3.0 Summary

This section summarizes stock status in 2004 as determined by current assessments, and compares that to stock status in 2001 as determined both by the current assessments and those conducted by the 2002 GARM. For some stocks, the current assessments provide different estimates of 2001 biomass and fishing mortality than those reported by the 2002 GARM. These cases are noted.

Assessment information is based on the calendar year. For stocks that are assessed with age-based methods, biomass estimates are for SSB at the beginning of the spawning season. Since most groundfish stocks spawn in the spring or early summer, the assessments provide an estimate of biomass at the beginning of the implementation of Amendment 13 (implemented May 1, 2004) and do not reflect the impact of Amendment 13 measures. For most index-based stocks the biomass index proxy includes the 2004 fall trawl survey and thus reflects a few months of Amendment 13 measures. Fishing mortality estimates reflect eight months of Amendment 13 measures.

3.1 Current Stock Status

Of the 18 stocks for which F_{MSY} (or its proxy) could be estimated, 10 were fished below F_{MSY} in 2004, and 8 above. Additionally, the biomasses of 6 of the 19 stocks for which B_{MSY} (or its proxy) could be estimated were at or above ½ B_{MSY}, while the biomasses of 13 stocks were below the threshold.

Stock biomasses have increased in only 6 of the 19 stocks since 2001. For the 6 stocks that increased in biomass between 2001 and 2004, the average increase was 50%. For the remaining stocks, the average decrease was 19%. For Georges Bank yellowtail flounder, alternative model formulations were used for assessment (denoted as GB YT1 and GB YT2, see Chapter C). One model suggested that the biomass increased (GB YT1) while the other (GB YT2) suggested a decrease. If model GB YT1 is used then 7 stocks increased. Landings of the complex of 19 groundfish stocks have declined by 7% since 2002, driven primarily by decreases in landings of Georges Bank cod and American plaice but offset primarily by increases in landings of Georges Bank haddock and pollock.

Fishing mortality (F) rates declined for 13 of 19 stocks between 2001 and 2004. For the 13 stocks where F declined, the average percent decline was 50% (range: 1% to 80%). For the 6 stocks where F increased, the average percent increase was 49% (range: 31% to 73%). The 6 stocks showing increases in F since 2001 were Georges Bank haddock (39%), Georges Bank yellowtail flounder (GB YT2 140%), Gulf of Maine cod (75%), Georges Bank winter flounder (50%), Gulf of Maine haddock (50%), and Atlantic halibut (50%).

Four stocks continue to exhibit high fishing mortality rates compared to their F_{MSY} reference levels. Cape Cod/Gulf of Maine and Southern New England/Mid-Atlantic yellowtail flounder fishing mortality rates in 2004 were at least three times their respective F_{MSY} levels, compared to over five times the F_{MSY} levels in 2001. Gulf of Maine cod and white hake experienced fishing mortality levels in 2004 that were at least two times their respective F_{MSY} levels. Mortality for these two stocks has increased since 2001. Fishing mortality for these four stocks also exceeded Amendment 13 targets for fishing years 2004-2005. Cape Cod/Gulf of Maine yellowtail flounder, Gulf of Maine Cod, and Southern New England/Mid-Atlantic yellowtail flounder were about three times the Amendment 13 targets, while white hake was 15% above the Amendment 13 target.

Two additional stocks, Georges Bank yellowtail flounder and Georges Bank winter flounder, exhibited fishing mortality rates in 2004 that are well above their respective F_{MSY} levels. The 2002 GARM assessments indicated that fishing mortality in 2001 for both of these stocks was less than F_{MSY}. The current assessments, however, now estimate that in 2001 Georges Bank yellowtail flounder fishing mortality was three times the F_{MSY} level, and Georges Bank winter flounder mortality was above F_{MSY}.

Changes can be seen in the status of the stocks from 2001 to 2004, as determined by the current assessments, by comparing Figures 3.1 and 3.2. Stocks falling into each category are listed in Table 3.1. The number of stocks where biomass was below ½ B_{MSY} remained the same, 12 below and 6 at or above ½ B_{MSY}, although there were changes in the stock composition of the categories. The number of stocks where F exceeded F_{MSY} declined from 11 in 2001 to 8 in 2004 and the number of stocks where biomass was below ½ B_{MSY} and F exceeded F_{MSY} declined from 9 in 2001 to 7 in 2004.

The current assessments indicate that Georges Bank yellowtail flounder, and Gulf of Maine and Georges Bank winter flounder were less than ½ BMSY in 2001, a change from status as reported by the 2002 GARM. Conversely, the current assessments indicate that plaice was above ½ BMSY in 2001, whereas the 2002 GARM reported that plaice was less than ½ BMSY.

Direct comparisons between the state of these stocks in 2001 and 2004 are also provided in Figures 3.3 and 3.4. Stocks showing substantial decreases in the ratio of F to F_{MSY} include Georges Bank Cod, Southern New England/Mid Atlantic and Cape Cod/Gulf of Maine yellowtail flounder, Gulf of Maine winter flounder, Southern New England/Mid Atlantic winter flounder, witch flounder, and American plaice. For stocks with F to F_{MSY} ratios above one, fishing mortalities have increased for Gulf of Maine cod, Georges Bank yellowtail flounder and Georges Bank winter flounder.

Stocks showing substantial increases in the ratio of B to B_{MSY} include Gulf of Maine winter flounder, witch flounder, pollock, and redfish. Georges Bank haddock and white hake also increased in biomass but are still below ½ B_{MSY}.

Stocks where the ratio of B to B_{MSY} have decreased by more than 25% include Southern New England/Mid Atlantic yellowtail flounder, Cape Cod/Gulf of Maine yellowtail flounder, Gulf of Maine haddock and ocean pout.

Atlantic halibut is excluded from Table 3.1 and Figures 3.1 and 3.2 because F_{MSY} reference points have not been estimated. These stocks are also categorized according to the status as determined at the 2002 GARM. Comparisons between these two assessment results are problematic for some stocks because of changing stock definitions (Southern New England, Mid Atlantic, and Cape Cod yellowtail flounder), a change in the basis of the assessment (Gulf of Maine winter flounder), and a recommended change in the status determination criteria (Georges Bank winter flounder).

Table 3.1. Classification of 18 groundfish stocks in 2004 and 2001 from the current assessments compared to classification from the 2002 assessment.

	Results from Current Assessments		**Results from 2002 GARM**
Stock Status	2004	2001	2001
Biomass <1/2 Bmsy	GB Cod	GB Cod	GB Cod
AND	GB YT	GB YT	
F > Fmsy	SNE/MA YT	SNE/MA YT	SNE YT and MA YT
	CC/GOM YT	CC/GOM YT	CC YT
	SNE/MA Winter	SNE/MA Winter	SNE/MA Winter
	W Hake	W Hake	W Hake
	GOM Cod	GOM Cod	GOM Cod
		Witch	
		GOM Winter	
			Plaice
Biomass < 1/2 Bmsy	GB Haddock	GB Haddock	GB Haddock
AND	GOM Haddock	GOM Haddock	GOM Haddock
F< Fmsy	So. Window	So. Window	So. Window
	Plaice		
	Pout		
Biomass > 1/2 Bmsy	GB Winter	GB Winter	
AND		Plaice	
F>Fmsy			Witch
Biomass > 1/2 Bmsy	Pollock	Pollock	Pollock
AND	Redfish	Redfish	Redfish
F< Fmsy	No. Window	No. Window	No. Window
		Pout	Pout
	GOM Winter		GOM Winter
			GB Winter
			GB YT
	Witch		

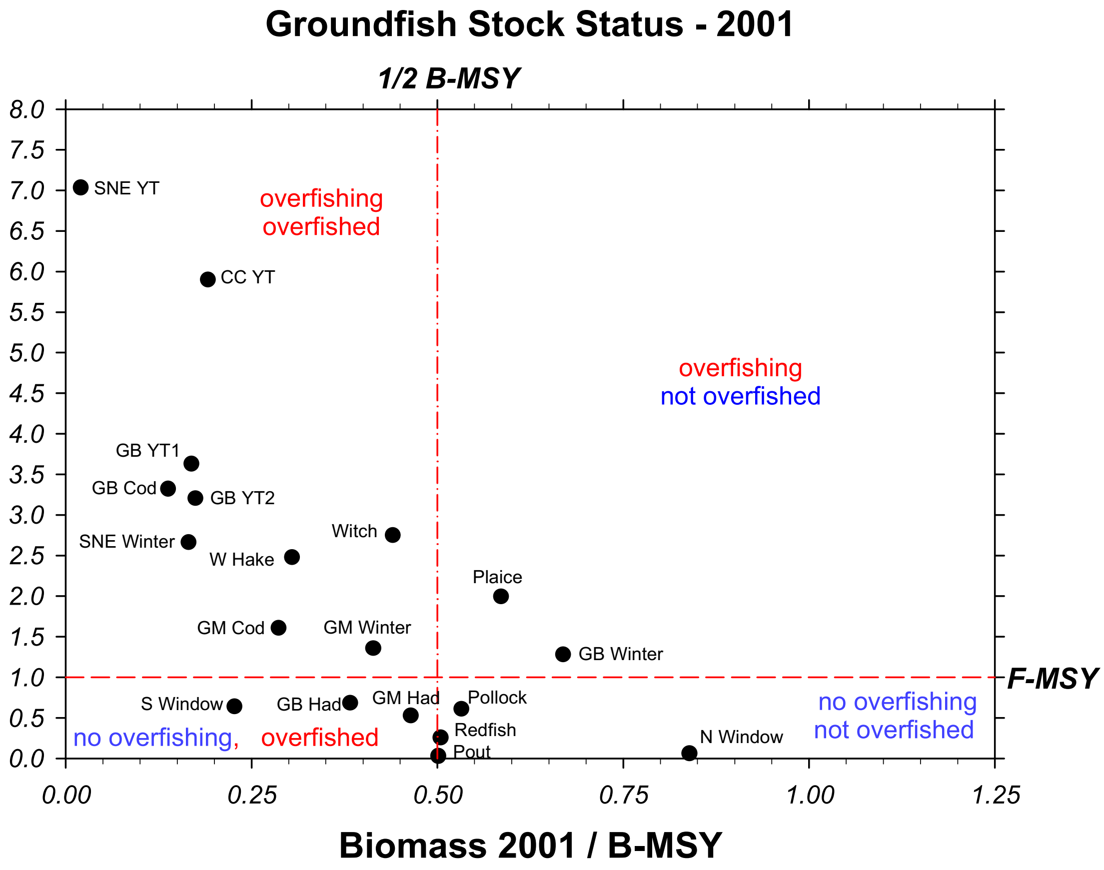


Figure 3.1. State of 18 groundfish stocks in 2001 with respect to F_{MSY} and B_{MSY} based on the current assessment.

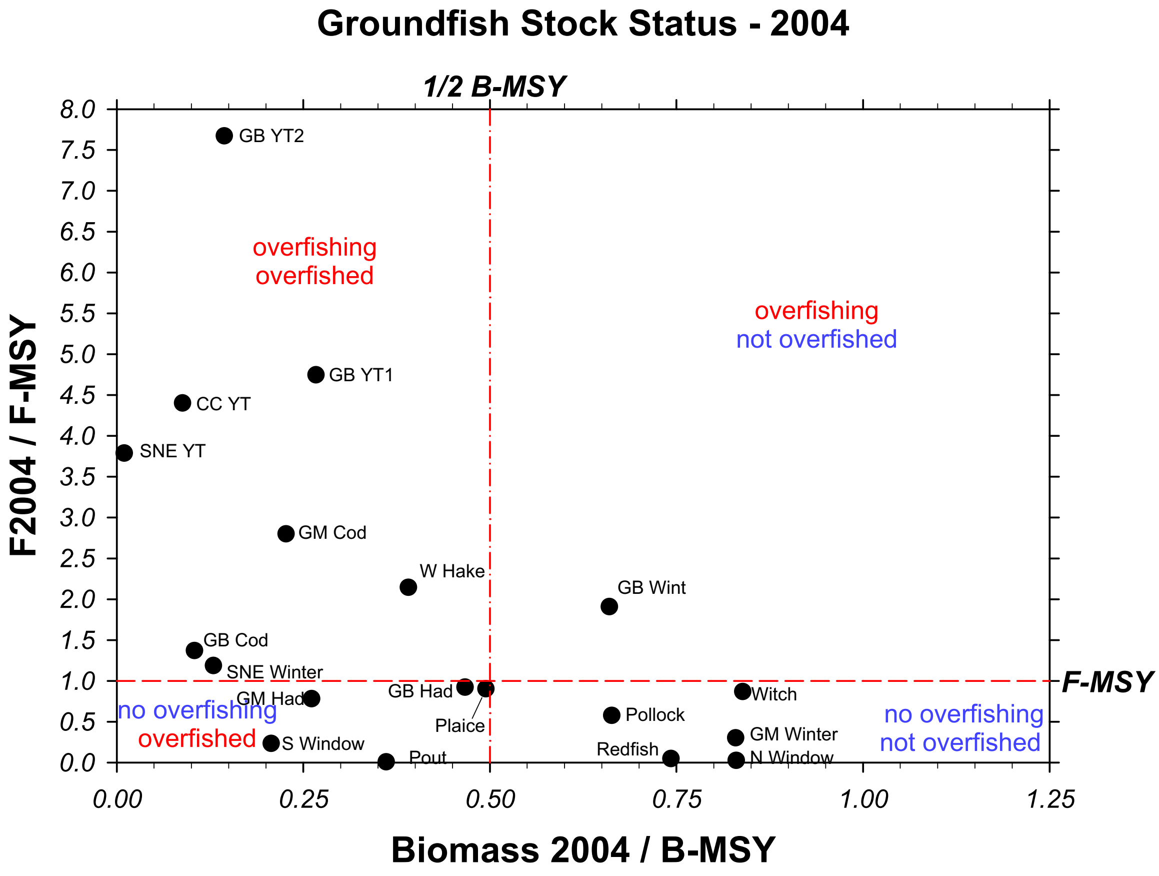


Figure 3.2. State of 18 groundfish stocks in 2004 with respect to F_{MSY} and B_{MSY}.

Figure 3.3. Comparisons between 2001 and 2004 F with respect to F_{MSY}, based on the current assessment.

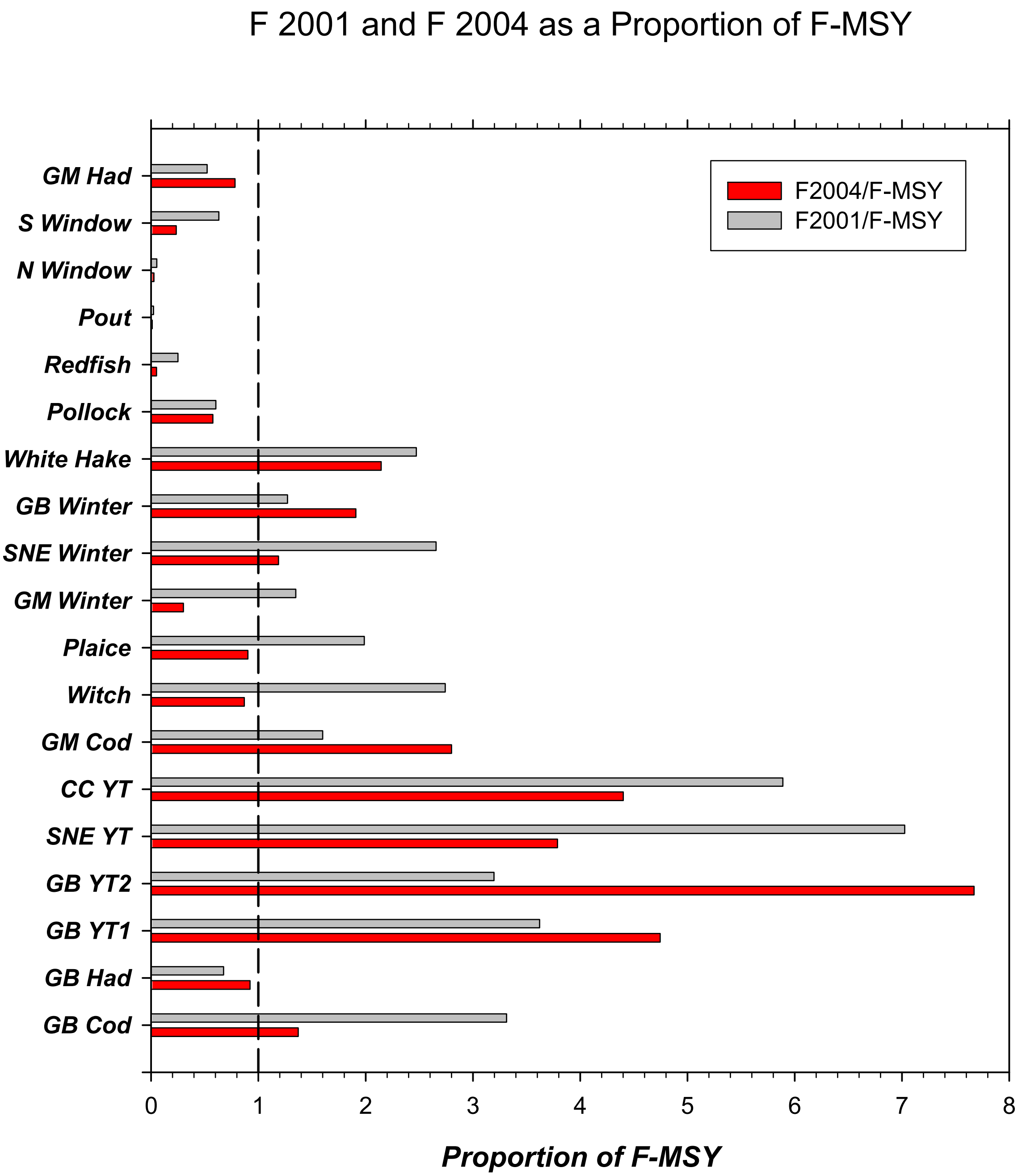
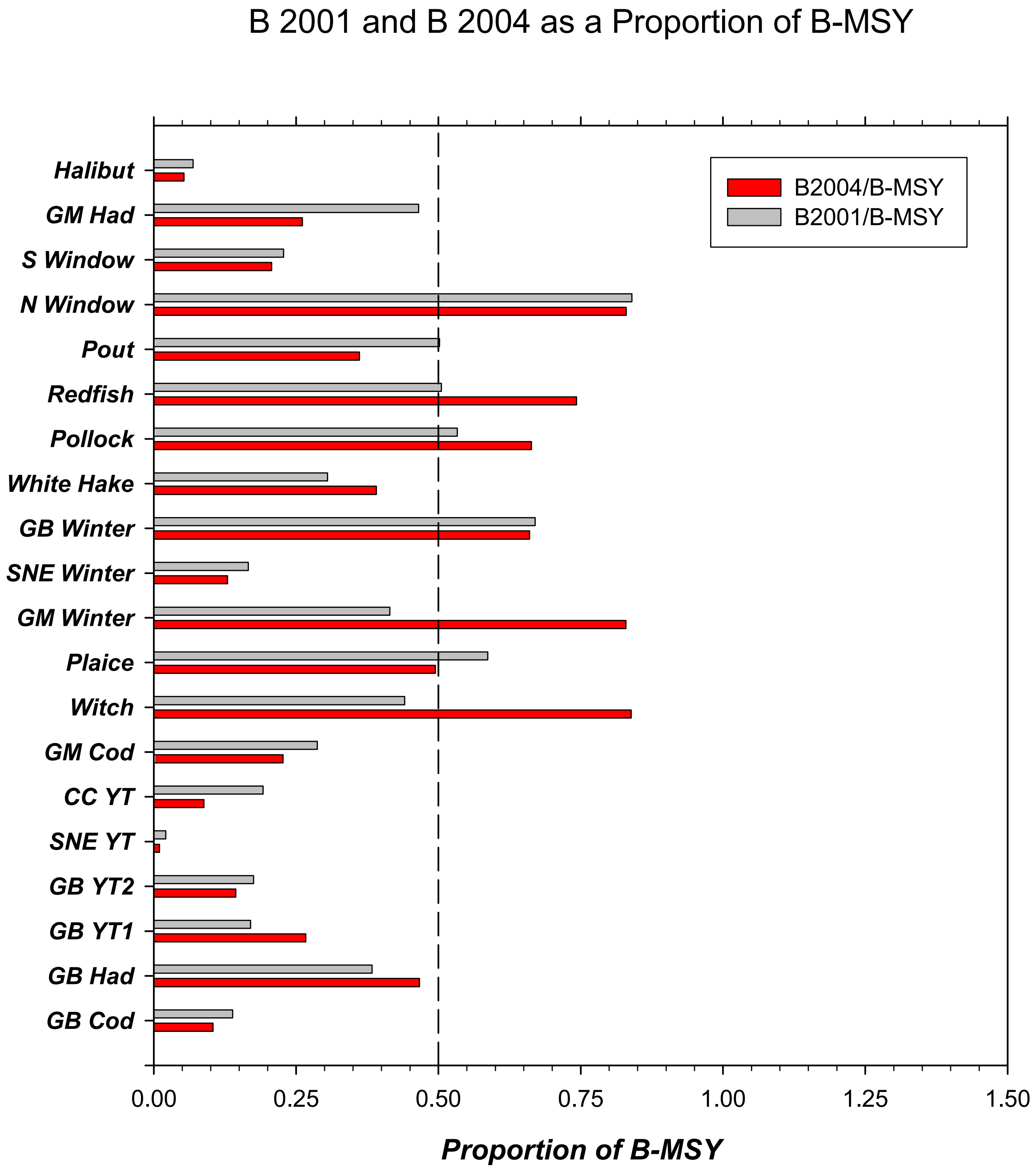


Figure 3.4. Comparisons between 2001 and 2004 stock biomass with respect to B_{MSY}, based on the current assessment.



3.2 Generic Issues

Three substantial issues affecting interpretation of the current assessment results were discussed by the GARM panel.

- Some stock assessments display relatively strong retrospective patterns in F, SSB and recruitment. The extent of the retrospective patterns was quantified to allow for comparisons among assessments.

- Many stocks exhibit persistent declines in mean weights at age over the most recent 5 years

- The 2004 commercial landings data were collected in a different manner after May 1, 2004. This change in procedure to self-reporting appears to have introduced additional uncertainty in the proration of total landings to stock area. In addition, lack of identifiers in the commercial landings records for B DAS trips and SAPs is problematic.

A summary of the GARM discussion on each of these issues is given in the full report. The discussion and a summary of the retrospective patterns observed in the age structured assessments follow.

Retrospective Patterns

Retrospective patterns are consistent changes in estimated quantities that occur when additional years of information are added to a model. There are two types of retrospective patterns: historical and within model. The historical retrospective analysis is conducted by examining the results of each final assessment for a number of successive years and determining whether there was a consistent pattern between assessments of overestimating or underestimating values such as fully recruited fishing mortality rate, spawning stock biomass, or recruitment in successive years; for example, by comparing results for assessments conducted at the 2002 GARM with current assessments (Table 1). This type of retrospective pattern can be caused by changes in the data, type of assessment model, or assessment model formulation.

Within-model retrospective analysis uses the same data, type of assessment model, and assessment model formulation and trims the most recent year's data in successive model runs. The within model retrospective patterns are most useful for determining if there is an internal inconsistency in the data because the only changes in the different runs are the number of years of data in the model. Within-model retrospective analyses were conducted for all eleven age-based stock assessments.

The within-model retrospective pattern can be clearly seen in the plot of fully-recruited F (Figure C4 in Section 2) for Georges Bank yellowtail flounder under the "Base Case" model formulation. As additional years of data are added, the 1999 value of fully-recruited F is consistently revised upward, from 0.16 in the model ending in year 1999, to

0.25 in the model ending in year 2000, and so on to 0.69 in the model ending in year 2004. Due to the backward convergence of virtual population analysis (VPA), the estimates are the same from all models for years 1973-1991.

Retrospective patterns are not an intrinsic property of VPA as they are not seen in some VPA results, such as for Georges Bank haddock. Moreover, retrospective patterns have been observed in other types of stock assessment models, including forward projecting models. Causes of retrospective patterns vary among assessments but have been attributed to missing catches, changes in natural mortality, stock misidentification, and changes in index catchability (Mohn 1999, Cadigan and Farrell 2005).

There are many different ways to quantify within-model retrospective patterns. The one-year update at the terminal year of each assessment was selected here to reflect how the terminal year estimate is changed with the addition of one year of data. This metric is computed as the relative change in the terminal year value to its new estimate as the terminal year is increased by one. The Georges Bank yellowtail flounder "Base Case" model formulation is used to illustrate this process. For example, the 1999 fully-recruited F in the assessment ending in 1999 was 0.16 while the 1999 fully-recruited F in the assessment ending in 2000 was 0.25, producing a retrospective statistic of (0.25-0.16)/0.16 = 56%. The statistic is computed for the 2000 estimate by comparing results for assessments ending in 2000 and 2001. Estimates for subsequent years are computed in an analogous manner such that the estimate for 2003 is based on a comparison of the estimated values assessments ending in 2003 and 2004. The arithmetic averages of these five statistics for 1999 to 2003, along with their minimum and maximum values, are shown in Figure 3.5 for fully recruited F, spawning stock biomass, and recruitment.

Stocks that are completely above or below the line demonstrate a strong retrospective pattern over the past five years, and those with means farther away from zero have stronger retrospective patterns than those with means closer to zero. Based on the one year updates over the past five years, the Georges Bank yellowtail flounder Base Case, Gulf of Maine winter flounder, witch flounder and Southern New England winter flounder demonstrate strong retrospective patterns in both fully recruited F and spawning stock biomass. Strong retrospective patterns in recruitment were observed for Cape Cod-Mid Atlantic yellowtail flounder, Gulf of Maine winter flounder, and Southern New England winter flounder. The fully-recruited F and spawning stock biomass relative changes are usually in opposite directions because the catch is constant (i.e., not estimated by the model) and fully-recruited F often occurs on ages that contribute most to the calculation of spawning stock biomass. In general retrospective patterns in recruitment do not correspond to either the fully-recruited F or the spawning stock biomass due to the differences in ages.

Demonstration of past retrospective patterns does not mean that the pattern will continue into the future, but should be used as a warning sign that more caution should be used when setting management measures. Since retrospective patterns have been observed to flip from positive to negative with no apparent explanation, ad hoc adjustments for retrospective patterns are not recommended. There is no apparent scientific consensus on methods for correcting for retrospective patterns. Recent papers on retrospective patterns have provided valuable insights on the sensitivity of models to changes in underlying data or parameters (Cadigan and Farrell 2005). However, the same authors have refrained from recommending adjustments without strong external evidence. Without such evidence retrospective patterns should be considered as an additional source of uncertainty in the assessment. This uncertainty is also relevant for the development of precautionary management regulations.

Changes in Average Weights at Age

Reductions in average weights-at-age were noted in some of the ten VPA-based assessments. The general patterns are described in this section and their implications for future yields and rebuilding trajectories are discussed. Possible causes for the apparent declines are identified, but a detailed discussion of the causal mechanisms and supporting evidence is beyond the scope of the GARM. Inferences about the reductions in average weight-at-age are based on the values used in the assessment model and are defined as the "Stock Weights". These stock weights represent the estimated average weight of a fish of age i at the beginning of the year (January 1). Data to estimate stock weights were derived from a number of sources including the fishery-independent surveys and the biological samples from the landings. For this source of data, the stock weights are derived from the average weights-at-age in the catch by extrapolation technique known as the Rivard (1982) method. This method can be biased if changes in the partial recruitment pattern of the fishery have occurred over time. To confirm that these changes were not simply artifacts of fishery changes, it was only possible to review average weights-at -age in the survey for Georges Bank haddock.

In general terms, the magnitude of the changes in average weight at age varied plus or minus 30% over the last decade. To illustrate the pattern of changes across species and years, for each stock and age combination, the average weights at age were binned by quintile intervals (i.e., 1=0-20%-ile, 2=21-40%-ile, 3=41-60%-ile, 4=61-80%-ile, 5=81-100%-ile) and coded by color and symbol (black full circle =highest, black half circle= 4th quintile, black open circle=3rd quintile, red half circle=2nd quintile, and red full circle=1st quintile= smallest average size). Results in Figures 3.6 to 3.9 show a general pattern of smaller average sizes in the last 6 years with a predominance of observations falling into the first quintile (smallest) .

On Georges Bank, average sizes of both cod and haddock fall into the lowest quintile (Figure 3.6). Georges Bank yellowtail flounder exhibited smaller than average sizes at age between 1990 and 1997 but have rebounded slightly since then. In the Gulf of Maine (Figure 3.8), average weights of cod and yellowtail flounder do not show a consistent pattern across ages since 2000. In contrast, winter flounder, American plaice and witch flounder have average weights in the lowest quintile in recent years (Figure 3.8). Southern New England stocks of yellowtail flounder and winter flounder have average weights in the highest quintiles (Figure 3.9).

Changes in average weights at age have been noted in a number of stocks around the world. One of the most notable has been the Pacific halibut where changes have been ascribed to changes in oceanic productivity (Sullivan et al. 1999). Other possible explanations for the changes in average weights include density dependence, changes in fishery selectivity, and genetic selection. Regardless of the underlying causal mechanism(s), lower average weights-at-age will tend to retard progress to attaining spawning stock biomass targets and reduce total yields under any rebuilding strategy. Persistent changes in average weights-at-age may also change the estimates of biological reference points when they are re-evaluated in 2008. The GARM has recommended the use of the most recent average weights-at-age for projections (See relevant chapters in Section 2).

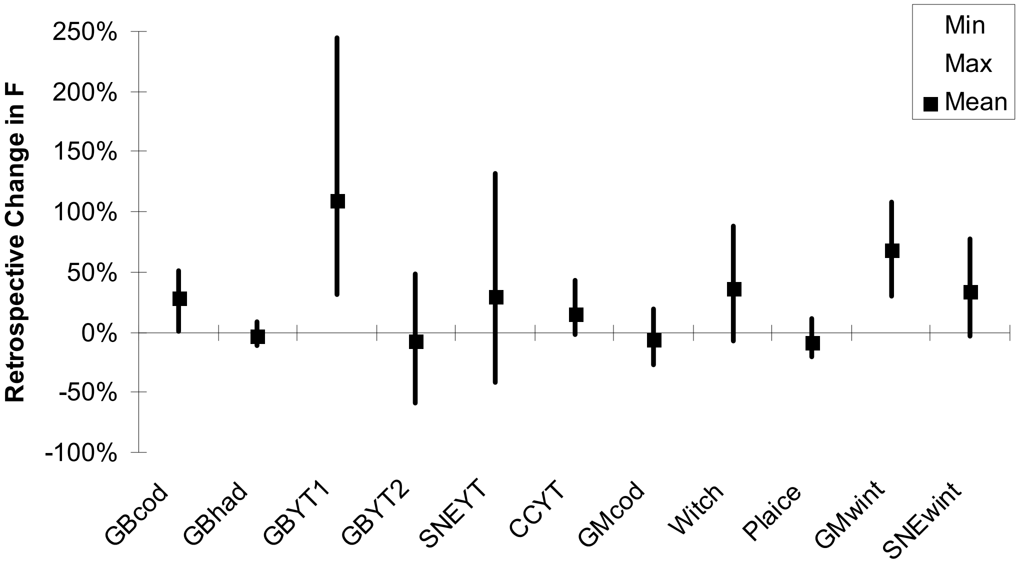
2004 Commercial Fishery Landings Data

Mandatory Dealer Electronic Reporting (DER) was implemented on May 1, 2004 as part of Amendment 13. All federal Dealers were required to submit trip information (vessel permit and hull numbers), species and market category weight and price information on a daily and/or weekly basis. The Dealers were not required to report the gear type used by the fishermen. Consequently, there was a high proportion of landings without gear type in the 2004 landings data. The gear information in 2004 Vessel Trip Report (VTR) data was used to augment the 2004 landings data Vessels which reported using a single gear type in the 2004 VTR were identified. The gear type associated with each vessel was then applied to all landings made by the vessel. Gear type is a necessary data element in the landings data because gear type is used as a stratification variable in the singlespecies proration algorithm to partition total species landings into stock landings.

Further work continues to augment gear type in the 2004 landings data by linking the Dealer and VTR databases on a trip-by-trip basis using the unique trip identification. Another data issue in the 2004 landings data is the identification of trips participating in the various Special Access Programs (SAPs) allowed under Amendment 13. The 2004 DER and VTR databases do not identify whether trips fished in a SAP or in the US/CAN Resource Sharing Area. Landings from these trips cannot be directly identified without linking these data to other databases containing this information. Many stock assessments use a discard weight to kept weight (d/k) ratio and expand this ratio by the landings to estimate discards. Without the capability to separate trips participating in the SAPs and US/CAN Resource Sharing Area, landings data could not be partitioned appropriately to correspond to SAP-specific discard ratios derived from the Fisheries Observer Program.

As in previous years, 2004 State data and late Dealer data continue to enter the Commercial Fisheries Database System (CFDBS) throughout the months following the end of a calendar year. Thus, 2004 landings are subject to changes over time.

Figure 3.5. Arithmetic average, minimum and maximum of one year retrospective change in terminal year estimates of fully recruited fishing mortality (F), spawning stock biomass (SSB), and recruitment (R) over the past five years for each of the age based assessments.



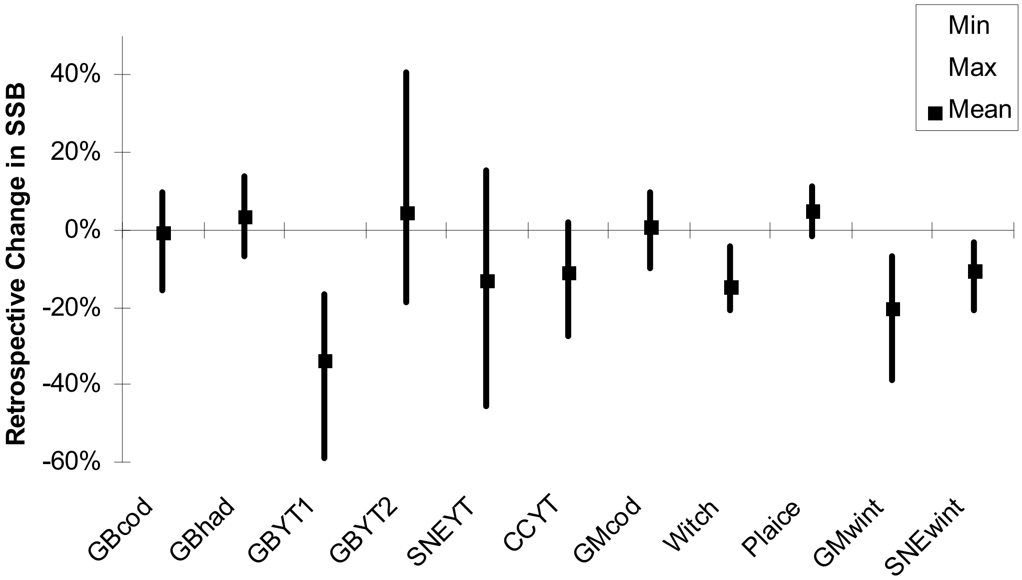
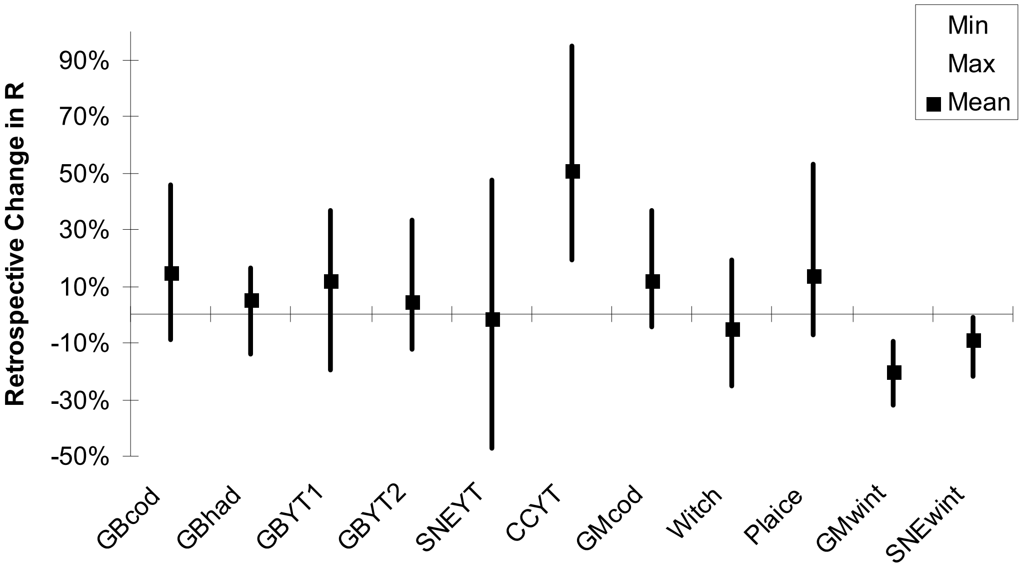


Figure 3.5 (continued).



Projected vs. Realized Catches

Subsequent to the 2002 GARM, projections were carried out to evaluate rebuilding strategies. Total catches were derived from the final projections conducted under either the phased or adaptive strategy for the age-based stocks, and for the index stocks based on the 3-year average survey biomass index and an assumed population growth. From 2002 to 2004 the total realized catches for all stocks were 18% less than projected (Table 3.2). Differences ranged from –95% for Gulf of Maine/Georges Bank windowpane flounder to +29 % for white hake (>60 cm). Realized catches for most of the gadids and flounders fell short of projections by about 10 to 30% except for Gulf of Maine cod where realized catches exceeded projections by 11% and Gulf of Maine winter flounder where realized catches fell short of projections by 60%. In 2002 realized catches exceeded projections by 4%, but in 2003 and 2004, realized catches were 18% and 33%, respectively, below the projections.

3.3 Recommendations

The GARM participants considered a number of generic recommendations for improving stock assessments and associated management advice: Estimation and inclusion of discards in the stock assessment models. Examine methods for deriving maturity ogives over time. Further examination of possible causes of the recent declines in mean weights at age. Numerous recommendations and comments pertaining to individual assessments are provided in the stock-specific chapters of the report.

3.4 Acknowledgements

The GARM participants extend their appreciation to Edgar Kleindinst for technical support and in particular the set up and maintenance of the local area network that provided for effective electronic file transfer among panel members. Colleen Close and Betty Holmes solved innumerable logistical difficulties. Additionally, the GARM appreciates the extraordinary efforts of the individuals involved in supplying information upon which these assessments and data summaries are based (e.g., aging information, research vessel survey abundance indices, port sampling and sea sampling, and landings data).

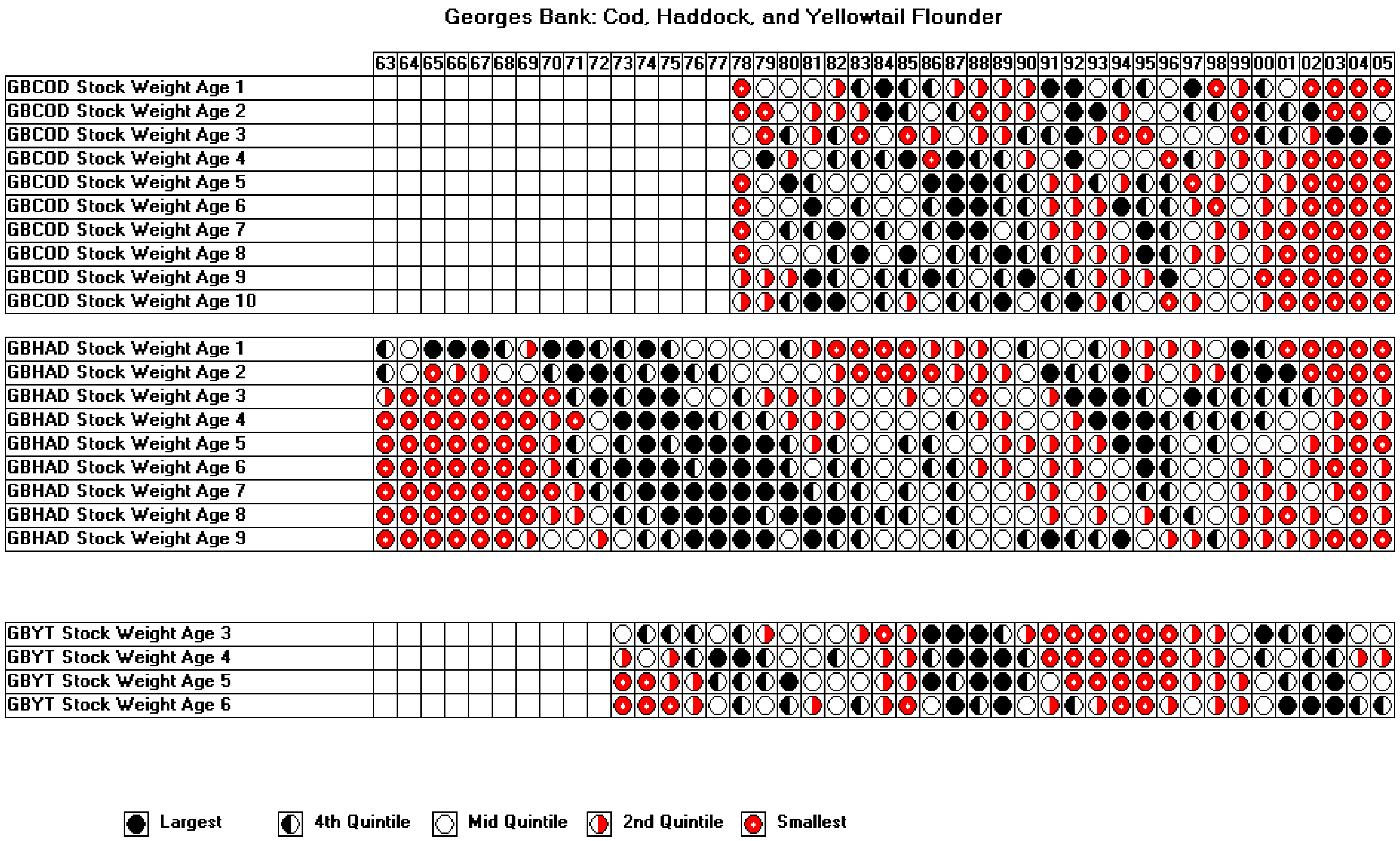


Fig. 3.6. Summary of relative changes in average stock weights-at-age for Georges Bank cod (GBCOD), haddock (GBHAD), and yellowtail flounder (GBYT).

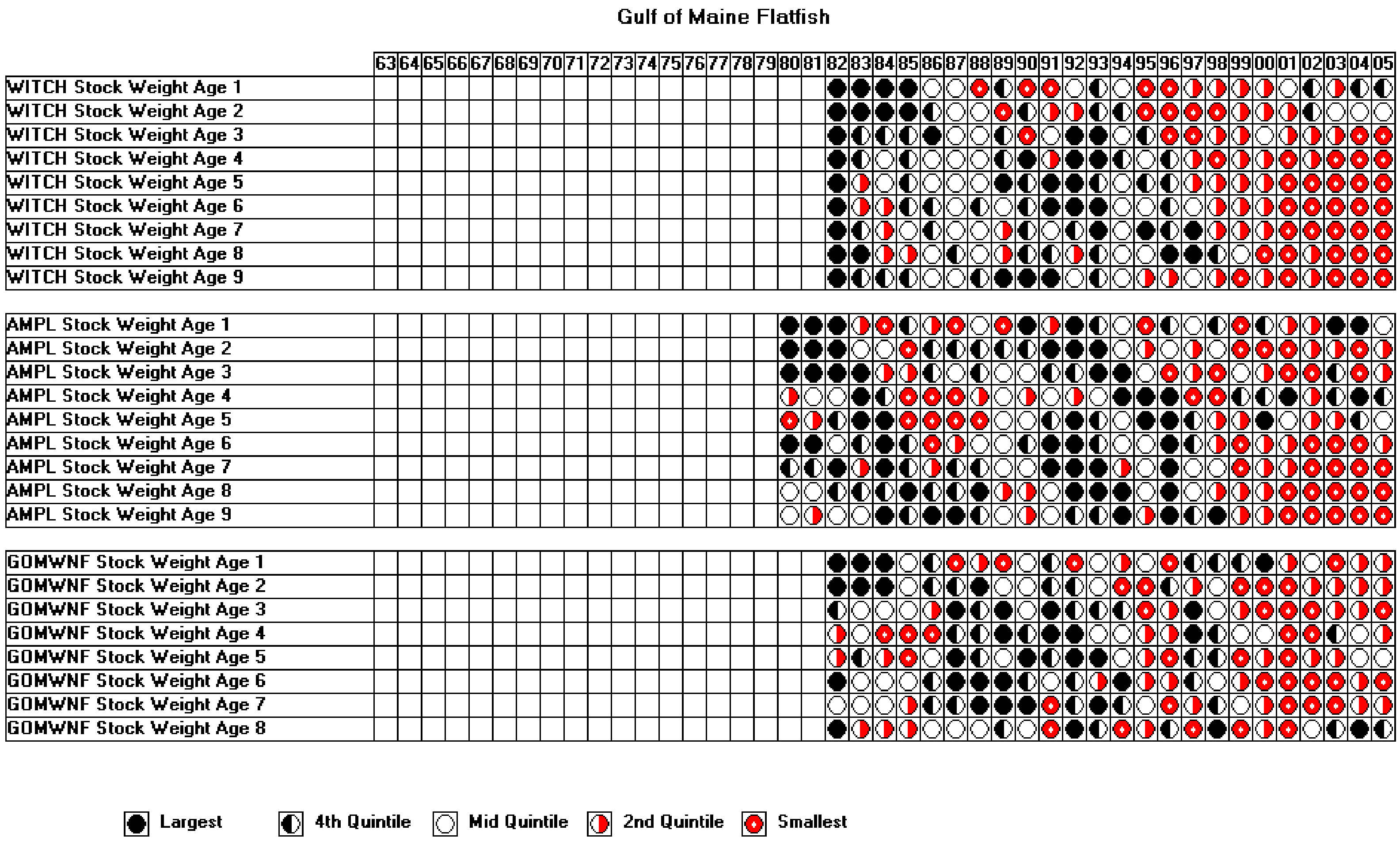
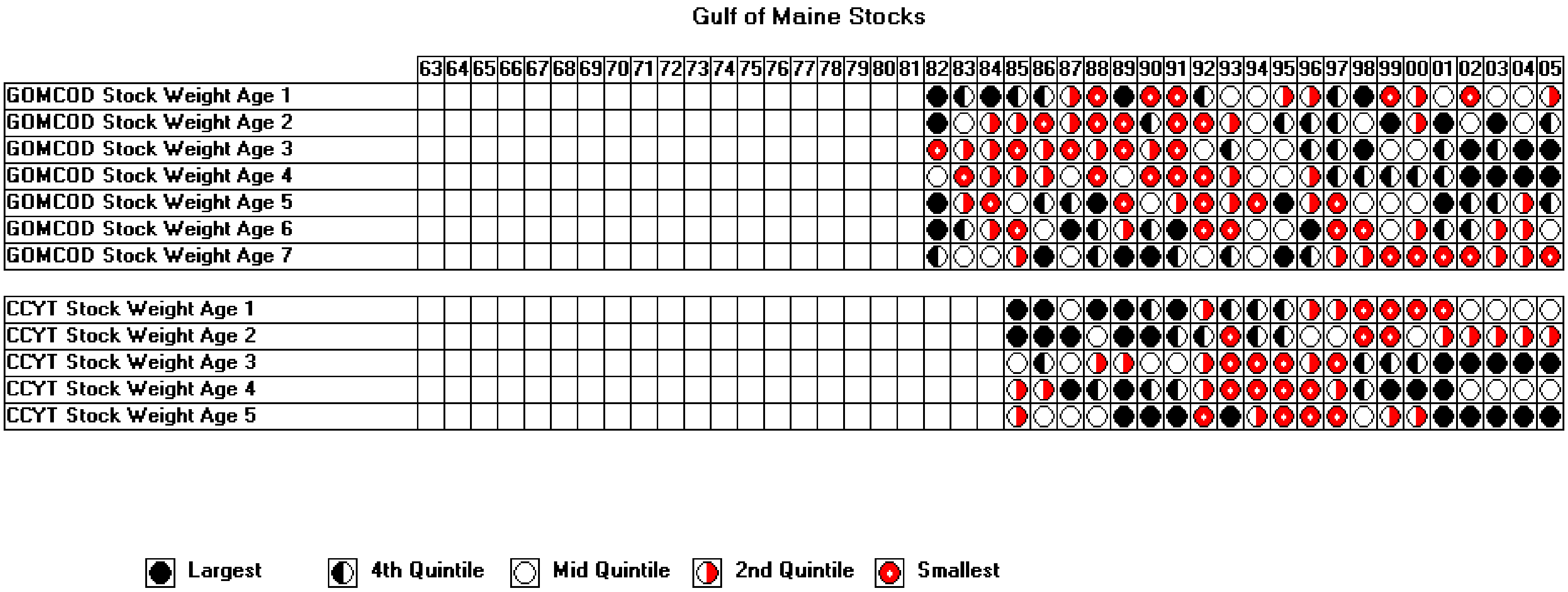


Fig 3.7. Summary of relative changes in average stock weights-at-age for Gulf of Maine flatfish: witch flounder (WITCH), American plaice (AMPL) and winter flounder (GOMWNF).



Gulf of Maine Stocks

	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
GOMCOD Stock Weight Age 1																				●	◐	●	◐	◐	◑	◉	●	◉	◉	◐	○	○	◑	◑	◐	●	◉	◑	○	◉	○	○	◑
GOMCOD Stock Weight Age 2																				●	○	◑	◑	◉	◑	◉	◉	◐	◉	◉	◑	○	◐	◐	◐	○	●	◑	●	○	●	○	◐
GOMCOD Stock Weight Age 3																				◉	◑	◑	◉	◑	◉	◑	◉	◑	◉	○	◐	○	○	◐	◐	●	○	○	◐	●	◐	●	●
GOMCOD Stock Weight Age 4																				○	◉	◑	◑	◑	○	◉	○	◉	◉	◉	◑	○	○	◑	◐	◐	◐	◐	◐	●	●	●	●
GOMCOD Stock Weight Age 5																				●	◑	◉	○	◐	◐	●	◉	○	◑	◉	◑	◉	●	◑	◉	○	○	○	●	◐	◐	◑	◐
GOMCOD Stock Weight Age 6																				●	◐	◑	◉	○	●	◐	◑	◐	●	◉	◉	○	○	●	◉	◉	○	◑	◐	◐	◑	◑	○
GOMCOD Stock Weight Age 7																				◐	○	○	◑	●	○	◐	●	●	◐	○	◐	○	●	◐	◑	◑	◉	◉	◉	◉	◑	◑	◉
CCYT Stock Weight Age 1																							●	●	○	●	●	◐	●	◑	◐	◐	◐	◑	◑	◉	◉	◉	◉	○	○	○	○
CCYT Stock Weight Age 2																							●	●	●	○	●	●	◐	◐	◉	◐	◐	○	○	◉	◉	○	◑	◑	◑	◑	◑
CCYT Stock Weight Age 3																							○	◐	○	◑	◑	○	○	◑	◉	◉	◉	◑	◉	◐	◐	◐	●	●	●	●	●
CCYT Stock Weight Age 4																							◑	◑	●	◐	●	◐	◐	◑	◉	◉	◉	◉	◑	◐	●	●	●	○	○	○	○
CCYT Stock Weight Age 5																							◑	○	○	○	●	●	●	◉	●	◑	◉	◉	◉	○	◑	◑	●	●	●	●	●

● Largest ◐ 4th Quintile ○ Mid Quintile ◑ 2nd Quintile ◉ Smallest

Figure. 3.8. Summary of relative changes in average stock weights-at-age for Gulf of Maine stocks: cod (GOMCOD) and yellowtail flounder (CCYT).

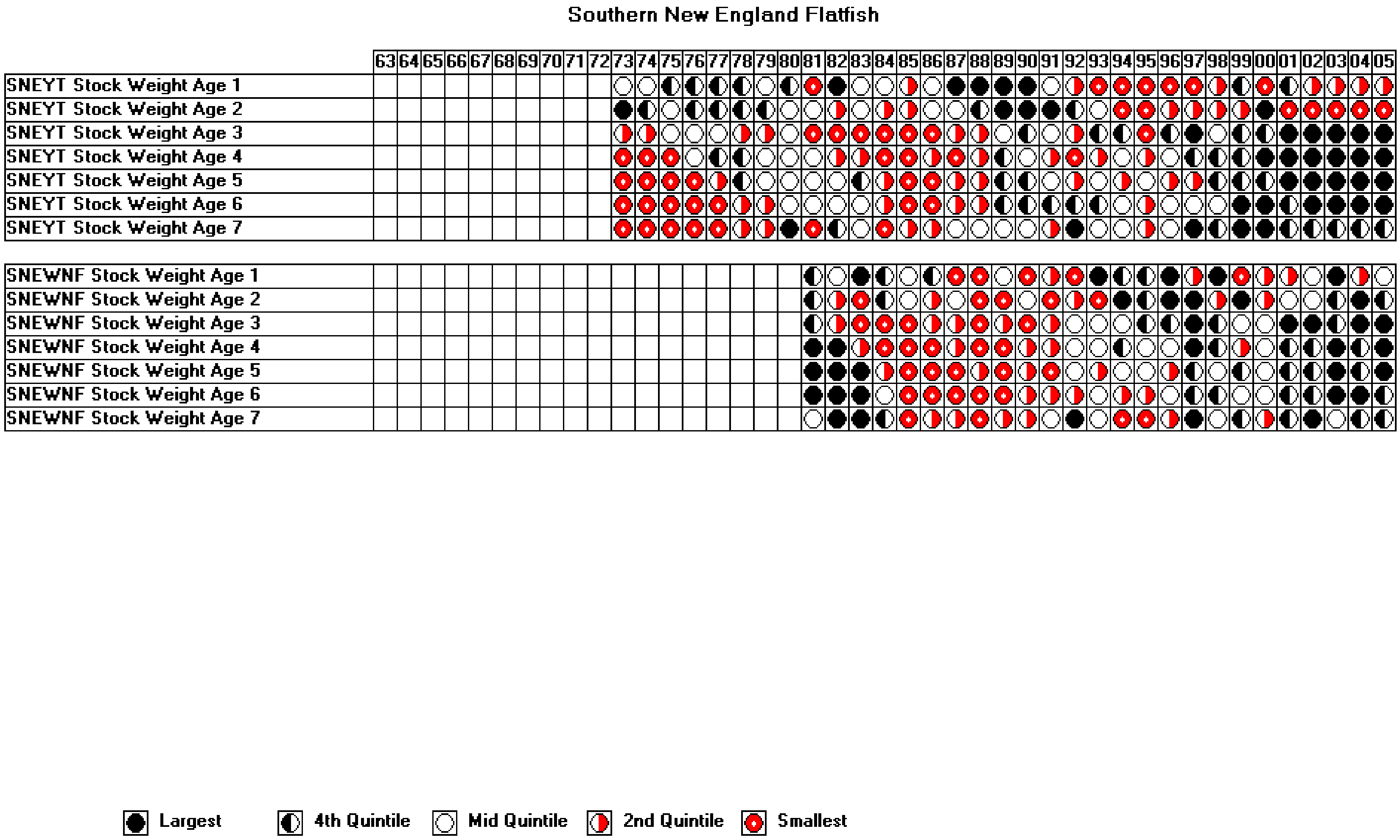


Figure. 3.9. Summary of relative changes in average stock weights-at-age for Southern New England stocks: yellowtail flounder (SNEYT) and winter flounder (SNEWNF).

Table 3.2. Projected and realized catches (mt) for 18 groundfish stocks, 2002-2004.

	2002		2003		2004	
	Projected	Actual	Projected	Actual	Projected	Actual
GB Cod	10,375	10,274	8,705	7,963	3,949	4,583
GB Haddock	12,859	12,994	19,492	12,576	27,145	17,584
GB Yellowtail	6,123	5,900	6,887	6,600	11,713	7,300
SNE/MA Yellowtail	828	880	859	500	707	300
CC/GOM Yellowtail Flounder	2,119	2,127	1,935	1,967	968	962
GOM Cod	6,684	7,195	6,876	7,406	4,850	5,898
Witch Flounder		3,222	6,254	3,154	5,174	2,917
American Plaice	4,023	4,496	4,393	3,232	3,695	2,132
GOM Winter Flounder	733	679	824	729	3,286	508
SNE/MA Winter Flounder	3,438	3,481	3,669	3,010	2,860	1,699
GB Winter Flounder	3,233	2,354	3,193	3,101	3,167	3,122
White Hake (> 60 cm)	3,460	3,065	2,821	4,444	2,300	3,560
Pollock	5,323	5,170	6,727	6,215	10,584	7,108
Redfish	428	368	1,524	361	1,632	398
Ocean Pout	16	12	19	26	77	5
GOM/GB Windowpane	239	12	267	17	534	25
SNE/MA Windowpane	113	85	143	47	266	44
GOM Haddock	1,110	1,211	2,061	1,221	4,831	1,021

3.5 References

Cadigan, N. and P. J. Farrell. 2005.Local influence diagnostics for the retrospective problem in sequential population analysis. ICES Journal of Marine Science., 62:256-265.

Mohn, R. 1999. The retrospective problem in sequential population analysis: an investigation using cod fishery and simulated data. ICES Journal of Marine Science, 56:473-488.

Rivard, D. 1982. APL programs for stock assessment (revised). Can Tech. Rep. Fish. Aquat. Sci. 1091: 146 p

Sullivan, P. J., A. M. Parma, and W. G. Clark. 1999. The Pacific Halibut Stock Assessment of 1997. Scientific Report No. 79, International Pacific Halibut Commission. Seattle, WA.

3.6 List of Appendices

Appendix I. Summary of Groundfish Management Measures, 2002-2004

Appendix II. Accuracy and Precision Exercises Associated with the 2005 GARM Production Ageing