EXECUTIVE SUMMARY

GARM III Overview

The Groundfish Assessment Review Meeting (GARM) conducted during November 2007 – August 2008 was a regional scientific peer review process to provide benchmark assessments for the 19 groundfish stocks managed under the Northeast Multispecies Fishery Management Plan. The first two GARM reviews took place in October 2002 (GARM I) and August 2005 (GARM II), respectively. The GARM III was the most comprehensive review to date, and provided peer reviewed assessments on the following Northeast Groundfish stocks managed by the New England Fishery Management Council:

A. Georges Bank Cod
B. Georges Bank Haddock
C. Georges Bank Yellowtail Flounder
D. Southern New England/Mid-AtlanticYellowtail Flounder
E. Gulf of Maine/Cape Cod Yellowtail Flounder
F. Gulf of Maine Cod
G. Witch Flounder
H. American Plaice
I. Gulf of Maine Winter Flounder
J. Southern New England/Mid-Atlantic Winter Flounder
K. Georges Bank Winter Flounder
L. White Hake
M. Pollock
N. Acadian Redfish
O. Ocean Pout
P. Gulf of Maine/Georges Bank Windowpane
Q. Southern New England/Mid-Atlantic Windowpane
R. Gulf of Maine Haddock
S. Atlantic Halibut

Whereas GARM II considered updates of the assessments reviewed in GARM I, the GARM III process was much more extensive and involved in-depth reviews of the data, models, biological reference points, and assessments of each of the 19 groundfish stocks. A total of 18 reviewers over four panels were involved in the four GARM III meetings, representing an exceptional level of peer review. Panel Summary Reports from the first three GARM III meetings are available in NEFSC (2008).

The four meetings of GARM III included:

- Data Inputs (29 Oct – 2 Nov 2007)
- Assessment Models (25 – 29 Feb 2008)
- Biological Reference Points (28 April – 2 May 2008)
- Assessments (4 – 8 August 2008)

The 'Data Inputs' meeting focused on the data inputs to be used in the assessments. A number of enhancements to the data used in GARM II were developed, including a new multitier trip-based allocation system to match vessel trip and dealer reports. The new system is comprehensive, consistent across species, provides continuity with the previous interview system, is a common data source for all species, and provides a finer scale of spatial resolution than previously possible. While landings allocations among stocks were mostly unchanged from GARM II, the new system provides the opportunity to explore the impact of uncertainty in reported stock area of the landings. The 'Data Inputs' review also considered how best to estimate discards, with a common approach (termed the 'ratio of sums' method) proposed and used in all assessments. The discard estimates in GARM III are similar to those used in GARM II. A number of tagging studies were reviewed that became available since GARM II, and which informed the stock assessments through quantification of migration patterns, spawning areas, age-length keys, and other biological characteristics. Some of these data and results were used in the subsequent GARM III meetings. In addition to reviewing sampling plans and analyses of both NMFS and industry-based resource surveys, the 'Data Inputs' review undertook an extensive stock by stock analysis of temporal trends in a variety of biological and population dynamics parameters including length-at-age, weight-at-age, maturity-at-age, and condition factor. Since GARM II, many stocks have exhibited long term declines in weights-at-age which have significant implications for biological reference points. These analyses informed the subsequent GARM III reviews.

The 'Assessment Models' review considered the most appropriate analytical approaches to be applied to the individual stock datasets vetted and reviewed at the 'Data Inputs' meeting. For each groundfish stock, the appropriate type of assessment model (relative trend survey index model; production model; length-based model; age-based model) was considered given the available data and underlying model assumptions and uncertainties. For 14 of the 19 groundfish stocks, the Virtual Population Analysis (VPA) approach used in GARM II was considered appropriate for the GARM III benchmark assessments. Many of the assessments, however, continued to exhibit a retrospective pattern (systematic over- or under-estimation of stock size, recruitment, or fishing mortality in recent years) which the 'Models' review deemed important be taken into account (a) in determining current stock status and (b) in conducting short-term forecasts and rebuilding plan projections. Two approaches for adjusting for retrospective patterns were developed: splitting survey time series, and adjusting current population numbers based on the observed retrospective pattern in the recent past (used if the first approach did not significantly ameliorate or eliminate the pattern). Adjusting for the retrospective pattern in the current assessments is a marked procedural difference from GARM II, where the extent of the pattern was reported but not formally incorporated into the determination of stock status. The GARM III 'Assessment Models' review resulted in significant improvements to a number of assessments. For example, the assessments of Gulf of Maine haddock, Georges Bank winter flounder, and white hake are now based on age-based formulations, as opposed to the previous relative trends and production model formulations. Atlantic halibut, which had no assessment in GARM II, is now assessed using a production model. Overall, significant advances in assessment methodology are reflected in the GARM III assessments relative to the GARM II assessments.

The GARM 'Biological Reference Points' meeting focused on the fishing mortality and stock biomass biological reference points (BRPs) to be used in the assessments and rebuilding plans for the 19 groundfish stocks. Whereas an array of methods was used to compute BRPs in GARM II, the principal method in GARM III was to (a) estimate F_{MSY} based upon $F_{40\%MSP}$ (50 % for Acadian redfish) from a spawner per recruit analysis, and (b) estimate the associated

B_{MSY} using recruitment values from the population time series. Considerable attention was given in the meeting to the most appropriate historical time period to be used in estimating the BRPs and, by inference, in the stock and rebuilding plan projections. As noted in the GARM III 'Data Inputs' review meeting, the reductions in weights-at-age observed in GARM II has continued for many of the 19 groundfish stocks. As well, age-specific fishery selectivity has shifted in many stocks to older age groups due to a combination of reduced growth, fishery management measures, and changing fishing practices. These trends were incorporated into the updated BRPs for the 19 groundfish stocks, and resultingly many of the newly-estimated biomass reference points are now lower and the fishing mortality reference points higher than those estimated in GARM II. However, a direct one-to-one comparison between the old and new BRPs is inappropriate because of the aforementioned changes in weights and partial recruitment at age. This necessitates a careful and transparent understanding of why the changes in the BRPs have occurred.

In the fourth and last GARM III review (the 'Assessments' meeting), the data and results from the first three GARM III meetings were included and synthesized in the benchmark assessments of the 19 Northeast groundfish stocks. The "Assessments' meeting also identified the appropriate analytical procedures to perform the stock and rebuilding plan projections. The key element in the projections was to use the same assumptions for growth, maturity, natural mortality, and recruitment as used in estimating the BRPs - but with the additional use of historical recruitment values at SSBs below specified 'breakpoints' during the rebuilding period. The meeting also examed the productivity of the Northeast Shelf ecosystem, with particular regard to the joint sustainability of the 19 groundfish stocks and the inclusion of other ecosystem groups (invertebrates, pelagics and elasmobranches). This examination revealed that at the current low biomass of many of the groundfish stocks, the aggregate Maximum Sustainable Yield (MSY) for the multispecies groundfish complex is almost equivalent to the sum of the MSY estimates from each of the stocks. However, as stock biomasses improve, the estimated aggregate MSY could be significantly lower than the sum of the individual stock MSY estimates. The review recognized the ecosystem work as being innovative and early in its development for implementation, and encouraged efforts to more fully explore how broader ecosystem considerations could be used to complement single stock management inthe Northeast Region.

Stock Assessments of 19 Northeast Groundfish Stocks

Of the 19 groundfish stocks, the GARM III benchmark assessments indicated that six stocks were fished below F_{MSY} (or its proxy) in 2007 and 13 above (Tables 1 and 2; Figures 1 and 2). This compares to 10 below and eight above F_{MSY} in 2004 based on the GARM II assessments. Biomass of six of the 19 stocks were at or above ½ B_{MSY}, while the biomasses of 13 stocks were below the threshold, a situation comparable to that in 2004. Eleven of the stocks are now both overfished and experiencing overfishing, compared to seven in 2004. Pollock, witch flounder, Georges Bank (GB) winter flounder, Gulf of Maine (GOM) winter flounder and northern windowpane have deteriorated in status, while GOM cod has improved. This latter stock, while still experiencing overfishing, is no longer overfished. In 2004, five stocks (pollock, redfish, northern windowpane, GOM winter flounder, and witch flounder) were classified as not overfished and not experiencing overfishing. In 2007, four stocks achieved this status – redfish, American plaice, GB haddock, and GOM haddock.

Table 1. Comparison of status of the Northeast groundfish stocks in 2004 (GARM II) and 2007 (GARM III). GARM II used catch data through 2004, and did not assess halibut; GARM III used catch data through 2007.

Stock Status	2004 (GARM II)	2007 (GARM III)
Overfished and Overfishing Biomass < ½ B_{MSY} AND $F > F_{MSY}$	GB Cod GB Yellowtail SNE/MA Yellowtail GOM/CC Yellowtail SNE/MA Winter Flounder White Hake GOM Cod	GB Cod GB Yellowtail SNE/MA Yellowtail GOM/CC Yellowtail SNE/MA Winter Flounder White Hake Pollock Witch GB Winter Flounder GOM Winter Flounder No. Windowpane
Overfished but not Overfishing Biomass < ½ B_{MSY} AND $F \leq F_{MSY}$	GB Haddock GOM Haddock So. Windowpane Plaice Ocean Pout	Ocean Pout Halibut
Not Overfished but Overfishing Biomass ≥ ½ B_{MSY} AND $F > F_{MSY}$	GB Winter Flounder	GOM Cod So. Windowpane
Not Overfished and not Overfishing Biomass ≥ ½ B_{MSY} AND $F \leq F_{MSY}$	Pollock Redfish No. Windowpane GOM Winter Flounder Witch	Redfish Plaice GB Haddock GOM Haddock

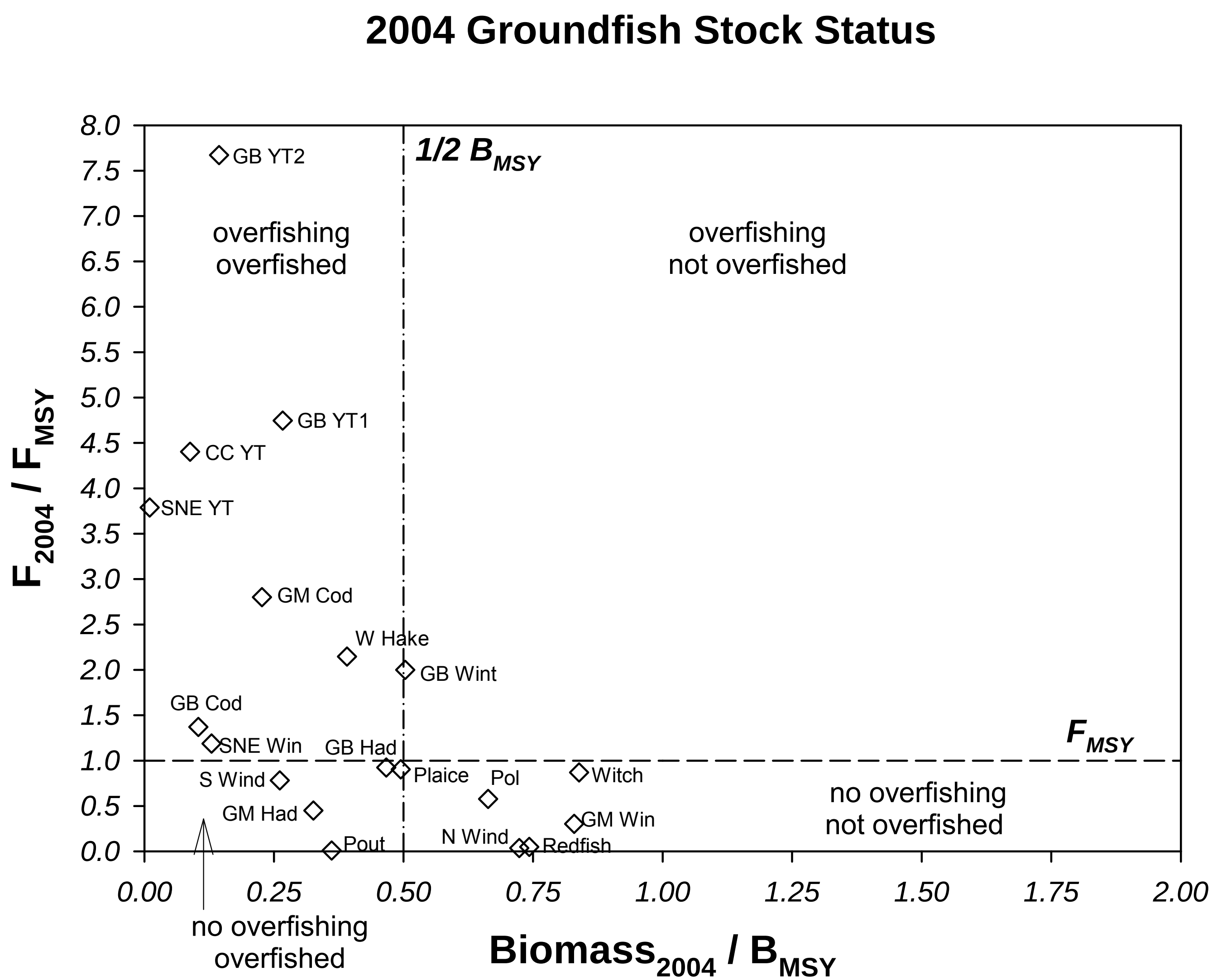

Figure 1. Status of 18 groundfish stocks in 2004 with respect to F_{MSY} and B_{MSY} or their proxies based on the GARM II review.

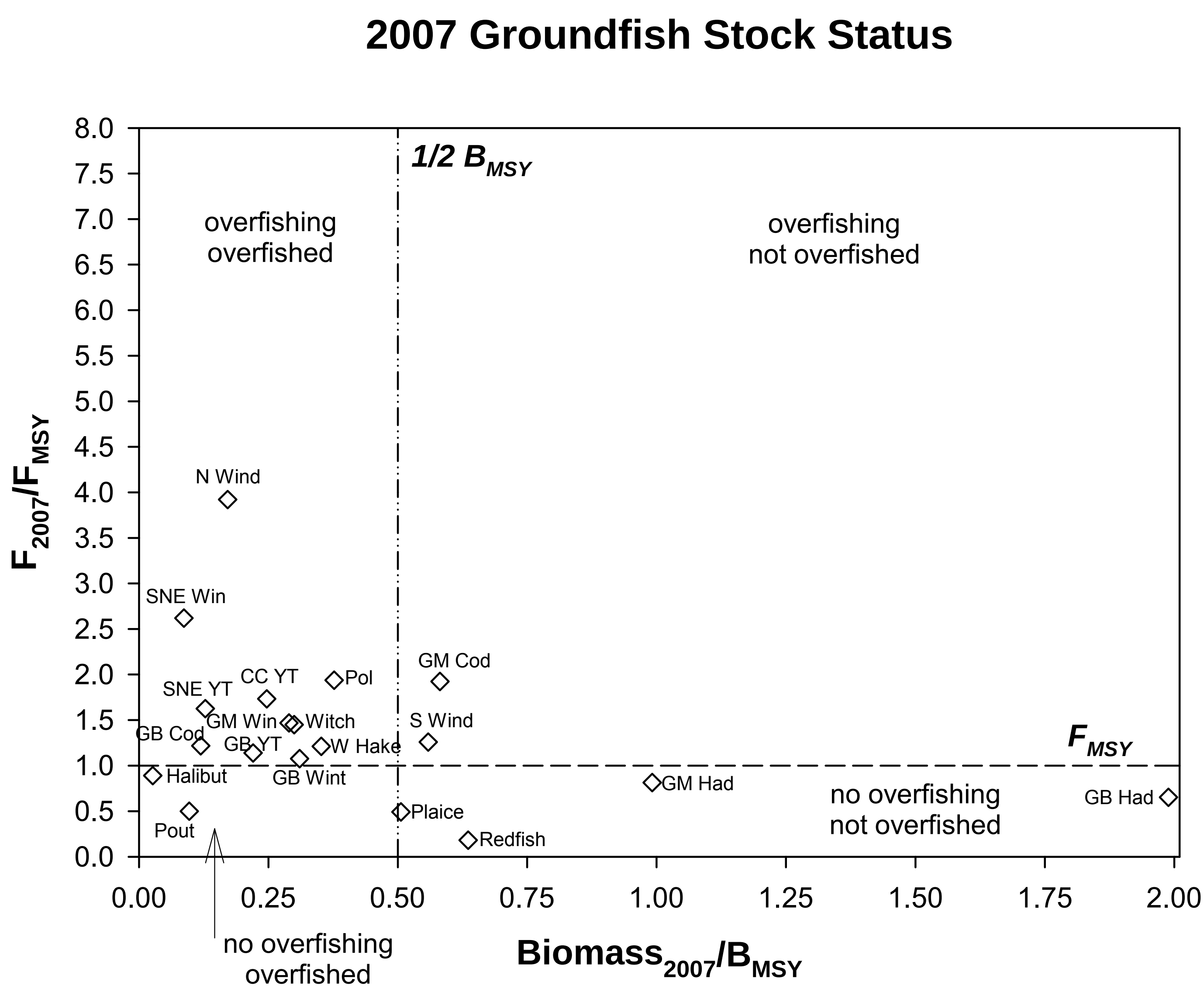

Figure 2. Status of 19 groundfish stocks in 2007 with respect to F_{MSY} and B_{MSY} or their proxies based on the GARM III review

Since 2004, reductions in fishing mortality have occurred for some stocks although exploitation on these stocks remains above F_{MSY}. A comparison of fishing mortality and biomass levels (relative to their BRPs) between GARM II and GARM III (Table 2; Figs. 3 and 4) indicates that moderate to large declines in fishing mortality occurred for the three yellowtail stocks, as well as for GB winter flounder, white hake, and plaice. More modest declines were observed for the GB and GOM cod stocks and for GB haddock. However, moderate to large relative increases in fishing mortality occurred for witch, GOM winter flounder, Southern New England / Mid-Atlantic (SNE/MA) winter flounder, redfish, pollock, northern and southern windowpane, and ocean pout. Fishing mortality of GOM haddock increased slightly.

Large relative increases in biomass occurred in the GB and GOM haddock stocks, and in GOM cod, SNE/MA yellowtail, Cape Cod/Gulf of Maine (CC/SNE) yellowtail, and in southern windowpane. Biomass did not change appreciably change in five stocks (GB cod, GB yellowtail, plaice, redfish and white hake). Moderate relative declines in biomass were observed for witch, the three winter flounder stocks and pollock, while large relative declines in biomass occurred for northern windowpane and for ocean pout.

It is important to note that these trends in fishing mortality and biomass are relative to their biological reference points. In a number of cases, the trends in fishing mortality and biomass without regard to the BRPs are different. For instance, Georges Bank yellowtail biomass is currently increasing due to the strong 2005 year-class. However, relative to B_{MSY}, biomass has slightly declined since GARM II. The value of considering the trends relative to the BRPs is that they provide a clearer indication of progress towards mandated thresholds and targets.

Based on the new B_{MSY} value (Table 2), the GB haddock stock is rebuilt. In 2007, GOM haddock, redfish, plaice, and southern windowpane are between ½ B_{MSY} and B_{MSY}, as is GOM cod. The GOM haddock stock is projected to be rebuilt in 2009 (Section 2.R). For the remaining 13 groundfish stocks, biomass is still well below B_{MSY}.

For most of the groundfish stocks, $F_{REBUILD}$ (the fishing mortality estimated to ensure recovery to B_{MSY} by the end of the rebuilding period) is lower than the 2007 fishing mortality (Table 3). This is particularly so for GB yellowtail, SNE/MA yellowtail, and SNE/MA winter flounder. For some stocks (plaice and redfish), however, $F_{REBUILD}$ is higher than the 2007 fishing mortality. GB haddock is now estimated to be above B_{MSY} (i.e., rebuilt). In the case of SNE/MA winter flounder, $F_{REBUILD}$ is zero implying that the stock cannot be rebuilt to B_{MSY}, even with no catch in 2009. Overall, the trends in projected 2009 catch at $F_{REBUILD}$ are consistent with the general changes in the status of the groundfish stocks between GARM II and GARM III.

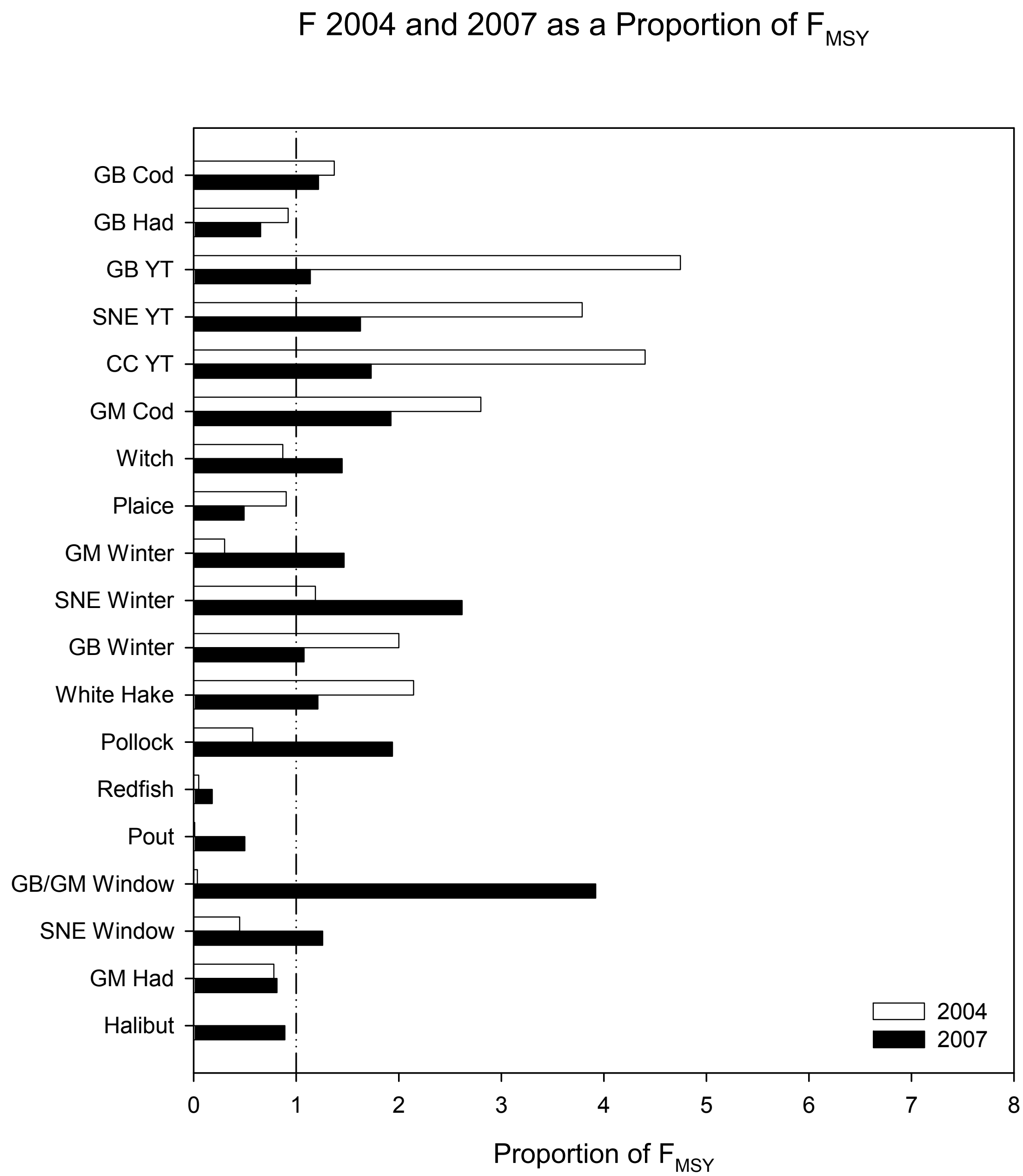

Figure 3. Comparison between 2004 and 2007 fishing mortality with respect to F_{MSY} based on the GARM II and GARM III reviews.

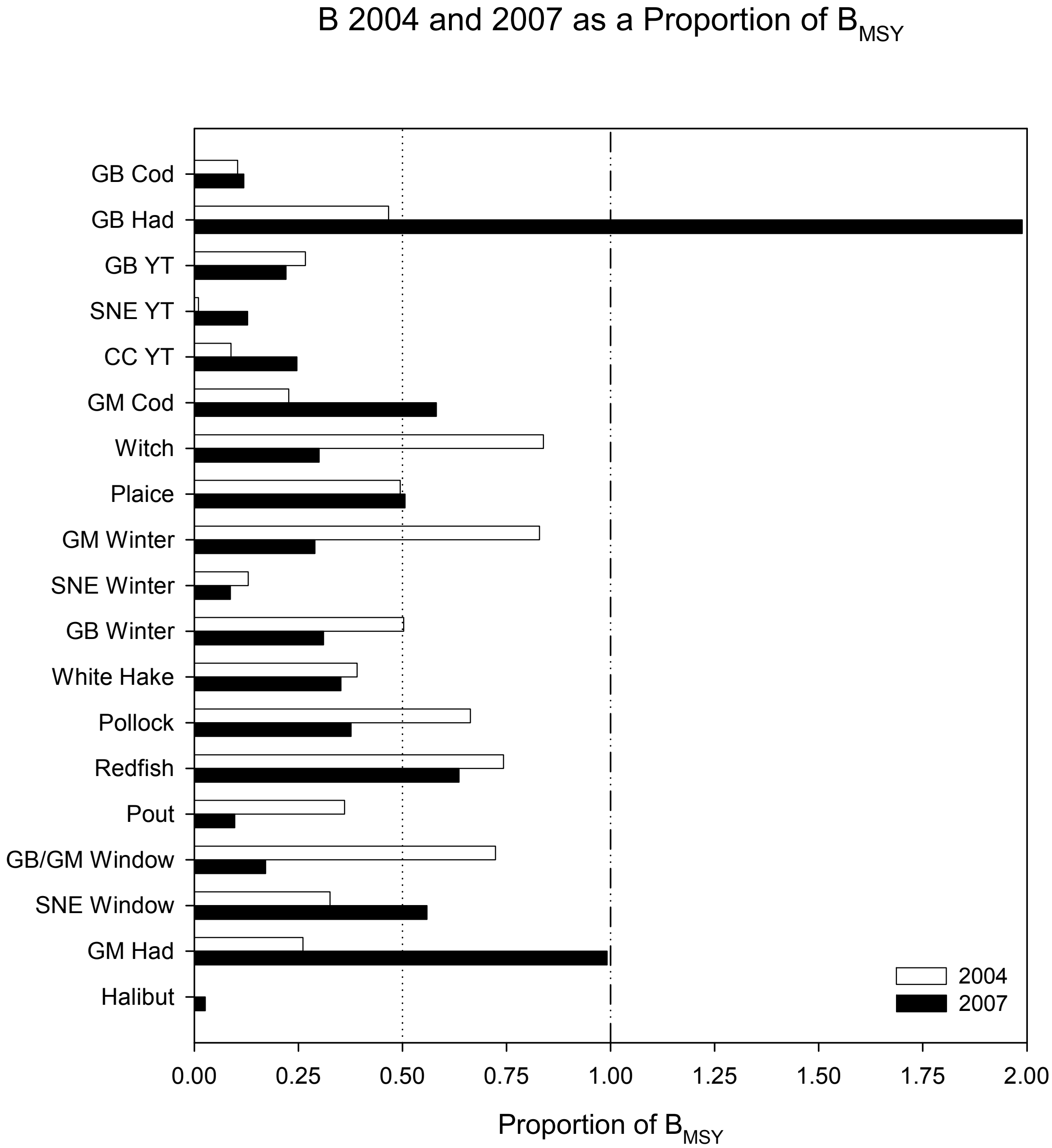

Figure 4. Comparisons between 2004 and 2007 stock biomass with respect to B_{MSY} based on the GARM II and GARM III reviews.

Table 2. 2007 Estimates of fishing mortality (F) and biomass (B), Biological Reference Points, and a comparison of the relative (to Biological Reference Points) change in F and B between GARM II and GARM III; Relative change: small (0-25%), moderate (25-75%) and large (> 75%) increases and decreases are indicated by +, ++, +++ and -, --, --- respectively. "c/i" = catch (mt)/survey index (kg/tow). For survey index stocks, biomass represents total biomass per survey tow; for other stocks, it represents spawning stock biomass (SSB) of the stock.

		2007 Estimates (GARM III)		Biological Refernce Points (GARM III)			Relative Change (2007-2004) / 2004	
Species	Stock	Fishing Mortality	Biomass (mt)	*Fmsy or proxy*	*Bmsy or proxy (mt)*	*MSY (mt)*	Fishing Mortality	Biomass
Cod	GB	0.300	17,672	0.25	148,084	31,159	-	+
Cod	GOM	0.456	33,878	0.24	58,248	10,014	--	+++
Haddock	GB	0.230	315,975	0.35	158,873	32,746	--	+++
Haddock	GOM	0.350	5,850	0.43	5,900	1,360	+	+++
Yellowtail Flounder	GB	0.289	9,527	0.25	43,200	9,400	---	-
Yellowtail Flounder	SNE/MA	0.413	3,508	0.25	27,400	6,100	--	+++
Yellowtail Flounder	CC/GOM	0.414	1,922	0.24	7,790	1,720	--	+++
American Plaice	GB/GOM	0.090	11,106	0.19	21,940	4,011	--	+
Witch Flounder		0.290	3,434	0.20	11,447	2,352	++	--
Winter Flounder	GB	0.280	4,964	0.26	16,000	3,500	--	--
Winter Flounder	GOM	0.417	1,100	0.28	3,792	917	+++	--
Winter Flounder	SNE/MA	0.649	3,368	0.25	38,761	9,742	+++	--
Redfish		0.007	172,342	0.04	271,000	10,139	+++	-
White Hake	GB/GOM	0.150	19,800	0.13	56,254	5,800	--	-
Pollock	GB/GOM	10.975 c/i	0.754 kg/tow	5.66 c/i	2.00 kg/tow	11,320	+++	--
Windowpane Flounder	GOM/GB	1.96 c/i	0.24 kg/tow	0.50 c/i	1.40 kg/tow	700	+++	---
Windowpane Flounder	SNE/MA	1.85 c/i	0.19 kg/tow	1.47 c/i	0.34 kg/tow	500	+++	+++
Ocean Pout		0.38 c/i	0.48 kg/tow	0.76 c/i	4.94 kg/tow	3,754	+++	--
Halibut		0.065	1,300	0.07	49,000	3,500	n/a	n/a

Table 3. Short-term implications of GARM III assessments on fishing mortality ($F_{REBUILD}$) estimated to ensure recovery by end of rebuilding period (see "Footnotes to the TORs") and 2009 Catch assuming $F_{REBUILD}$. "c/i" = catch (mt)/survey index (kg/tow).

						Rebuild Date	
Species	*Stock*	*2007 Fishing Mortality*	*Frebuild*	*2008 Assumed Catch (mt)*	*2009 Catch at Frebuild (mt)*	Date given in Plan	Date Assumed for analysis (no formal plan in place)
Cod	GB	0.300	0.186	5,957	3,722	2026	
Cod	GOM	0.456	0.281	5,268	12,714	2014	
Haddock	GB	0.230	n/a[1]	21,929	n/a[1]	2014	
Haddock	GOM	0.350	n/a[6]	1,368	n/a[6]	2014	
Yellowtail Flounder	GB	0.289	0.107[3]	2,500[4]	2,114[5]	2014	
Yellowtail Flounder	SNE/MA	0.413	0.080	396	425	2014	
Yellowtail Flounder	CC/GOM	0.414	0.238	627	904	2023	
American Plaice	GB/GOM	0.090	0.208	1,126	3,499	2014	
Witch Flounder		0.290	0.194	1,172	896		2018
Winter Flounder	GB	0.280	0.254	980	1,907		2018
Winter Flounder	GOM	0.417	0.275	305	376		2018
Winter Flounder	SNE/MA	0.649	0.000	1,857	0	2014	
Redfish		0.007	0.038	1,160	8,631	2051	
White Hake	GB/GOM	0.150	0.078	2,200	2,200	2014	
Pollock	GB/GOM	10.975 c/i	5.31 c/i	7,756	8,003		2018
Windowpane Flounder	GOM/GB	1.96 c/i	n/a[2]	n/a[2]	n/a[2]		n/a[2]
Windowpane Flounder	SNE/MA	1.85 c/i	n/a[2]	n/a[2]	n/a[2]	2014	
Ocean Pout		0.38 c/i	n/a[2]	n/a[2]	n/a[2]	2014	
Altantic Halibut		0.065	0.044	84	68		2056

[1] Stock is rebuilt, not applicable.
[2] Panel did not recommend estimation of $F_{REBUILD}$ as these stocks are primarily discard fisheries.
[3] This Frebuild achieves a 75% probability of rebuilding by 2014.
[4] 2,500 for GByt is based on recommendations called for by the TRAC, August 2008.
[5] 2009 catch is based on $F_{REBUILD}$ necessary to achieve a 75% chance of rebuilding by 2014.
[6] For GOM haddock, SSB in 2007 is close to B_{MSY}, and SSB is projected to be > B_{MSY} in 2009.

Retrospective Patterns and the Determination of Current Status

Of the 14 groundfish stocks assessed in GARM III using an analytical assessment model, seven stocks exhibited retrospective patterns that were considered severe enough that an adjustment to the population numbers and fishing mortality in 2007 was deemed necessary before determining current stock status and subsequently conducting projections. The largest retrospective patterns were observed in GB yellowtail, GOM winter flounder, and SNE/MA winter flounder. Moderate retrospective patterns occurred in GB cod, plaice, witch, and redfish.

Retrospective pattern adjustments were approached in two ways. The first involved an analysis to determine whether a split in the survey time series would either reduce or eliminate the retrospective pattern. This split survey approach had previously been recommended by the GARM III 'Assessment Models' review as a way to adjust for the retrospective pattern in the Georges Bank yellowtail flounder assessment, and thus the same approach was attempted on the other stocks. The second approach was an adjustment to the population numbers at age in the terminal year in the VPA based upon a measure of the age-specific retrospective pattern during the past seven years. The split survey approach was used to adjust for retrospective patterns in five of the seven assessments where it was deemed necessary. Only for plaice and redfish was the second approach used, although both approaches produced similar levels of adjustment.

The retrospective pattern adjustments changed the status of four of the seven stocks (Table 4). For both GB cod and GB yellowtail, the adjustment resulted in the stocks being classified as experiencing overfishing (both stocks had already classified as being overfished, which did not change with the adjustments). However, the retrospective patterm adjustments for witch and GOM winter flounder resulted in these stocks being classified as both experiencing overfishing and being overfished. The status of the other three stocks (plaice, SNE/MA winter flounder, and redfish) did not change due to the adjustments.

There are a number of potential causes for retrospective patterns, all related to some unexplained change within the time series of observations. The GARM III 'Assessment Models' review identified four potential causes of retrospective patterns: (1) an unrecorded change in catches; (2) a change in natural mortality; (3) a change in the abundance index catchability; and (4) a change in fishery selectivity. It is important to emphasize that retrospective patterns adjustments do not resolve the underlying problem. Rather, further work on the nature and causes of the retrospective pattern is required to facilitate more explicit treatments of these patterns in future assessments.

Table 4. Change in status of GARM III groundfish stocks as a consequence of adjustment for observed retrospective pattern; Base and Final refer to the unadjusted and adjusted assessment model respectively; shaded rows indicate where a change in status occurred (not overfishing or overfished to overfishing or overfished). Adjustments are based on average values of Mohn's rho (see "Issues Relevant to All Assessments") rounded to two or three significant digits.

GARM III

Species	Stock	2007 Fishing Mortality			2007 Biomass		
		Base	Final	Percent Change	Base	Final	Percent Change
Cod	GB	0.141	0.300	112.8	25,377	17,672	-30.4
Yellowtail Flounder	GB	0.118	0.289	145.1	18,248	9,527	-47.8
American Plaice	GB/GOM	0.065	0.090	38.5	15,659	11,106	-29.1
Witch Flounder		0.143	0.290	102.7	7354	3,434	-53.3
Winter Flounder	GOM	0.115	0.417	262.6	2,765	1,100	-60.2
Winter Flounder	SNE/MA	0.438	0.649	48.2	4,565	3,368	-26.2
Redfish		0.005	0.007	36.8	234,609	172,342	-26.5