70	1.32	1.00	1.00	1.00
1978	0.22	0.33	0.97	0.95	0.95	0.95
1979	0.01	0.39	0.71	0.99	0.99	0.99
1980	0.01	0.24	0.77	0.72	0.72	0.72
1981	0.00	0.06	0.67	1.24	1.24	1.24
1982	0.11	0.49	0.79	1.10	1.10	1.10
1983	0.13	0.73	1.19	0.67	0.67	0.67
1984	0.05	0.62	1.36	1.81	1.81	1.81
1985	0.07	0.83	0.80	1.03	1.03	1.03
1986	0.02	0.78	0.53	0.80	0.80	0.80
1987	0.02	0.75	1.23	1.34	1.34	1.34
1988	0.02	0.59	1.02	1.56	1.56	1.56
1989	0.02	0.14	0.45	0.93	0.93	0.93
1990	0.02	0.36	0.88	0.94	0.94	0.94
1991	0.03	0.02	0.46	1.34	1.34	1.34
1992	0.16	0.82	0.60	1.19	1.19	1.19
1993	0.53	0.13	0.82	1.47	1.47	1.47
1994	0.01	0.25	1.51	1.83	1.83	1.83
1995	0.00	0.03	0.45	0.93	0.93	0.93
1996	0.01	0.08	0.31	0.57	0.57	0.57
1997	0.00	0.12	0.33	0.51	0.51	0.51
1998	0.01	0.15	0.63	0.67	0.67	0.67
1999	0.00	0.18	0.51	0.67	0.67	0.67
2000	0.01	0.24	0.70	0.96	0.96	0.96
2001	0.01	0.22	0.88	0.97	0.97	0.97
2002	0.02	0.29	0.44	0.64	0.64	0.64
2003	0.02	0.42	0.62	0.60	0.60	0.60
2004	0.01	0.15	0.72	1.82	1.82	1.82
2005	0.00	0.22	1.09	1.16	1.16	1.16
2006	0.00	0.13	0.40	0.89	0.89	0.89
2007	0.00	0.04	0.26	0.29	0.29	0.29

Table C12a. Estimated spawning stock biomass (mt).

Year	age 1	age 2	age 3	age 4	age 5	age 6+	sum
1973	0	3198	9079	5754	2651	1479	22161
1974	0	2730	4580	4142	2201	1127	14780
1975	0	3285	2760	1404	964	601	9014
1976	0	4616	3232	928	438	810	10024
1977	0	2135	4177	1218	340	480	8351
1978	0	1606	2415	1449	475	224	6169
1979	0	4230	2483	984	480	323	8501
1980	0	2551	6282	1461	416	175	10884
1981	0	2688	4358	2489	506	102	10144
1982	0	5380	4616	2096	783	98	12975
1983	0	1552	6202	2328	779	242	11103
1984	0	373	1257	1402	646	168	3847
1985	0	912	672	529	380	65	2558
1986	0	1342	1152	341	226	150	3210
1987	0	682	1342	516	116	93	2750
1988	0	806	847	385	125	34	2198
1989	0	2392	1287	347	107	36	4170
1990	0	822	3159	636	108	25	4750
1991	0	897	1203	1124	213	48	3485
1992	0	1583	1827	678	344	41	4472
1993	0	1394	1546	810	161	54	3966
1994	0	671	1459	471	162	61	2823
1995	0	1237	1100	457	116	32	2941
1996	0	1079	2705	897	261	51	4993
1997	0	1335	2271	2045	556	174	6380
1998	0	1969	2326	1609	1138	221	7262
1999	0	2637	4059	1546	935	424	9600
2000	0	2957	3964	2122	688	548	10280
2001	0	2270	3674	1902	875	579	9300
2002	0	2600	3782	2060	920	838	10201
2003	0	1606	3608	2627	1118	1260	10219
2004	0	1122	1959	1231	792	766	5869
2005	0	1126	1685	906	281	158	4157
2006	0	1464	1729	652	332	250	4427
2007	0	4855	2742	1337	387	206	9526

Table C12b. Estimated Jan-1 biomass (mt).

Year	age 1	age 2	age 3	age 4	age 5	age 6+	sum 1+	sum 3+
1973	1607	7046	11898	8038	3927	2344	34860	26207
1974	3622	4424	6289	6382	3427	1990	26134	18088
1975	4803	7736	4483	2626	1887	1187	22722	10183
1976	1501	10075	4085	1351	627	1345	18984	7408
1977	1218	3781	6289	1861	506	792	14447	9448
1978	3092	2636	3335	2039	681	362	12145	6417
1979	1729	6523	3094	1427	765	531	14069	5817
1980	1334	3946	7938	1799	547	256	15820	10540
1981	4895	3566	5265	4092	887	186	18891	10430
1982	1638	9864	6000	3121	1203	169	21995	10493
1983	705	3091	9449	2994	1050	348	17637	13841
1984	1177	870	2203	3039	1445	388	9122	7075
1985	2209	2034	726	680	525	109	6283	2040
1986	1146	3189	1321	448	298	227	6629	2294
1987	676	1641	2029	872	205	176	5599	3282
1988	1320	1471	1112	696	234	71	4904	2113
1989	567	3349	1388	488	154	58	6004	2088
1990	784	1318	4665	963	177	39	7946	5844
1991	1755	1415	1451	1927	364	91	7003	3833
1992	1053	3365	2122	1012	529	73	8154	3736
1993	864	2065	2152	1390	313	109	6893	3964
1994	2131	1084	2764	983	340	142	7444	4229
1995	1613	2471	1293	638	163	51	6229	2145
1996	1006	2085	2844	979	292	71	7277	4186
1997	3550	2074	2408	2388	655	233	11308	5684
1998	2773	4123	2852	1996	1486	317	13547	6651
1999	3604	4655	4437	1815	1141	608	16260	8001
2000	3620	5578	5217	3085	1019	888	19407	10209
2001	4549	4652	5433	2742	1241	943	19560	10359
2002	3885	5604	4432	2436	1121	1192	18670	9181
2003	2355	3989	4714	3144	1402	1759	17363	11019
2004	1738	2466	2682	2566	1739	1775	12966	8762
2005	1065	2284	2428	1378	434	279	7868	4519
2006	2912	2256	2095	919	463	394	9039	3871
2007	2372	6845	2997	1436	405	252	14307	5090
2008	1669	3147	11534	2629	1246	535	20760	15944

Table C13. Bootstrap estimates of uncertainty in 2007 fishing mortality rates at age, 2007 spawning stock biomass (mt), and 2008 January 1 biomass (mt).

	Point	10th%ile	90th%ile
F 2007			
age 1	0.0032	0.0019	0.0056
age 2	0.0408	0.0270	0.0610
age 3	0.2603	0.1826	0.3809
age 4	0.2892	0.2170	0.3820
age 5	0.2892	0.2170	0.3820
age 6+	0.2892	0.2170	0.3820
SSB 2007	9526	7653	12328
Jan-1 B 2008	15944	11980	22121

Table C14. Values for partial recruitment, maturity, and weight at age (kg) used in yield per recruit calculations and age based projections.

Age	PR	Maturity	WAA
1	0.0069	0.000	0.161
2	0.2015	0.462	0.319
3	0.6490	0.967	0.435
4	1.0000	1.000	0.585
5	1.0000	1.000	0.769
6+	1.0000	1.000	1.000

Table C15. Biological reference points for Georges Bank yellowtail flounder from GARM II, GARM III Reference Points meeting, and this assessment.

	GARM II	GARM III BRP	GARM III Final
Fmsy	0.25	0.254	0.254
SSBmsy (mt)	58800	46000	43200
MSY (mt)	12900	10000	9400

Table C16. Three projections for 2009 catch all of which assume catch in 2008 equal to catch in 2007: F status quo applied F2007 in 2009; F_{MSY} applies F_{MSY} in 2009; and $F_{REBUILD}$ is solved iteratively to produce 50% probability of SSB>SSB_{MSY} in 2014 when the F is applied every year from 2009 to 2014.

	2007	2008	2009		
			F st quo	Fmsy	$F_{REBUILD}$
C (mt)	1686	1686	5503	4908	3989
F (4-5)	0.289	0.126	0.289	0.254	0.202
SSB (mt)	9527	18760	22196	22468	22895

Table C17. Two additional projections requested by the TRAC assuming catch in 2008 equal to the quota of 2,500 mt: Fref where F in years 2009-2014 is set equal to Fref of 0.25 and Freb75 where a constant F in years 2009-2014 is calculated to achieve SSB_{MSY} in 2014 with 75% probability.

	2007	2008	2009		2010	
			Fref	Freb75	Fref	Freb75
C (mt)	1686	2500	4648	2114		
F (4-5)	0.289	0.191	0.25	0.107		
SSB (mt)	9527	18421	21719	22844		
3+ B (mt)	5090	15944	20520	20520	22347	24913

Table C18. Risk, defined as the probability that F in 2009 will exceed Fref = 0.25, and relative change in age 3+ Jan-1 biomass from 2009 to 2010 under different scenarios of catch in 2009.

Catch (mt)	Risk	Relative Change in Median Age 3+ B
1000	0	27%
2000	0	22%
3000	0.032	17%
4000	0.271	12%
4500	0.455	9%
5000	0.619	7%
6000	0.843	2%
7000	0.961	-3%
8000	0.992	-8%
9000	0.999	-13%

Table C19. Results of sensitivity analysis for change in age 3 partial recruitment used in projections.

	Age 3 PR		
	0.649	0.40	0.90
2008 C (mt)	2500	2500	2500
2009 C (mt)	4648	4370	4901
2008 F (4-5)	0.191	0.248	0.156
2009 F (4-5)	0.25	0.25	0.25
2008 SSB (mt)	18421	18429	18413
2009 SSB (mt)	21719	21842	21593

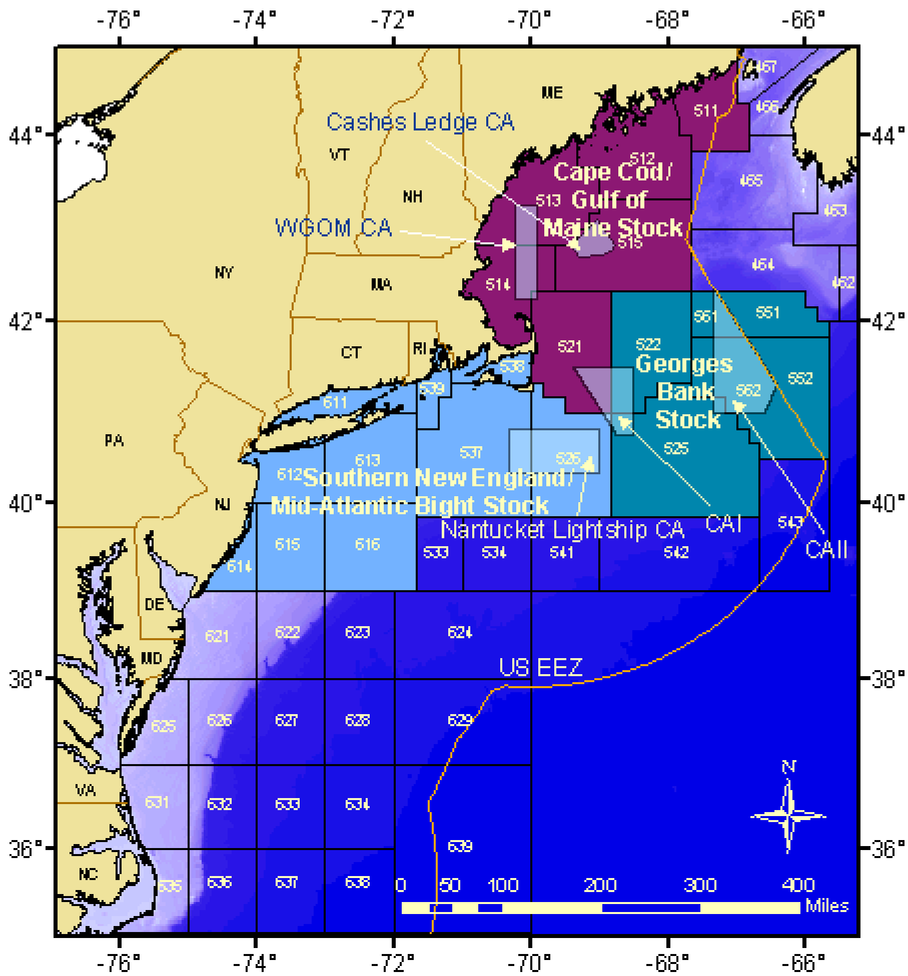

Figure C1. Stock area map for yellowtail flounder from Status of Stocks website (http://www.nefsc.noaa.gov/sos/).

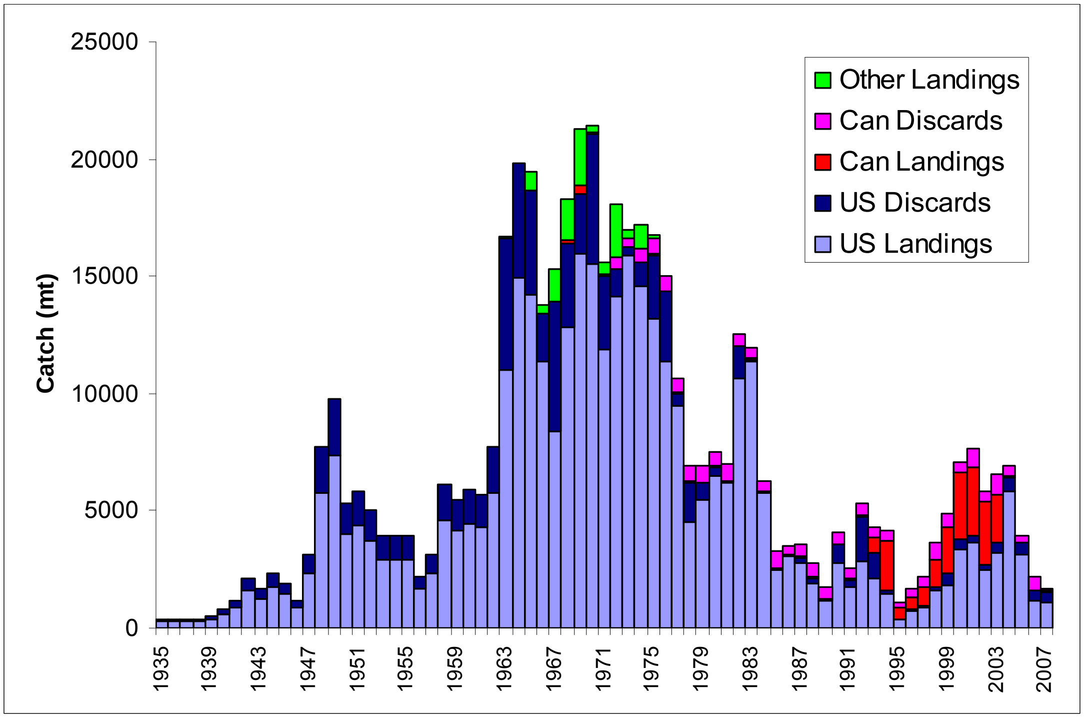

Figure C2. Total catch of Georges Bank yellowtail flounder.

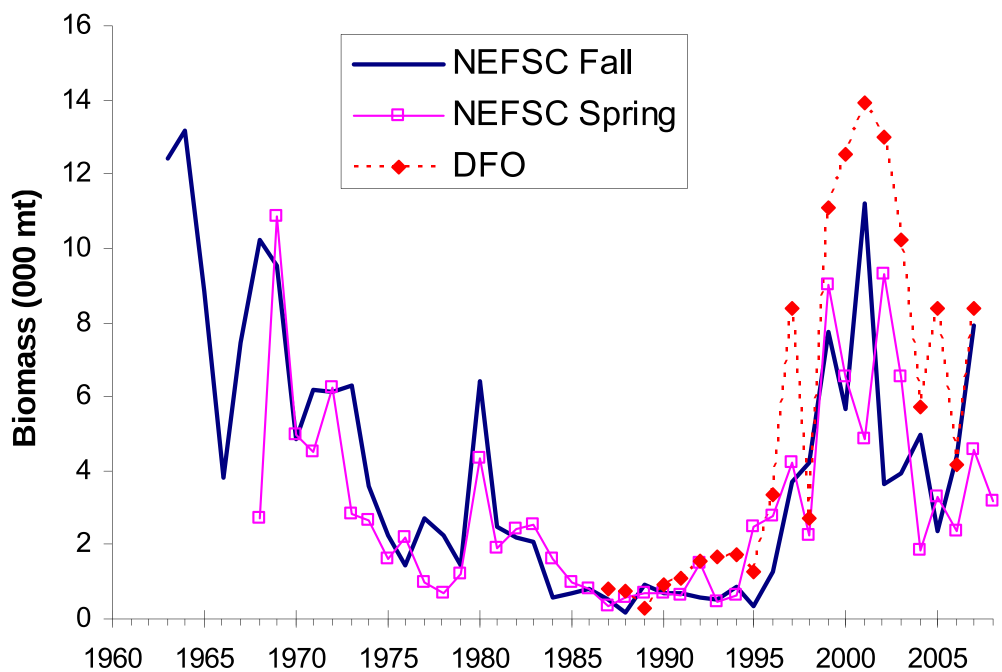

Figure C3. Trends in survey biomass for Georges Bank yellowtail flounder expressed as minimum swept area estimates. The 2008 value for the DFO survey is not shown.

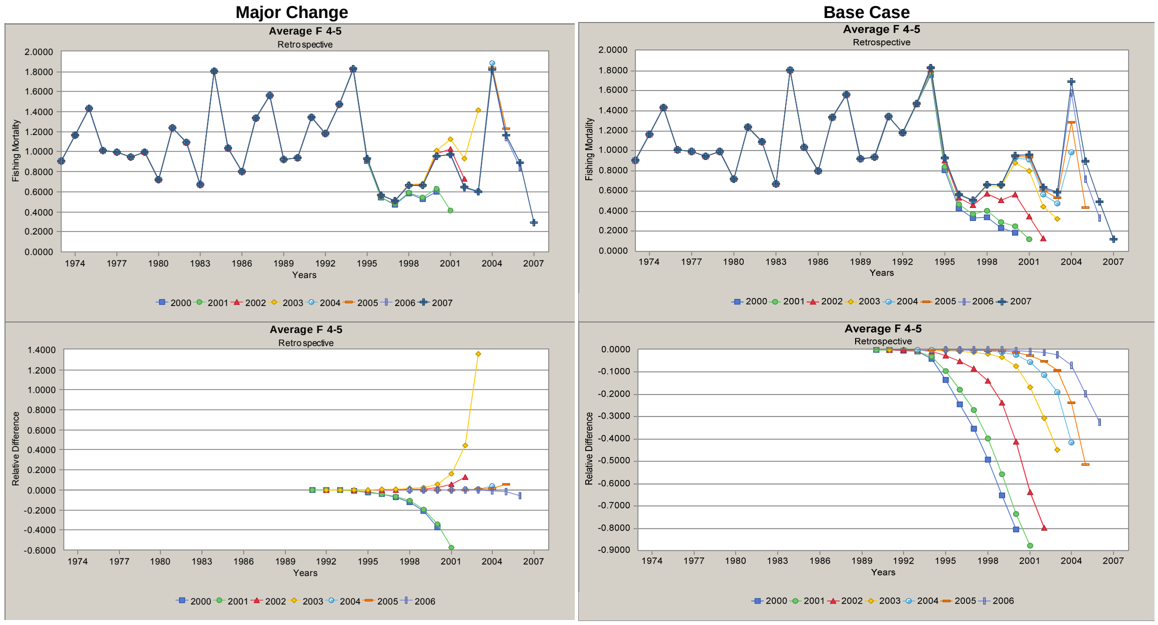

Figure C4a. Retrospective plots of fully recruited fishing mortality rate (ages 4-5).

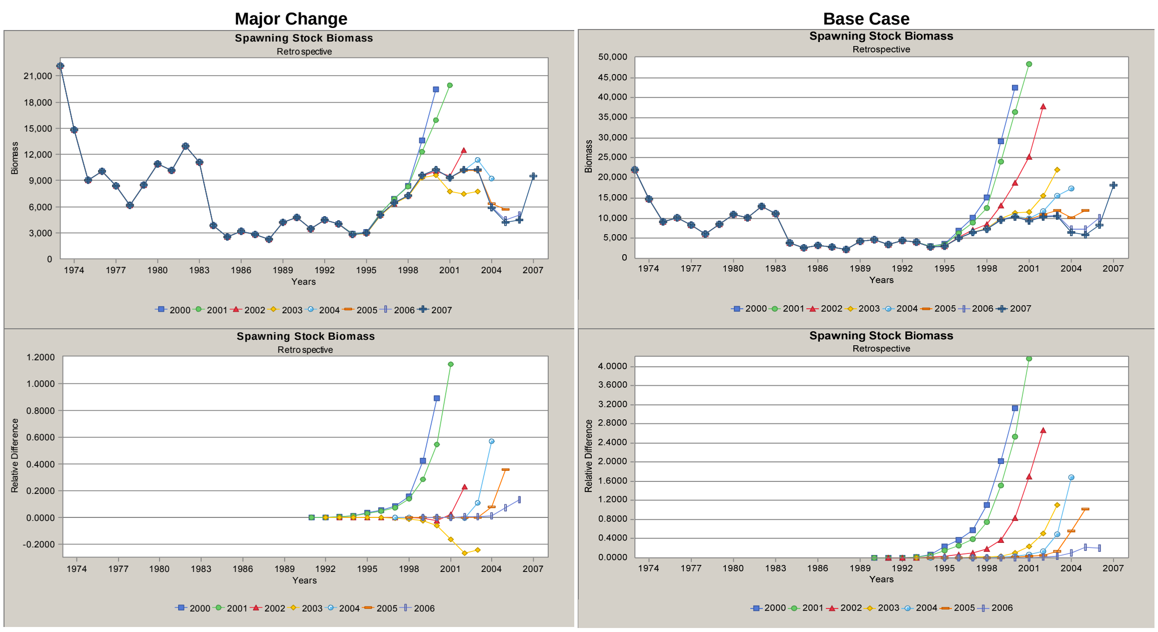

Figure C4b. Retrospective plots of spawning stock biomass.

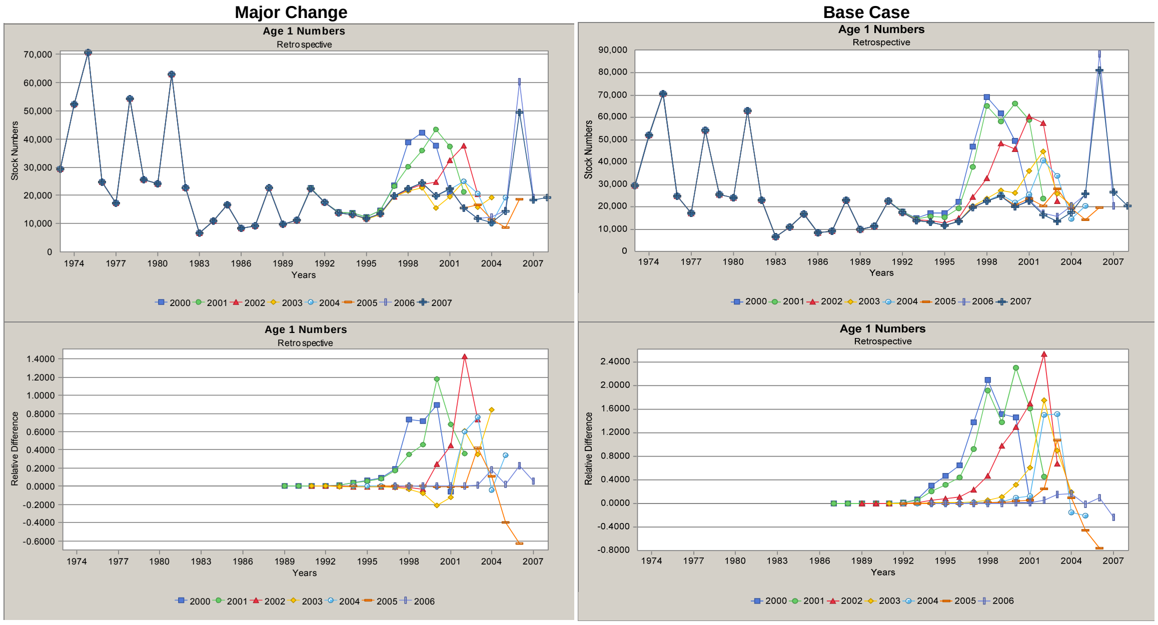

Figure C4c. Retrospective plots of recruitment. Note the final estimate in each series is the geometric mean of the previous values.

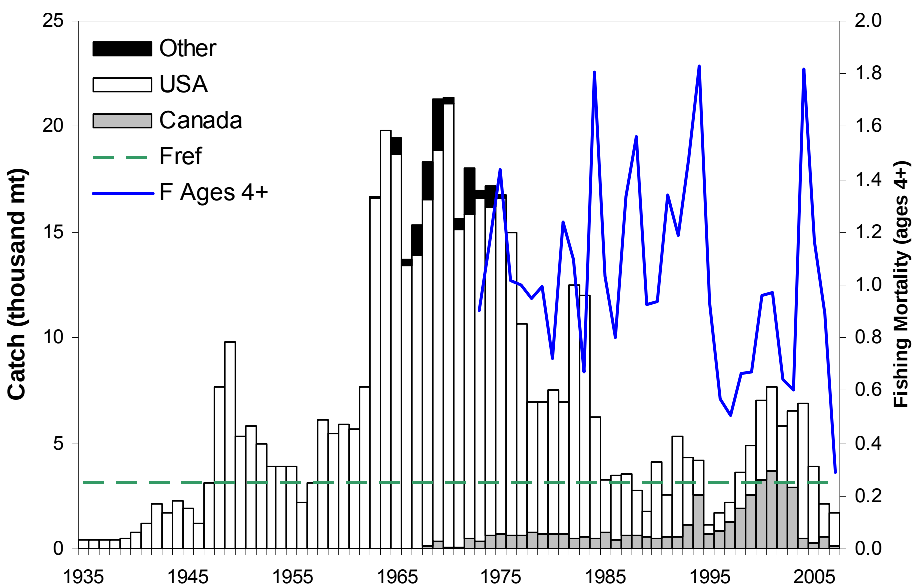

Figure C5. Catch and estimated fishing mortality rate (ages 4-5 unweighted) from the Major Change model.

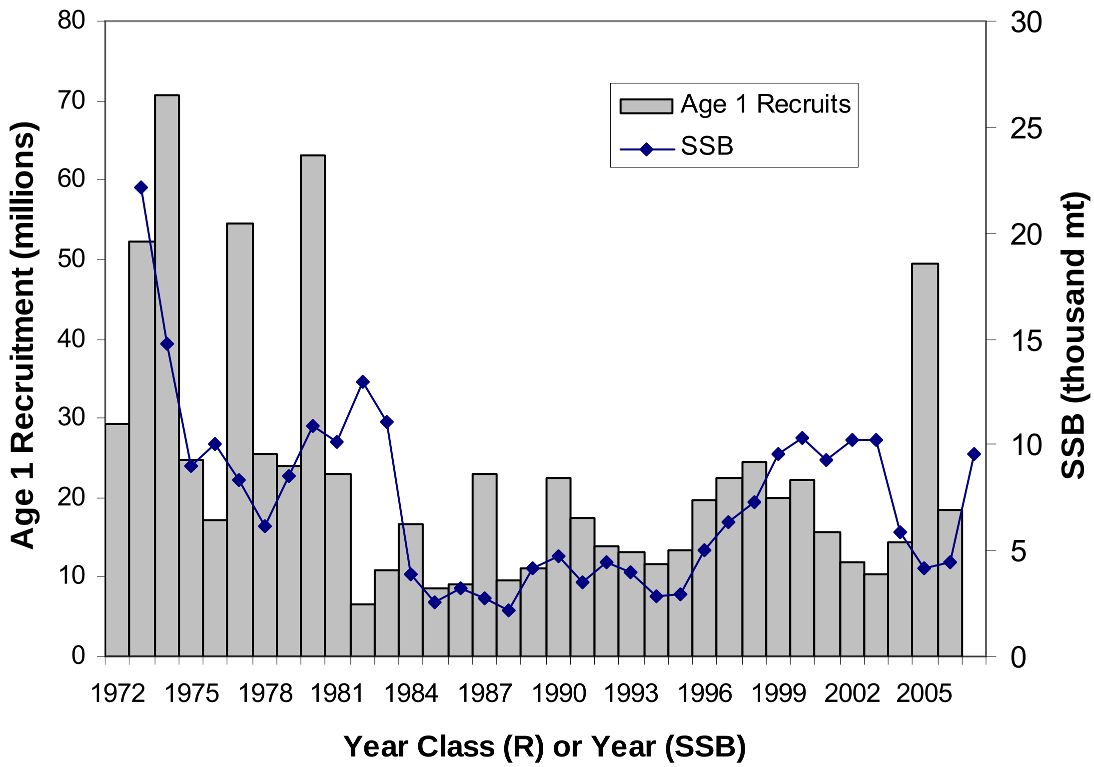

Figure C6. Recruitment (millions of fish) and spawning stock biomass (thousand mt) estimated from the Major Change model.

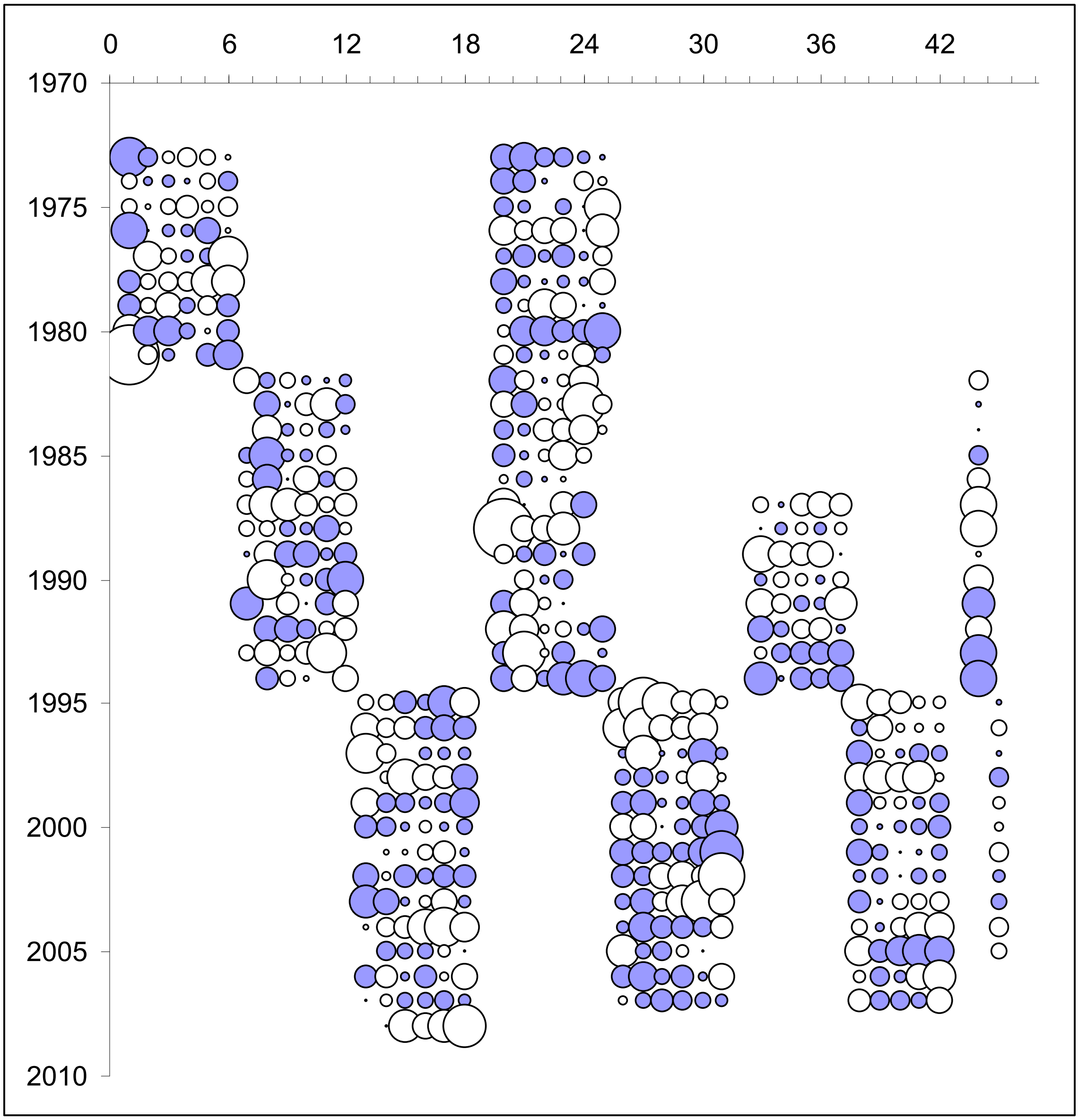

Figure C7. Residuals for indices of abundance in VPA grouped by survey: columns 1-18 are NEFSC Spring ages 1-6 separated into Yankee 41, Yankee 36 early, Yankee 36 recent, columns 20-31 are NEFSC Fall ages 1-6 separated into early and recent, columns 33-42 are DFO separated into early and recent, and columns 44-45 and NEFSC scallop separated into early and recent.

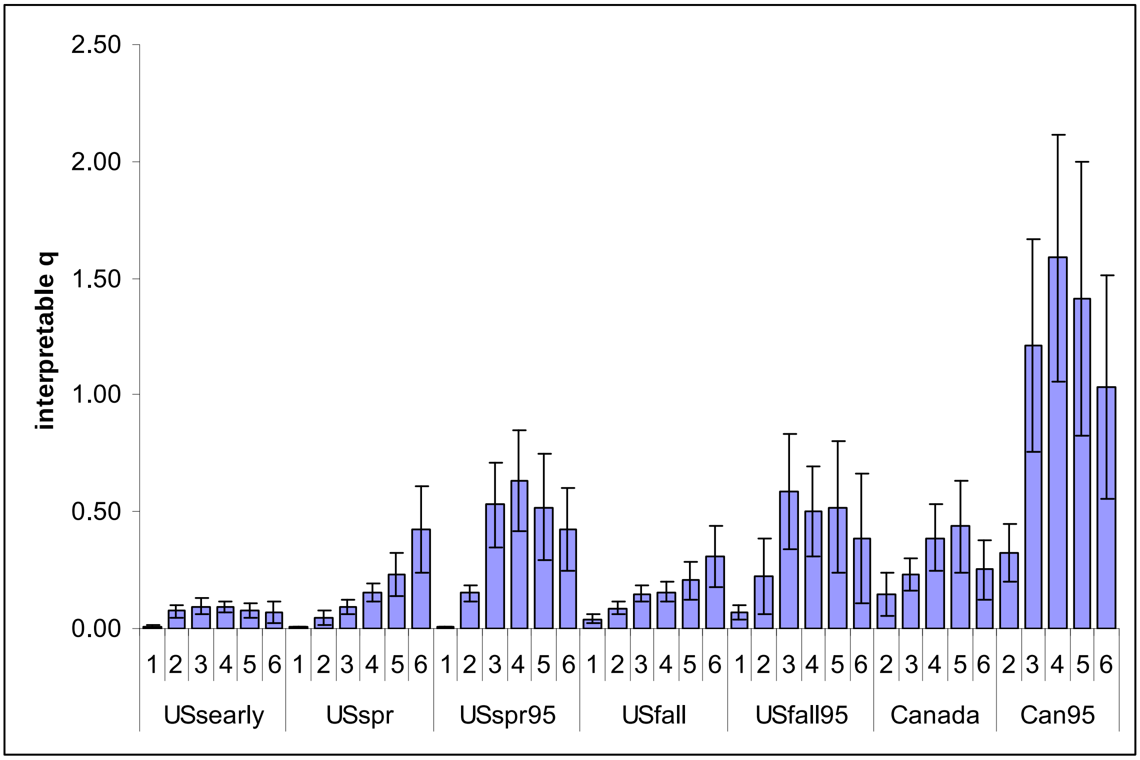

Figure C8. Catchability estimates with plus and minus two standard deviations for swept area indices for those surveys which have interpretable q values.

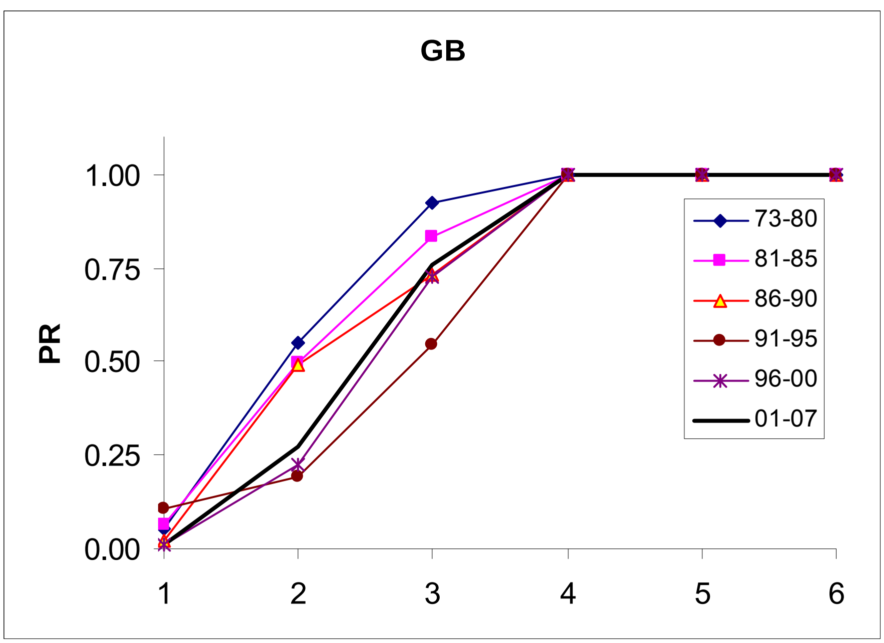

Figure C9. Average back-calculated partial recruitment from VPA.

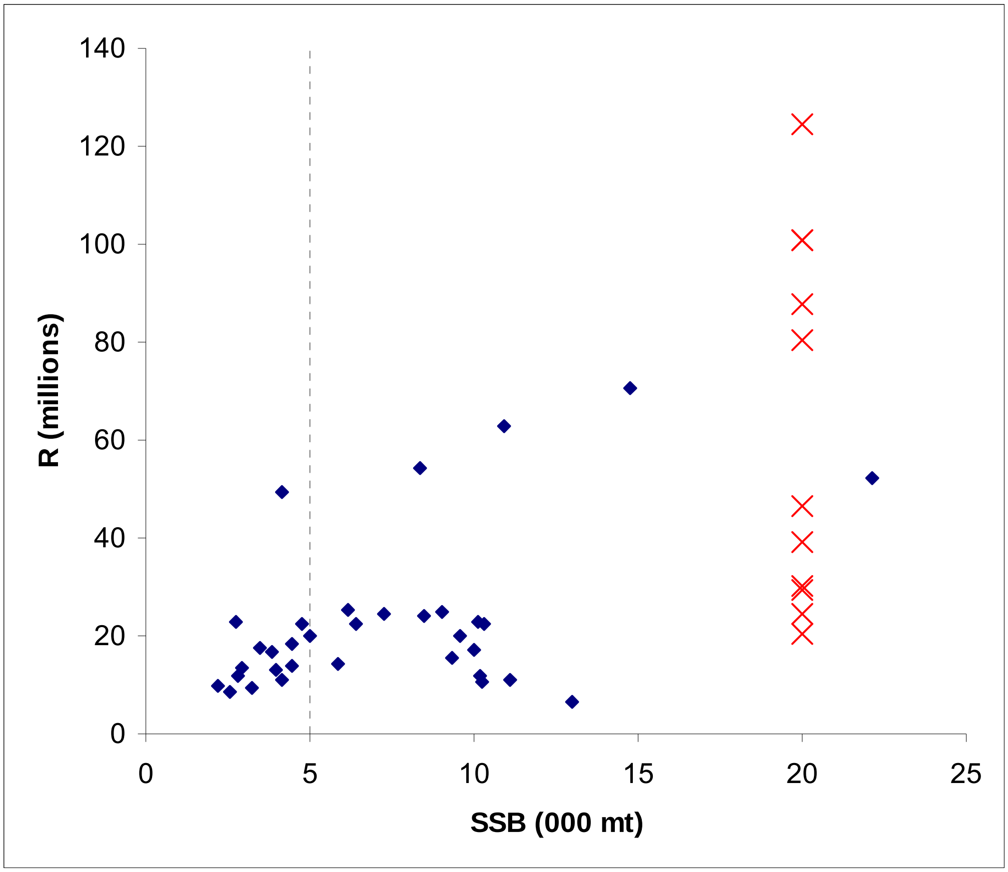

Figure C10. Stock recruitment relationship. Filled diamonds denote SSB and R pairs from VPA, crosses denote hindcast R estimates (SSB set to 20 kt for presentation purposes only), and dashed line denotes breakpoint at SSB of 5 kt for use in determining R values in projections.

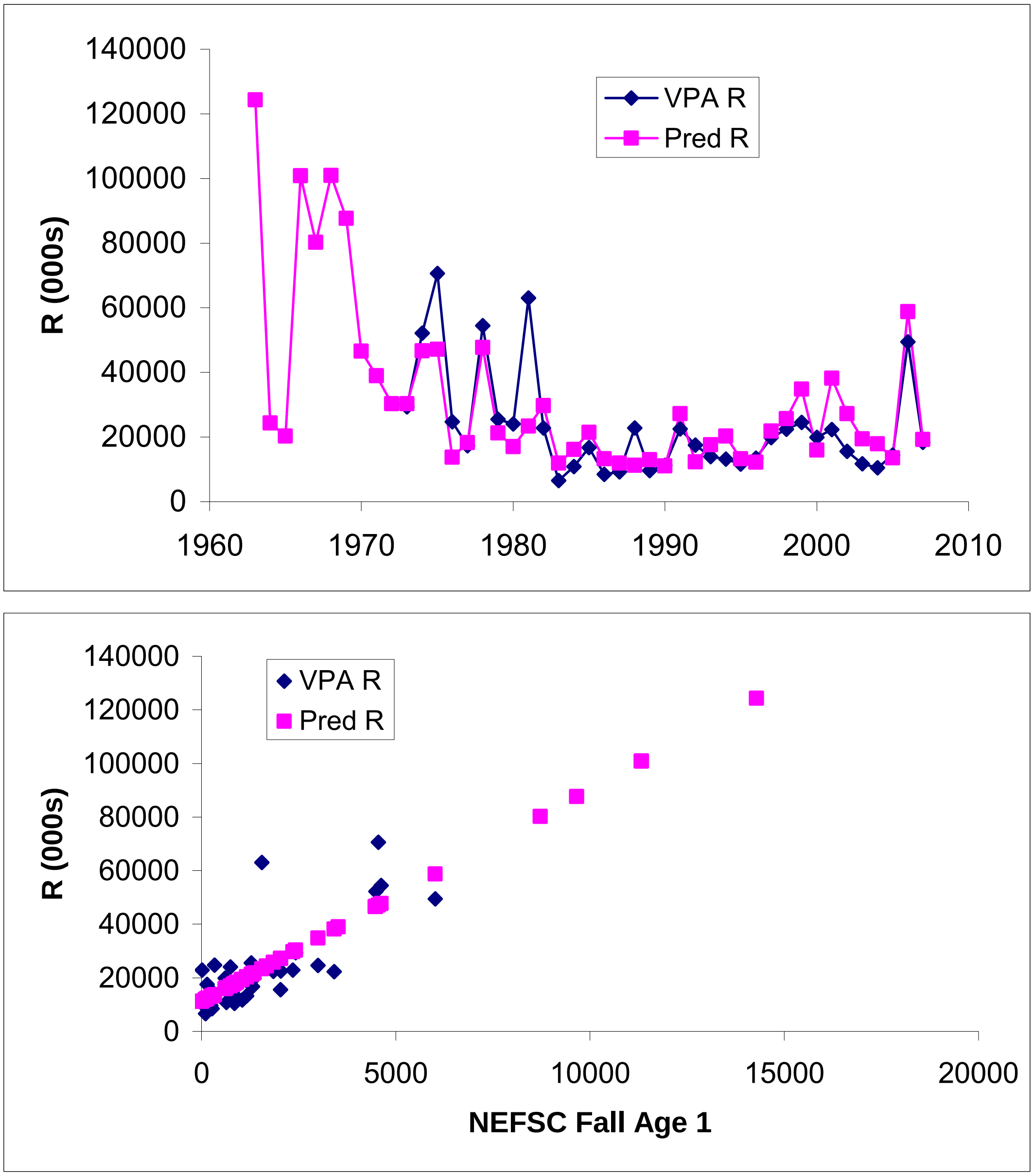

Figure C11. Hindcast estimates of recruitment using the NEFSC Fall survey at age 1.

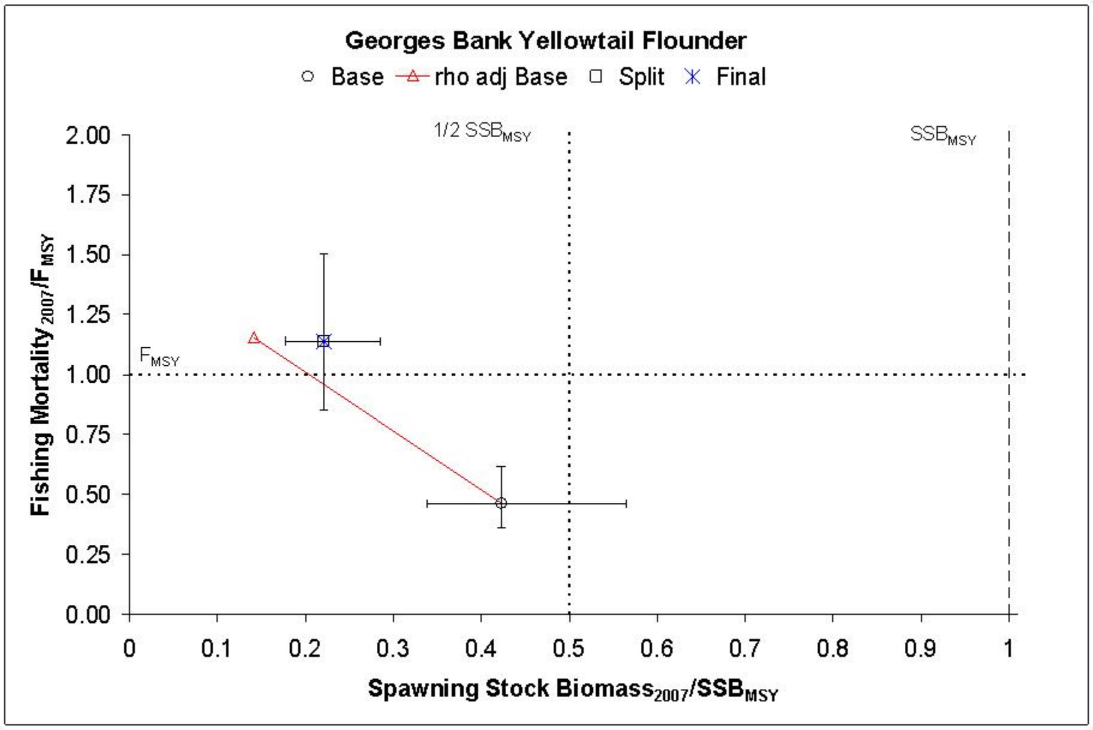

Figure C12. Current status of Georges Bank yellowtail flounder. The point labeled Split corresponds to the Major Change model, the model used for final status determination and projections. The Base and rho adj Base results are presented for comparison purposes only and were not used for status determination nor projections.

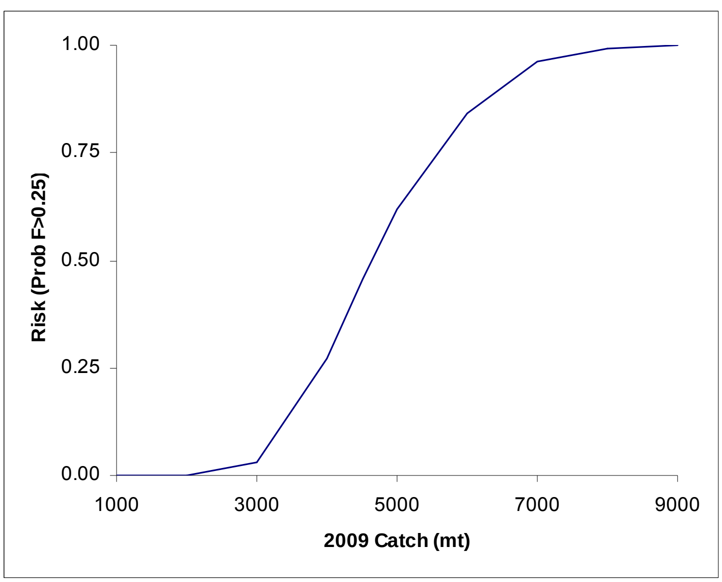

Figure C13. Risk of F_{2009} exceeding F_{ref}=0.25 for a range of 2009 catch (mt).