New England Fishery Management Council
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E.F. "Terry" Stockwell, *Chairman* | Thomas A. Nies, *Executive Director*

MEMORANDUM

DATE: Monday, November 5, 2013

TO: Scientific and Statistical Committee (SSC)

CC: Groundfish Oversight Committee (GF OSC)

FROM: Groundfish Plan Development Team (GF PDT)

SUBJECT: Revising Gulf of Maine (GOM) haddock ABCs, FY 2013-2015

1. Background

The most recent assessment of GOM haddock occurred during the 2012 Groundfish Updates. Since the update, the fishing industry has been increasingly concerned about the low annual catch limits (ACLs) of GOM haddock (compared to the Georges Bank (GB) haddock stock). In addition, the industry has reported recent increases in GOM haddock (i.e., information that suggests increases in the discards of the 2010 year-class of haddock). Industry contends that these stock increases have not been fully captured in the most recent assessment, due to the terminal year of the assessment (2010).

Some in the fishing industry argue that apparent increases in the GOM haddock stock are due to GB haddock "spillover". The GF PDT completed an extensive analysis to explore the "haddock spillover" issue, which the SSC reviewed in August, 2013. Within the analysis, the GF PDT explored projection scenarios for the two stocks, under different spillover assumptions. Quota adjustments (from the GB haddock stock to the GOM haddock stock) based on spillover were not supported by the analysis and would likely increase the risk of overfishing and spawning stock biomass (SSB) decline for the GOM stock in 2014 and beyond. Both the PDT and the SSC concluded there was no scientific basis for adjusting the haddock ACLs to account for immigration of GB haddock into the GOM stock area.

In the PDT's analysis of spillover, updated survey information since the 2012 assessment suggested the 2010 year-class of GOM haddock may be stronger than previously estimated. There is uncertainty surrounding the size of this year-class since the 2010 year-class has just begun to enter the catch and an updated assessment was not available. However, this updated survey information and the concerns from industry that the stock might be in better condition than indicated by the 2012 assessment, may suggest the ABCs for GOM haddock might have been set too low. Therefore, in September 2013, the New England Fishery Management Council passed a motion,

To ask the SSC to reconsider the ABC of GOM haddock.

2. Overview of the Approach

Given time constraints (i.e., since the September Council meeting), the PDT focused on:

- Examining additional survey and fishery-dependent information since the 2012 GOM haddock assessment,
- Comparing two methods of estimating t+1 abundance for use in catch projections, and
- Revisiting the projections for the original GOM haddock ABCs including a consequence analysis.

Sections 3-5 which follow detail the methods and results of these approaches.

3. Examining additional survey and fishery-dependent information since the 2012 GOM haddock assessment *Michael Palmer, Northeast Fisheries Science Center (NEFSC)*

Survey Trends

The NEFSC currently conducts seasonal (spring and fall) bottom-trawl surveys to assess fish stocks and other species on the Eastern US Continental Shelf. The fall survey index tends to better capture trends in the GOM haddock stock (e.g., lower inter-annual variability and better tracking of cohorts) (Figure 1). The large spike in the time series around 2000 was due to the influence of the 1998 year-class (which was the largest year-class in the assessment time series 1977-2010). There also appears to be some indication of small increases in the survey indices post 2010, which may be due to a 'moderate' 2010 year-class (discussed in more detail below).

There is also a large 2013 spring index value, although this has not yet been corroborated by the 2013 NEFSC fall survey. Upon further examination of the data, the survey distribution plot of 2013 NEFSC spring bottom-trawl survey suggests that the large 2013 spring index value is not the product of a single tow (and not near areas of high density of GB haddock) (Table 1; Figure 2). In particular, only eight Gulf of Maine survey stations caught more than 10 haddock, and of the five survey stations with larges catches, only three of these were predominately small fish. So while the 2013 spring index signal was dispersed across several survey stations, it was driven by relatively few observations. Subsequent survey year observations will be needed to corroborate the signal from the 2013 spring survey.

Cohort Tracking of the 2010 and 2012 year-classes

Updated cohort tracking, since the last assessment, provides some evidence of a 'moderate' 2010 year-class over several ages/years in both spring and fall surveys (Figure 3; Figure 4). When comparing the signal of the 2010 year-class to the 'large' 1998 year-class and the 'moderate' 2003 year-class, the 2010 year-class appears more similar to a 'moderate' year-class.
The large 2013 NEFSC spring bottom-trawl survey index is primarily due to a high abundance of age-1 fish in the survey catches. This could be suggestive of a strong 2012 year-class. However, the presence of a strong 2012 year-class is highly uncertain until more information is gathered on

this year-class (e.g., additional survey years, catches, etc.). An additional source of uncertainty when interpreting recent cohort strength using the NEFSC surveys stems from the added uncertainty surrounding the survey vessel calibration factors (e.g., between the Albatross and Bigelow).

Assessment model fits to high NEFSC spring age1 index values have been problematic in the past (Figure 5). Overall, the cohort tracking ability of the NEFSC spring survey is not as good as the NEFSC fall survey (Figure 6; Figure 7). Furthermore, it might be too soon to make any conclusions about the relative size of the 2012 year-class and additional corroborating information would be needed from fall surveys and subsequent spring surveys as well as from fishery catches. Regardless, the size of the 2012 year class will have little effect on projected catches from 2013-2015. *Of note, the next round of groundfish assessment updates (likely in 2014), may include only two or three additional survey observations; however it is unlikely that there will be any catch information with which to corroborate the survey signals with respect to the size of the 2012 year-class.*

Evidence of the 2010 year-class in the fishery

Based on previous assessment information on fishery selectivity, the GOM haddock 2010 year-class will be age 3 and age 4 fish in 2013 and 2014 respectively and should be starting to enter the fishery in 2013 (e.g., 2006-2010 VPA estimated selectivity-at-age in the 2012 assessment, see Figure 8).

For comparison with fishery-dependent information, GOM haddock lengths-at- age were summarized from survey information. Using the NEFSC spring bottom-trawl survey (1997-20101), GOM haddock mean lengths-at-age are: Age-1 ≈ 20 cm; Age-2 ≈ 32 cm; Age-3 ≈ 41 cm; Age-4 ≈ 47 cm; and Age-5 ≈ 53 cm. Further examination of mean length-at-age by year-class over time suggests no evidence of slower/faster growth in response to cohort size (unlike GB haddock) (Figure 9). These length-at-age break points were then used to examine length frequency information in fishery-dependent datasets (i.e., commercial and recreational fisheries).

Evidence suggests that that the 2010 year-class has begun to enter the commercial fishery, as corroborated in the catch data. Using large mesh (≥5.75”) trawl catches, the length frequency of total catch (from NEFOP and ASM data) was examined. There is evidence of a year-class signal for both 2003 and 2010 year-classes (Figure 10). However, length frequency distributions cannot be translated into absolute estimates of year-class size. Furthermore absent a full assessment, it is currently unknown how selectivity may have changed since 2006-2010 (Figure 8), but there have been changes in minimum size.

Year-classes do not track very well in the recreational discard length frequency distributions (Figure 11). There were some low sample sizes concerns for the catch in the recreational fishery. In addition, there are selectivity issues at smaller sizes, minimum retention size at larger sizes (e.g., 2005-2008=19” (48 cm); 2009-2012= 18“(46cm); 2013= 21“ (53 cm)). Of the data reviewed, 2013 is a partial year (waves 2-3), and by comparison between 2010 and 2012 about 40-60% of the annual catch was from waves 2-3. There is no clear signal of cohort tracking in the recreational discard length frequencies.

Estimate of the size of the 2010 year-class

The 2012 assessment's estimate of the size of the 2010 year-class is limited. There is only one data point with which to estimate the 2010 year-class – from the NEFSC spring age1 index. Plot of model fits to NEFSC spring age 1 index indicate that this index was a poor predictor of year-class strength (Figure 5). The NEFSC bottom-trawl surveys suggest that the 2010 year-class size may be 'moderate' (poor<moderate<large). A moderate year-class can be defined as reasonably decent tracking of the cohort over ages/years, shows up consistently from survey to survey, and clearly of a smaller size that known 'large' year-classes. However, surveys alone are a poor indicator of absolute size of year-class strength (see previous example), and short of a full assessment, year-class strength can only be described in broadly subjective terms. Given these uncertainties, the information available can only put the likely size of the year-class in a very broad range (e.g., consider the distribution of estimated age-1 population size from 1977-2010, see Figure 12). Given the uncertainty in the NEFSC spring age-1 index, and shortage of any other information, the 2012 assessment used the geometric mean age-1 recruitment (1977-2010) to estimate the age 1 t+1 values.

A retrospective analysis (described in Section 4) was performed to compare the performance of both the geometric mean proxy and NEFSC spring-based estimates of t+1 age-1 recruitment (relative to the 2012 assessment's estimates of age-1) (Figure 13). The geometric mean proxy performs better relative to estimating the t+1 age-1 recruitment using the NEFSC spring age-1 index. In addition, the geometric mean proxy has lower variability relative to the NEFSC spring age 1 index. Overall, estimation error is mitigated by using the geometric mean value as a proxy, particularly when there is no evidence that there was a large recruitment event (Figure 14). Even when there is evidence of large recruitment events, the geometric mean proxy has performed better than the NEFSC spring age1 index (see 2003 and 1998 year-classes) (Figure 15).

Conclusions

The large 2013 NEFSC spring bottom-trawl survey index is driven by high catches of age-1 (2012 year-class) fish. It is uncertain as to whether this is a real signal or noise. More information may be available by the 2014 groundfish updates, but this information may still be limited. This does not appear to be a significant issue for setting the 2013 and 2014 ACLs, since the 2012 year-class would be poorly selected until ages 3-4.

However, the largest potential issue for the 2013 and 2014 ACLs is the approximate size of the 2010 year-class. The survey information suggests that this year-class is of 'moderate' size (not poor, and not large). There is also some evidence of it showing up in commercial catches (only partially selected at ages 3-4). To date, the exact size of the year-class is unknown. Furthermore, short of an updated assessment, the size of the year-class can only be put into general terms.

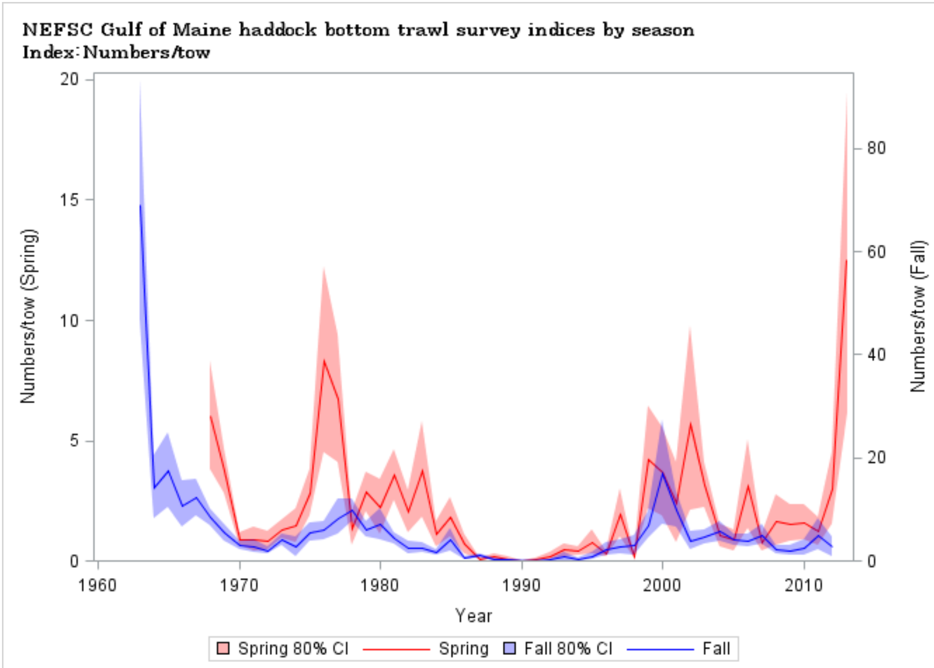
Furthermore, the 2012 assessment only had a single survey observation (spring age-1) with which to estimate the 2010 year-class strength. The method used in the 2012 assessment was to use a geometric mean proxy to estimate the t+1 size of the 2010 year-class. This method performs optimally over using the NEFSC spring age-1 index. Overall, the estimation error (both over- and under-) and bias are mitigated by using the geometric mean value as a proxy for the t+1 age-1 recruitment.

Table

CRUISE	STRATA	TOW	STATION	CATCHWT	CATCHNUM
201302	1390	5	325	0.07	0.39
201302	1390	2	326	0.09	0.41
201302	1370	6	375	0.11	0.40
201302	1380	6	333	0.11	0.42
201302	1370	4	355	0.11	0.40
201302	1370	7	378	0.12	0.42
201302	1270	1	382	0.13	0.42
201302	1270	5	349	0.16	0.43
201302	1380	3	329	0.20	0.81
201302	1370	2	377	0.26	0.84
201302	1360	5	373	0.27	0.83
201302	1390	6	332	0.41	2.33
201302	1280	4	356	0.60	0.60
201302	1260	16	406	0.80	1.00
201302	1270	3	381	1.08	1.10
201302	1280	3	219	1.23	1.20
201302	1280	1	220	1.29	1.98
201302	1390	3	327	1.33	3.75
201302	1380	2	330	1.39	0.86
201302	1360	8	311	1.50	1.62
201302	1360	6	312	1.72	0.86
201302	1360	3	313	1.96	0.86
201302	1270	2	347	2.89	1.63
201302	1360	1	366	3.23	4.09
201302	1270	4	384	4.74	6.16
201302	1400	2	383	5.86	9.37
201302	1400	1	385	6.69	11.99
201302	1260	5	392	8.40	6.41
201302	1380	5	335	13.81	29.04
201302	1360	7	310	20.69	13.96
201302	1260	15	404	44.51	41.34
201302	1260	8	391	51.77	138.41
201302	1370	8	354	59.46	128.15
201302	1370	5	376	75.13	250.86
201302	1260	11	393	101.60	89.40

Table 1: NEFSC spring 2013 bottom-trawl surveys sorted by catch weight (kg) of GOM haddock. Highlighted rows indicate the 5 stations with the largest catches (see Figure 2).

Figures



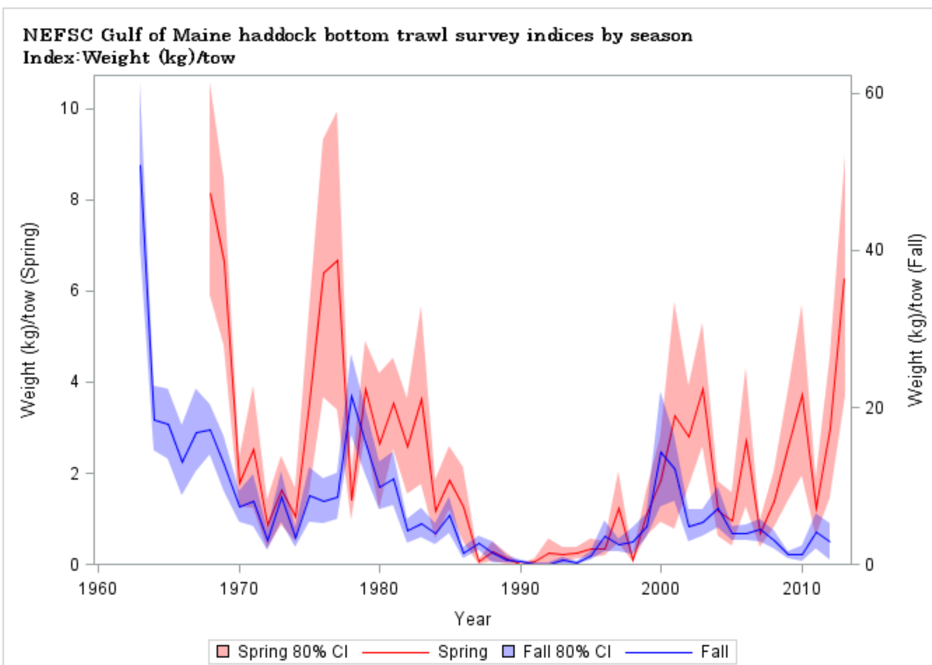


Figure 1: Indices for GOM haddock survey catch numbers (numbers/tow) (top) and weight (kg/tow) (bottom) derived from seasonal NEFSC bottom-trawl surveys (spring:1968-2013; and fall: 1963-2012). 80% confidence intervals provided for each survey

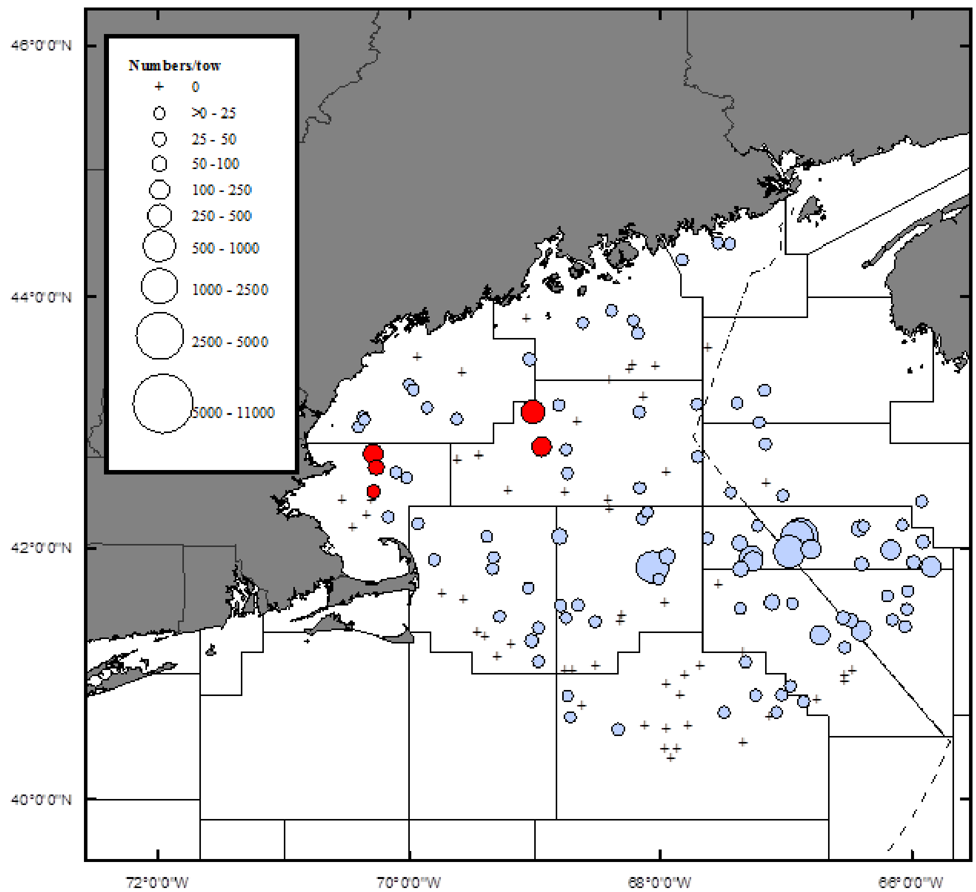


Figure 2: Distribution of haddock survey catches (numbers/tow) from the 2013 NEFSC spring bottom-trawl survey. Circles of increasing size correspond to relative catch size. Stations represented in red indicate the 5 stations with the largest catches of GOM haddock (see Table 1).

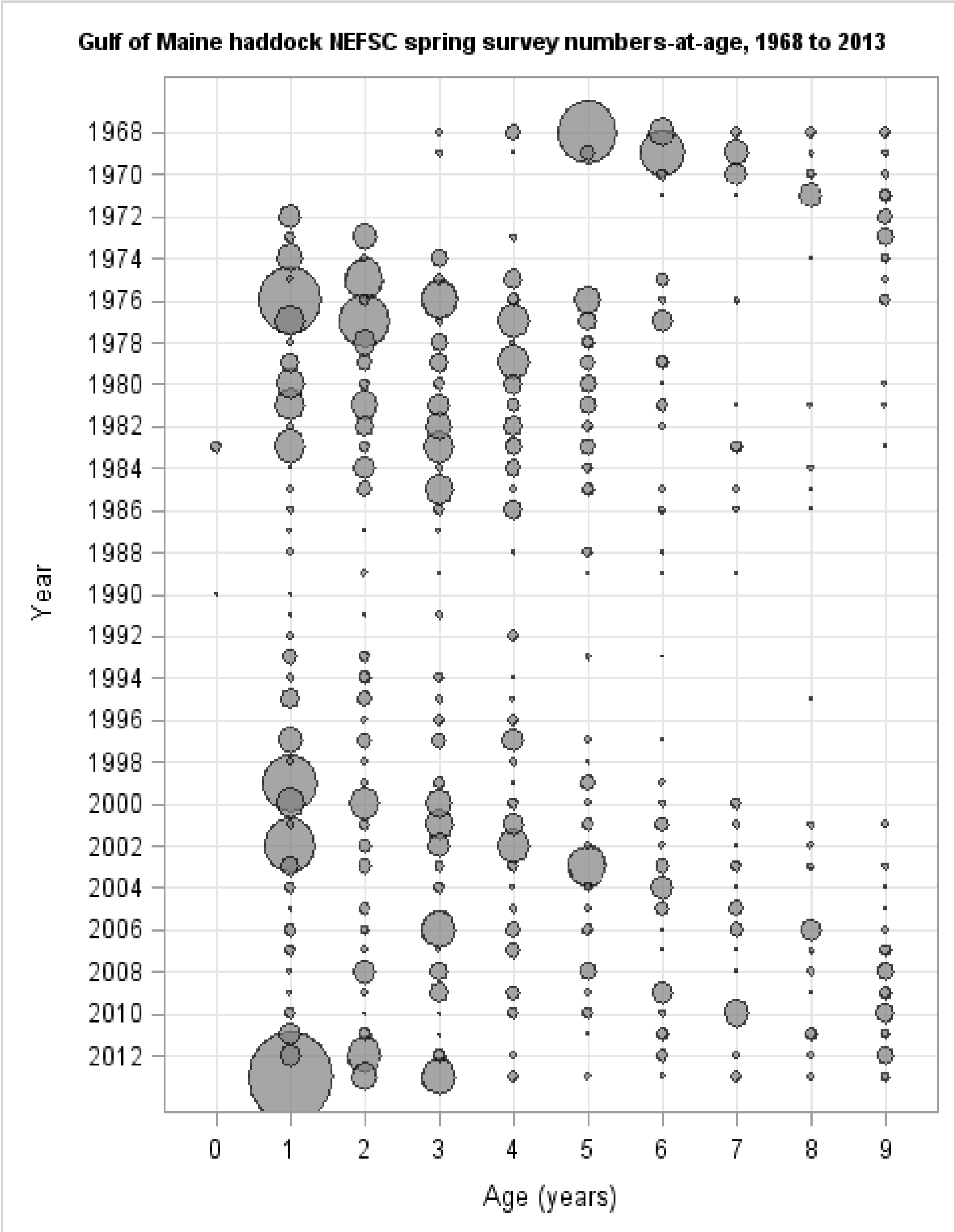


Figure 3: GOM haddock numbers-at-age from the NEFSC spring bottom trawl survey, 1968-2013. Note that age 9 is a plus group. Also, the comparability of bubble sizes over time is complicated by Bigelow calibration factors.

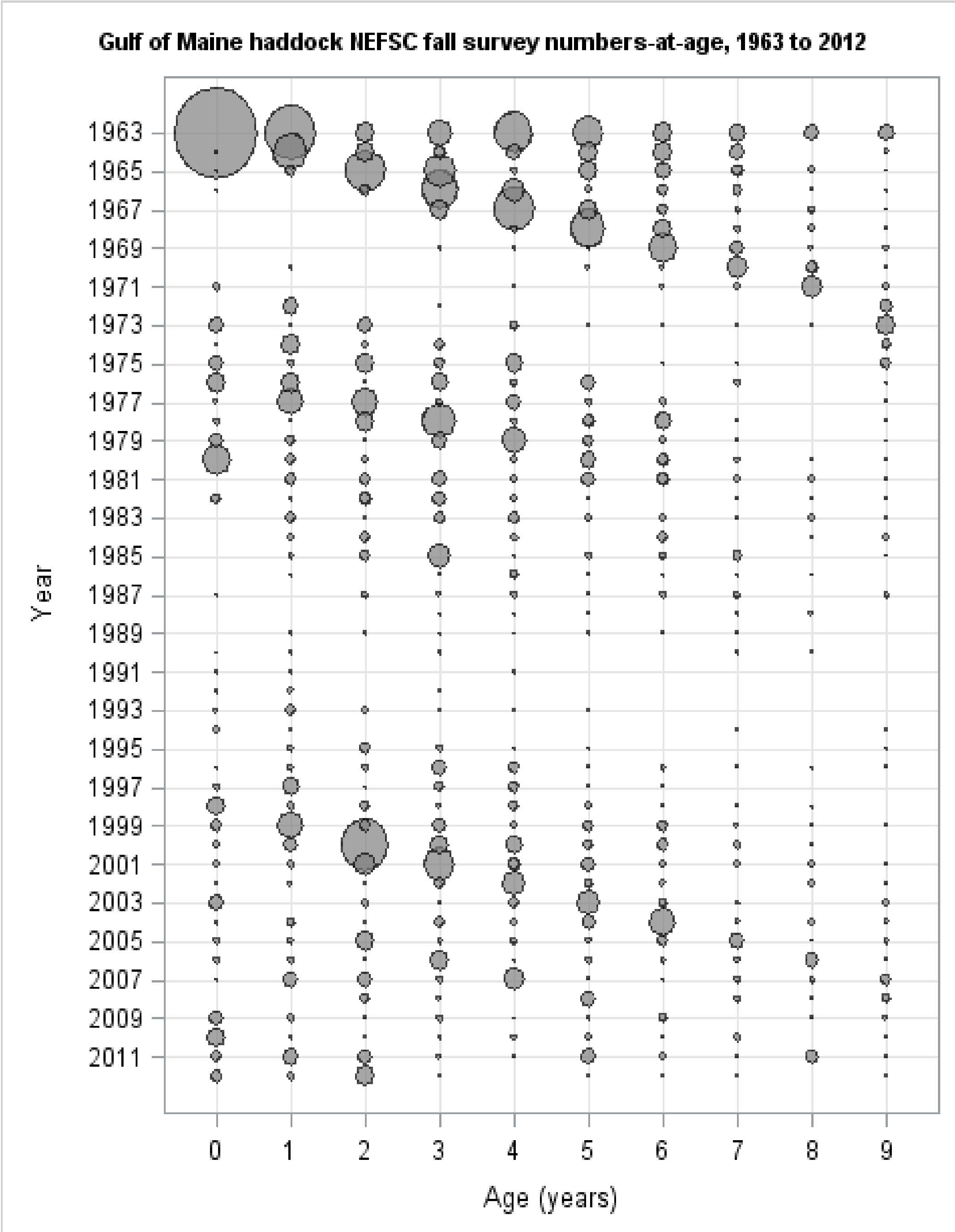


Figure 4: GOM haddock numbers-at-age from the NEFSC fall bottom trawl survey, 1963-2012. Note that age 9 is a plus group. Also, the comparability of bubble sizes over time is complicated by Bigelow calibration factors.

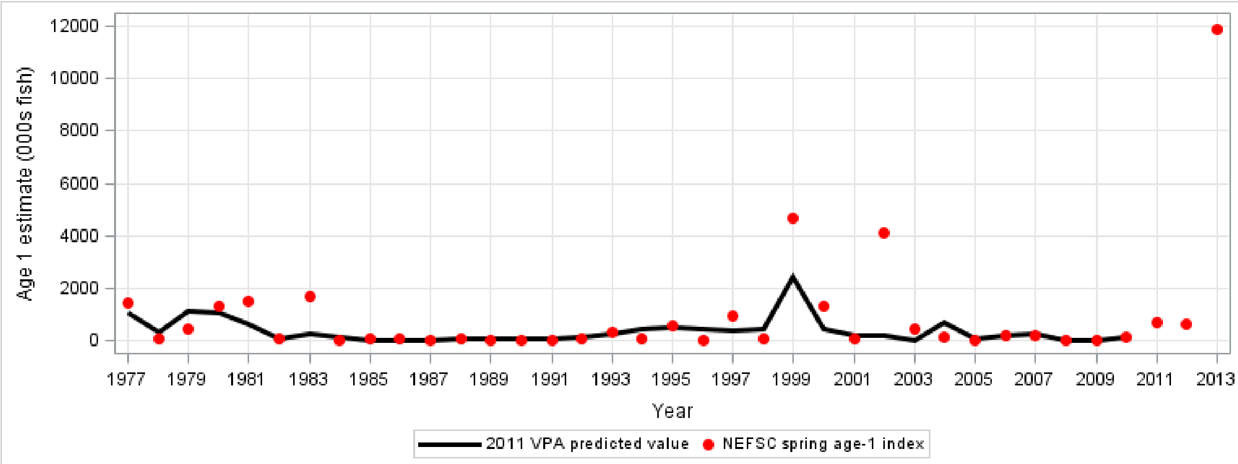


Figure 5: The 2011 VPA predicted values (1977-2010) and the NEFSC spring age-1 index values (1977-2013).

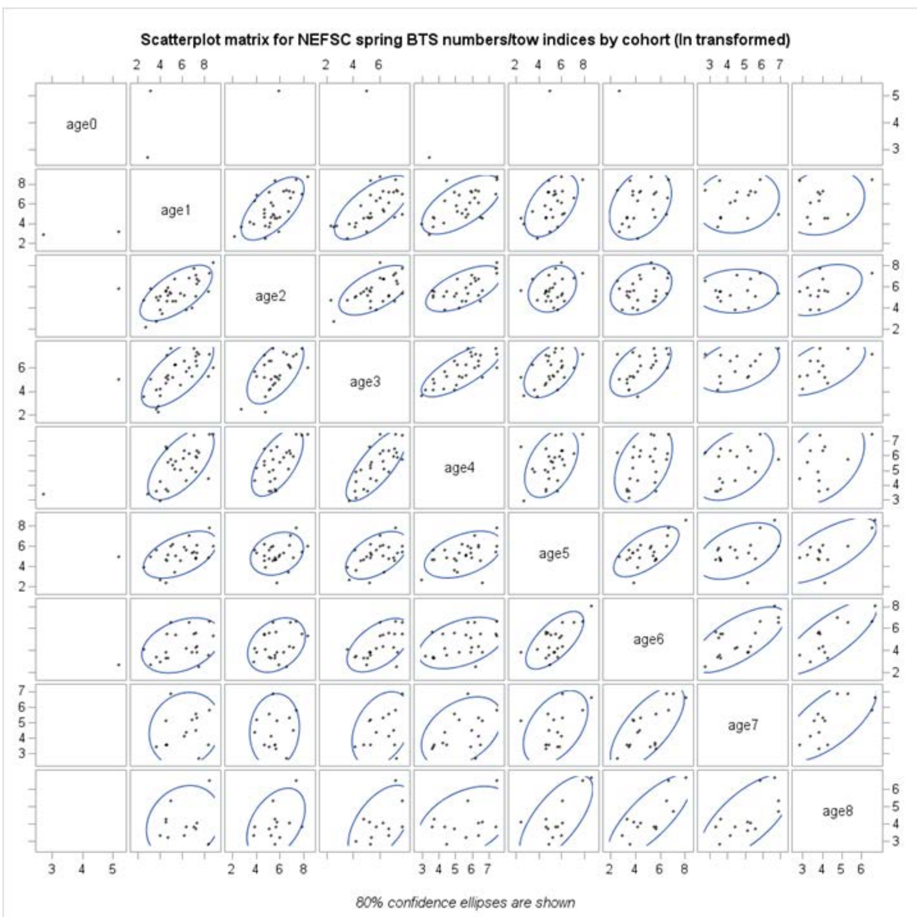


Figure 6: Scatterplot matrix for GOM haddock NEFSC spring bottom-trawl survey numbers per tow indices by cohort (log transformed). 80% confidence ellipses are shown.

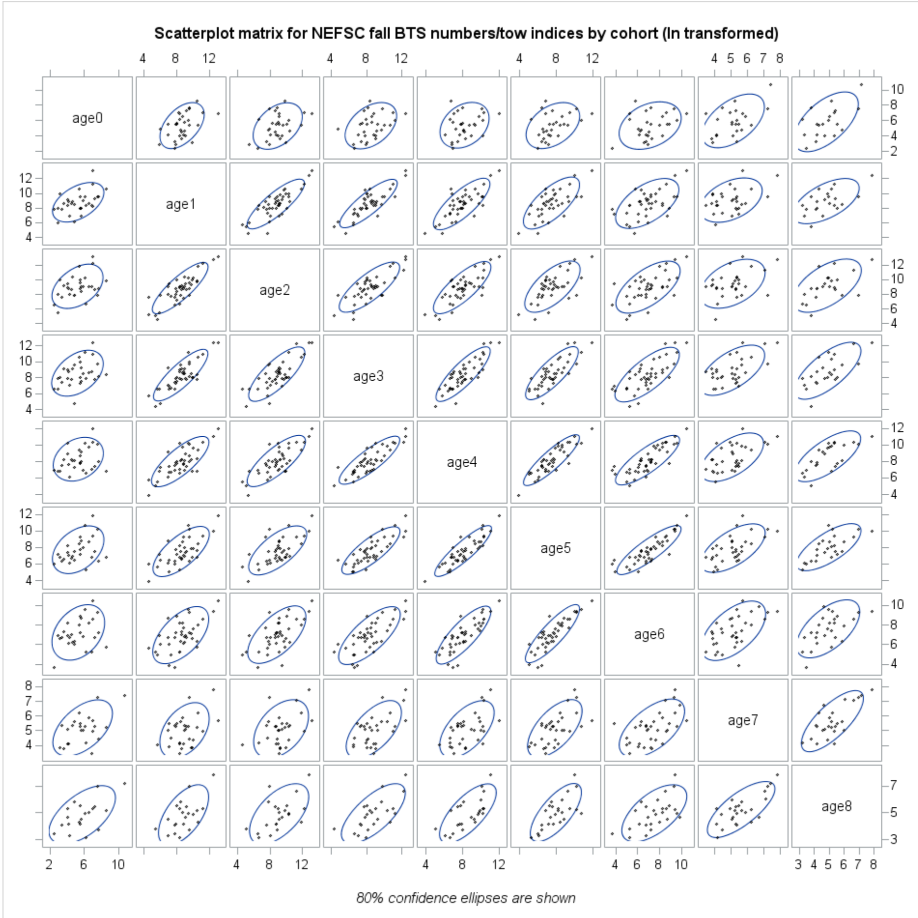


Figure 7: Scatterplot matrix for GOM haddock NEFSC fall bottom-trawl survey numbers per tow indices by cohort (log transformed). 80% confidence ellipses are shown.

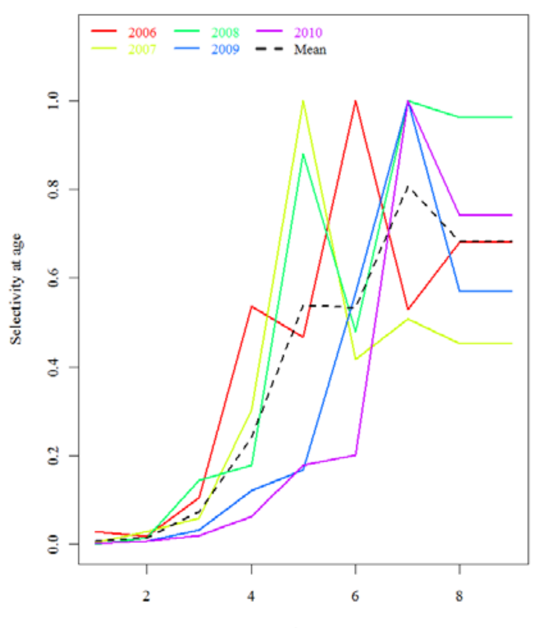


Figure 8: 2011 VPA estimated selectivity-at-age from the 2012 GOM haddock assessment.

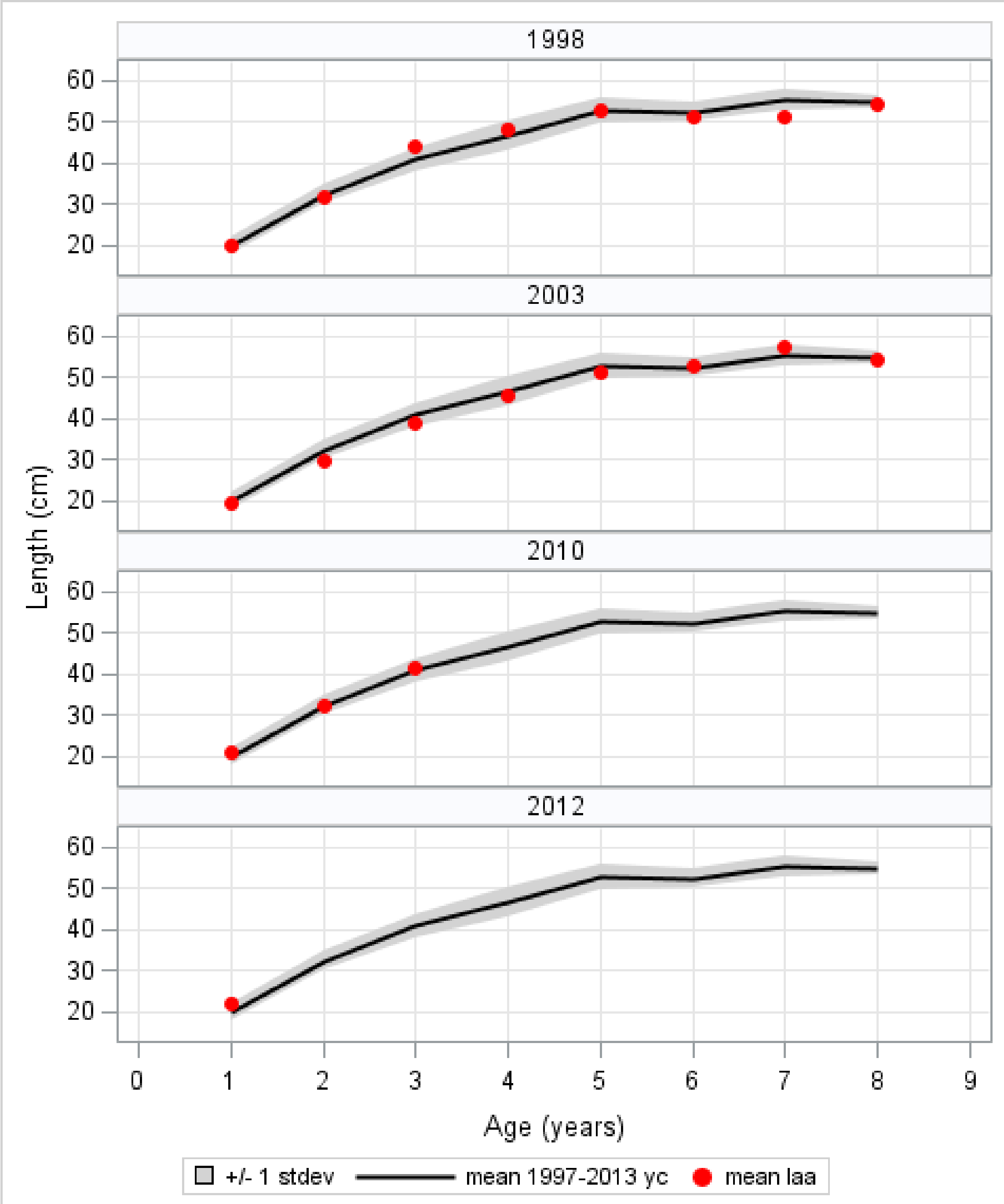


Figure 9: Mean length-at-age of GOM haddock and mean lengths-at-age (+/- 1 standard deviation) for the 1998, 2003, 2010, and 2012 year-classes, based on the NEFSC spring surveys, 1997-2013

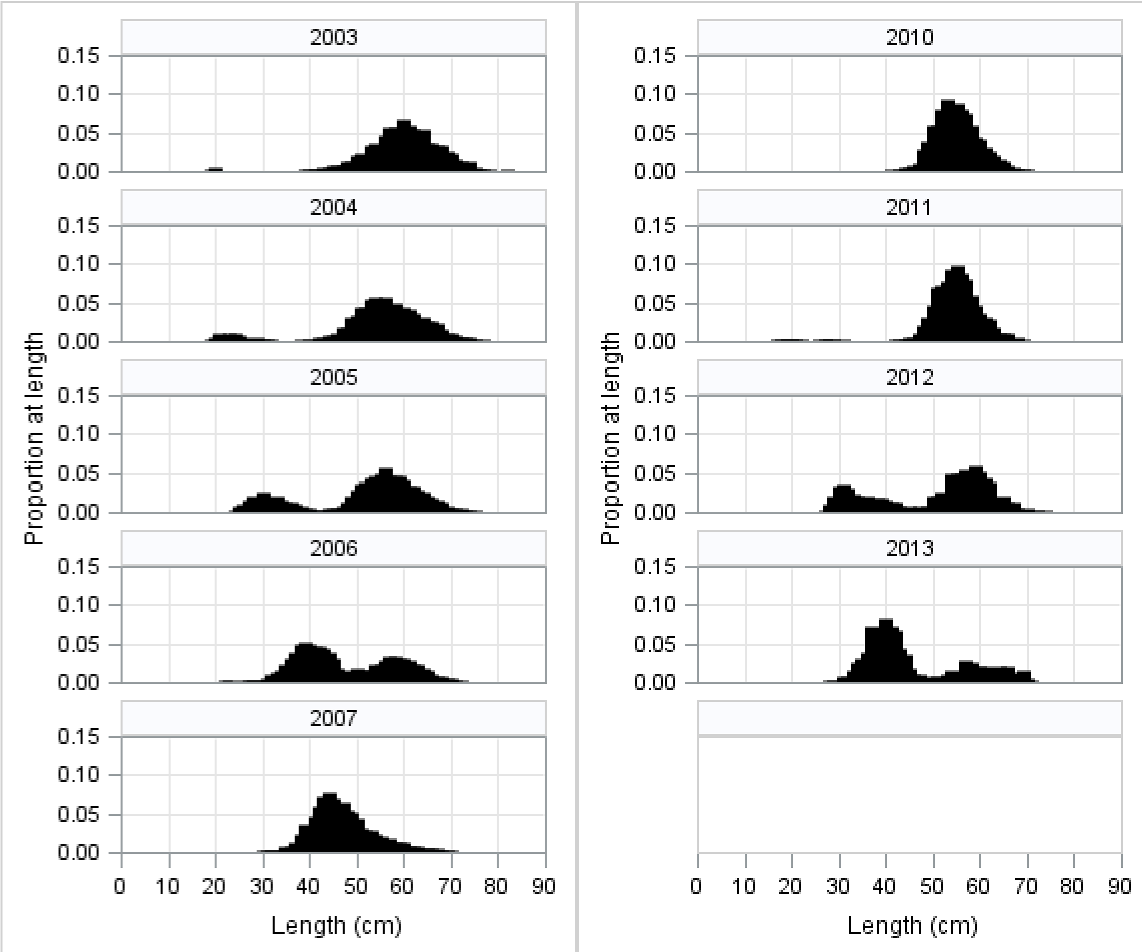


Figure 10: Length frequency of total catches of GOM haddock in large mesh (≥5.75") trawl fishery catches. Tracking signals for the 2003 (left) and 2010 (right) year-classes. Data: NEFOP and At-Sea Monitoring databases, 2003-2007; 2010-2013.

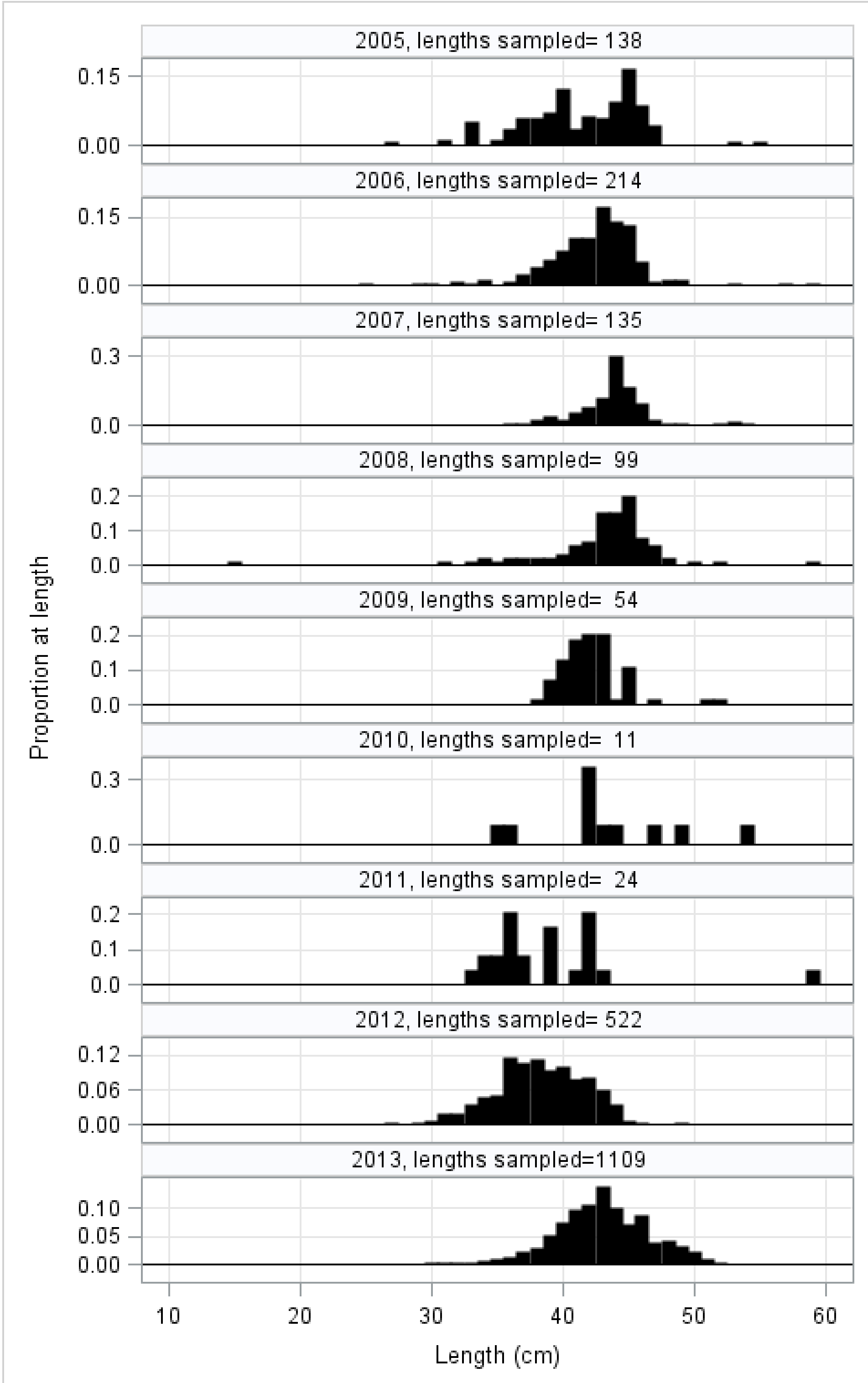


Figure 11: Length frequencies of recreational catches of GOM haddock. 2013 is a partial year (waves 2-3), and by comparison between 2010 and 2012 about 40-60% of the annual catch was from waves 2-3.

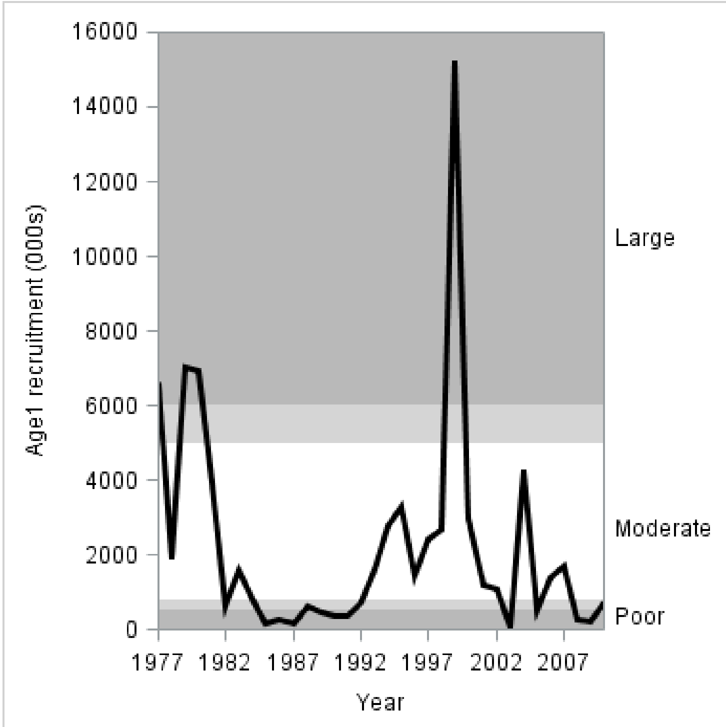


Figure 12: Distribution of estimated age-1 population size from 1977-2010 based on the 2010 GOM haddock assessment. Potential thresholds for large, moderate, and poor year-classes indicated.

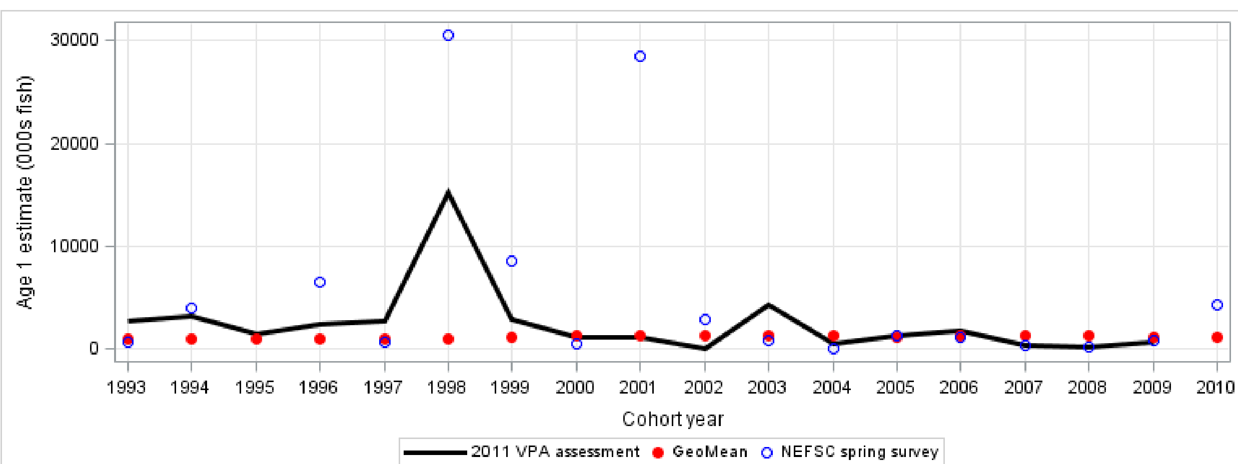


Figure 13: Retrospective analysis to compare the performance of both the geometric mean proxy and NEFSC spring-based estimates of t+1 age-1 recruitment, relative to the 2011 VPA estimates of age-1.

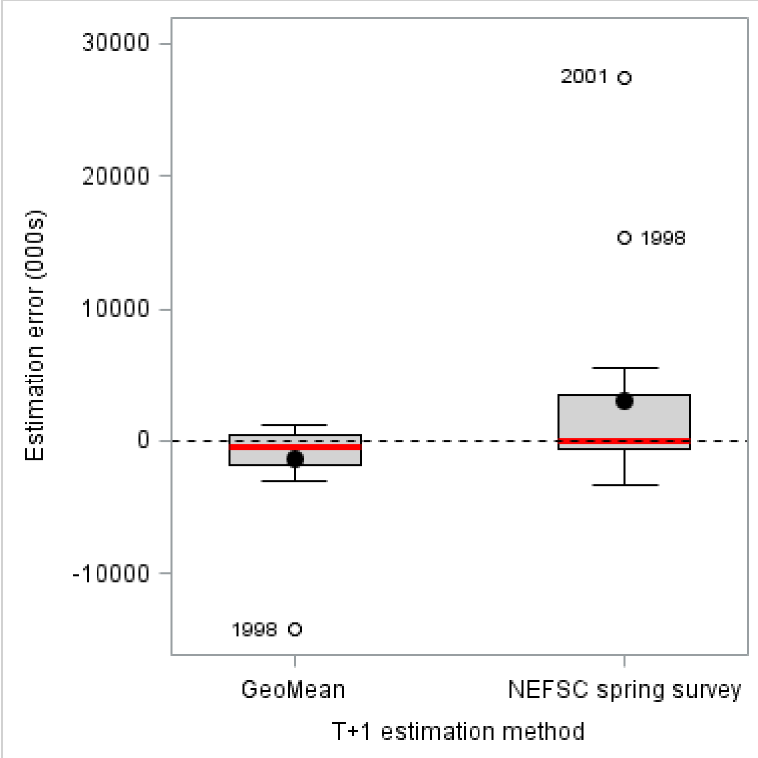


Figure 14: Comparison of the estimation error between the geometric mean and NEFSC spring survey index as t+1 estimation methods. Points indicate year-classes.

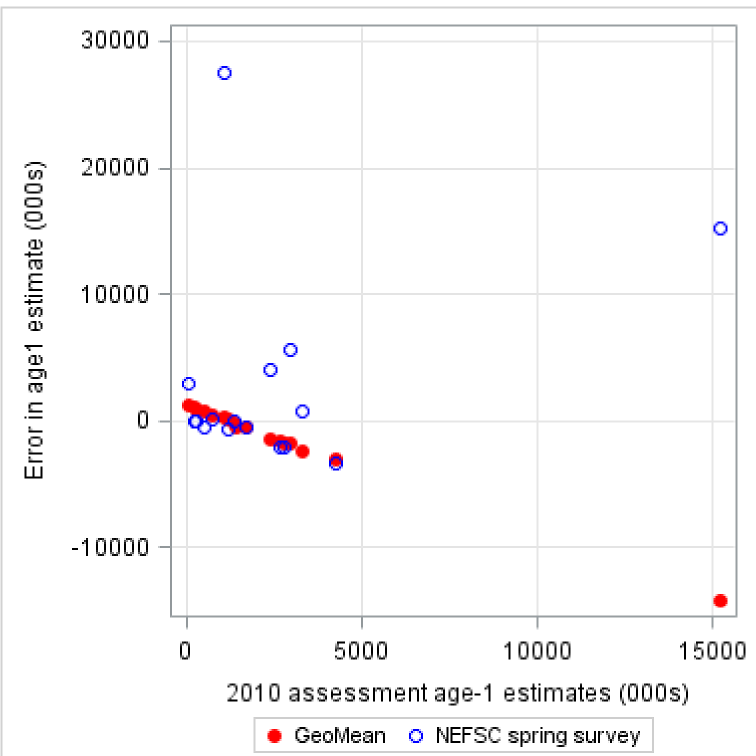


Figure 15: Comparison of the error in the age1 estimate between the geometric mean and NEFSC spring survey index based on the assessment age -1 estimates. Points indicate year-classes.

4. Distribution of errors in estimating T+1 abundance for use in catch projections for GOM haddock *Steven Correia, Massachusetts Division of Marine Fisheries*

Introduction

The PDT and other working groups have presented information suggesting that catch projections have tended to be optimistic. At the 2012 updated groundfish stock assessment meetings, the reviewers concluded that the geometric mean method for estimating the t+1 recruitment should be used in catch projections for GOM haddock. This analysis augments the analysis presented in Section 3 of this memo, by providing quantitative measures of bias and precision for two methods of estimating t+1 abundance for use in catch projections. GOM haddock are fully recruited at age 7 and partially recruited at age 5 (p=0.67). Given the current selectivity, the t+1 abundance estimate does not have much impact on projected catches for the first three years of the projections.

Methods

The performance of the two methods was evaluated using a retrospective analysis of the 2011 VPA model. The VPA model was run using both the geometric mean and direct estimate approaches to estimate age-1 recruitment in the year, t+1. An 18 year "peel" (1993-2010) was used in the retrospective analysis (Figure 13). The length of the retrospective analysis was subjective, but informed by a desire to capture the performance of the two estimators under a broad range of year-class sizes, including that of the large 1998 year-class. The age-1 recruitment estimate in year t+1 from each of the peels was then compared to the corresponding year-class estimate from the 2011 VPA model to evaluate the estimation error associated with both approaches.

Data used in this analysis are provided in Table 3. This analysis excludes the 1995 (survey index=0) and 2010 year-classes (VPA age 1 estimate not available for 2010 year-class at age 1). Error was defined as the method abundance estimate – VPA estimate of age 1 abundance. Note that this is reverse of the conventional measure of bias measured as Truth-predicted value (see Table 2). This changes the sign, but not the magnitude of the error and is consistent with the graphical analysis presented to the PDT. Bias was measured as the deviation of the error distribution's central location from zero. The root mean square error was taken as a measure of the method's precision.

Comparison of precision

Boxplots of the distribution of errors by method are shown in Figure 16. The distribution of errors from the calibration method is right skewed (toward over-estimation of year-class strength at age 1). The inter-quartile range is wider than the geometric mean, indicating that estimates from calibration method are less precise than estimates from the geometric mean. The distribution of errors using the geometric mean is left skewed (toward underestimation of age 1 VPA abundance). The inter-quartile range is smaller, indicating that the geometric mean is more precise than the calibration method. A similar conclusion is reached when comparing the root mean square error. The RMSE of the geometric mean was 3,808 compared with 8,155 for survey index calibration method indicating the geometric mean method is approximately twice as precise as the calibration method. Note that the root mean square error is sensitive to the presence of large outliers (1998 and 2001 year-classes).

Comparison of bias

Summary statistics for the distribution of errors are shown in Table 2. The mean is sensitive to presence of outliers. The trimean was used as a measure of central location that is insensitive to the presence of outliers, but will account for asymmetry within the middle 50% of the distribution. The calibration method has a tendency to produce estimates of abundance that are biased high. Abundance estimates from the geometric mean method tend to be biased low. Both the mean and the trimean indicate that estimates using the geometric mean method are less biased than those using the calibration method.

Conclusions

The geometric mean method provides less biased and more precise estimates of abundance in year t+1 than the survey calibration method (Figure 17). The geometric mean method should be the preferred method for estimating t+1 abundance of age 1 in catch projections for GOM haddock. Better estimates of abundance in year t+1 should help improve performance of projections.

Tables

Method	minimum	1st quartile	median	mean	3rd quartile	max	trimean	RMSE	IQR
geomean	-14,210	-1,786	-352	-1,377	559	1,233	-483	3,808	2,345
calibration	-3,396	- 547	20	2,937	3,180	27,440	668	8,155	3,727

Table 2: Summary statistics for the distribution of errors by method. The RMSE and IQR provide measures of precision. RMSE =root mean square error and IQR =interquartile range.

Method	Yearclass	VPA Age 1 000’s	t+1 estimate 000’s	Difference t+1-vpa 000’s
Geomean	1993	2763	979	-1784
Geomean	1994	3277	914	-2363
Geomean	1996	2391	960	-1431
Geomean	1997	2658	1067	-1591
Geomean	1998	15211	997	-14214
Geomean	1999	2961	1167	-1794
Geomean	2000	1205	1333	128
Geomean	2001	1081	1312	231
Geomean	2002	82	1315	1233
Geomean	2003	4251	1292	-2959
Geomean	2004	501	1230	729
Geomean	2005	1378	1166	-212
Geomean	2006	1723	1230	-493
Geomean	2007	287	1268	981
Geomean	2008	226	1230	1004
Geomean	2009	722	1224	502
Calibration	1993	2763	662	-2101
Calibration	1994	3277	3962	685
Calibration	1996	2391	6478	4087
Calibration	1997	2658	625	-2033
Calibration	1998	15211	30507	15296
Calibration	1999	2961	8513	5552
Calibration	2000	1205	589	-616
Calibration	2001	1081	28518	27437
Calibration	2002	82	2959	2877
Calibration	2003	4251	855	-3396
Calibration	2004	501	73	-428
Calibration	2005	1378	1374	-4
Calibration	2006	1723	1199	-524
Calibration	2007	287	288	1
Calibration	2008	226	265	39
Calibration	2009	722	837	115

Table 3: VPA estimates of age 1 abundance (000’s) and estimates of abundance (000’s) in year t+1 using the geometric mean and the estimate using t+1 survey calibration method. Data were taken from the 2012 GOM haddock assessment. Geomean= geometric mean method for t+1 abundance, Calibration = method based on VPA calibration of survey index.

Figures

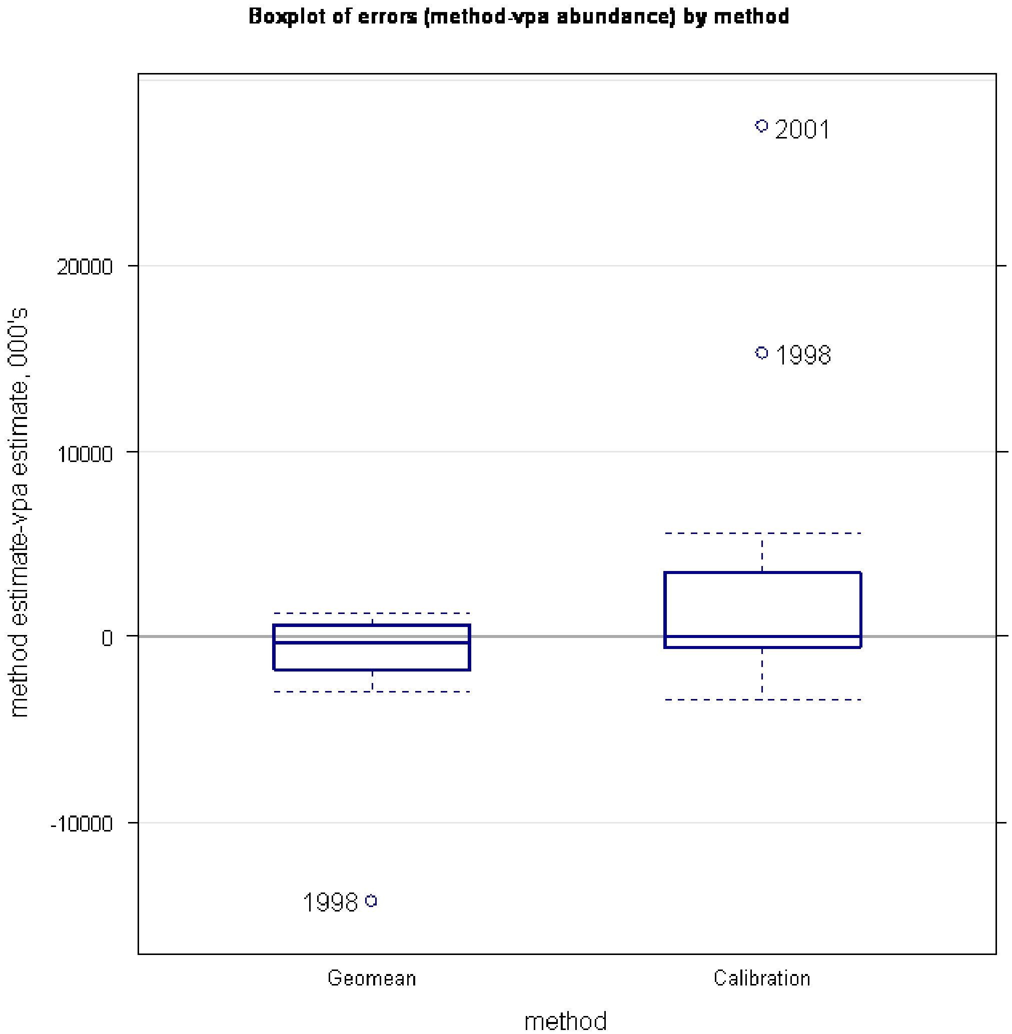


Figure 16: Boxplots of the distribution of errors (VPA estimate-method estimates) for two methods of estimating abundance in t+1. Geometric mean uses geometric mean of time series and calibration uses calibration of survey index from VPA assessment. Positive values overestimates VPA age 1 abundance and negative values underestimates of VPA age 1 abundance. Points are labeled with year-class.

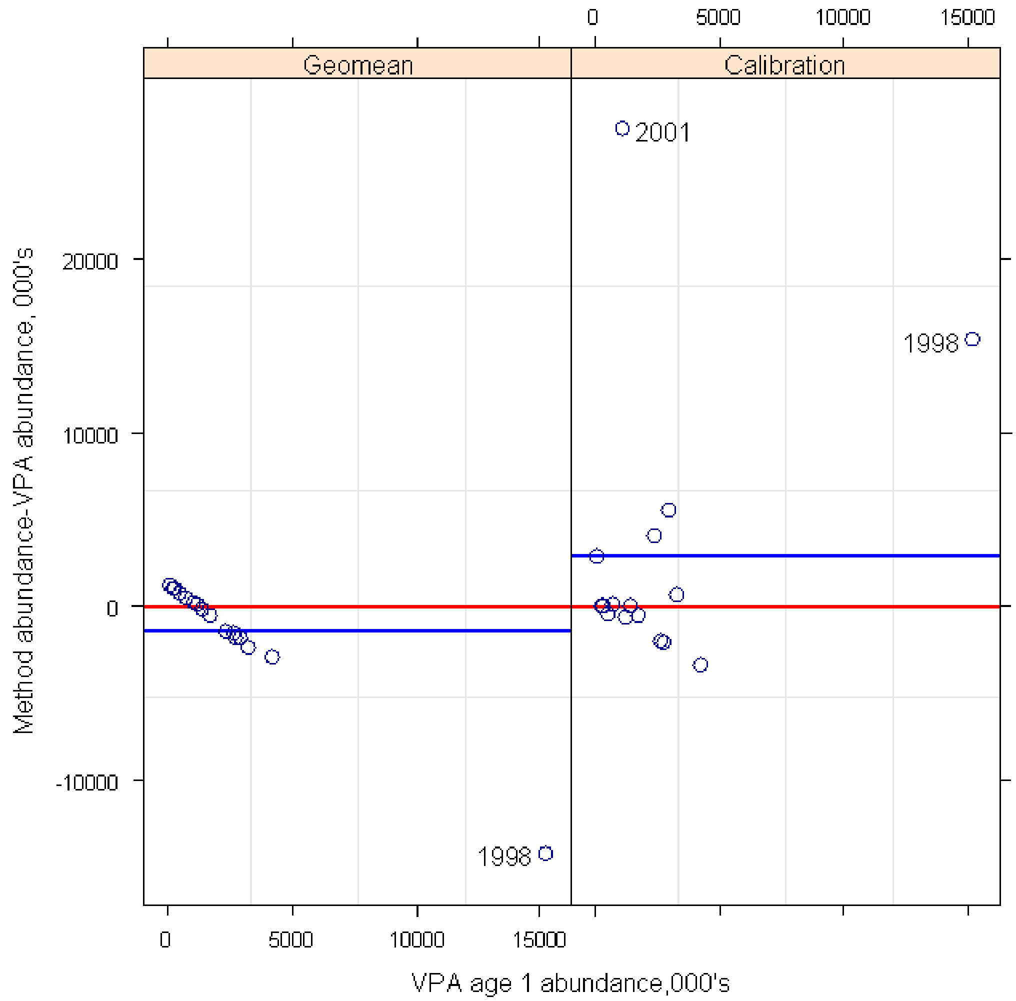


Figure 17: Plot of differences between t+1 estimate of abundance compared and VPA abundance against VPA age 1 abundance. Blue line is mean of differences. Points are labeled with year-classes

5. Revisited Projections and Consequence Analysis *Paul Nitschke, NEFSC*

The PDT updated the catch estimates from the quota monitoring database for the bridge years used in the 2012 groundfish update projections. There was little change in the updated catch estimates. The 2011 catch estimate increased from 696 mt to 713 mt and the 2012 catch decreased from 727 mt to 708 mt. This results in insignificant changes in the 75%F_{MSY} projections (Table 4; Table 5; Table 6; Table 7 and Figure 18; Figure 19; Figure 20). The PDT also re-ran the GOM haddock VPA bootstrap while estimating the t+1 age-1 directly from the NEFSC spring 2011 survey. The 2010 year-class is the t+1 age-1 recruitment estimate from the 2012 updated groundfish assessments. This t+1 age-1 recruitment estimate tends to be the most uncertain due to the lack information available with age-0 fish in the terminal year of the assessment.

The PDT ran a projection at 75%Fmsy with the update catch using the direct estimate of t+1 age-1 recruitment as a comparison to the geometric mean ABCs. However, a retrospective analysis showed that the spring age-1 index was not a good predictor of the year-class strength in the past (Figure 13). The t+1 direct estimate of age-1 recruitment (4.4 million fish) was about 4 times higher than the original geometric mean estimates of 1.1 million fish. This single year-class assumption would increase the ABC 134% in 2013, 160% in 2014, and 189% in 2015. Effects of this t+1 recruitment estimate on exploitable biomass can be seen in Figure 21. The influence on the catch of the t+1 assumption increases as the year-class becomes more fully selected with time. Age-3 fish in 2013 have a selectivity of only 9%, age-4 in 2014 are selected at 30% and age-5 in 2015 are at 67%.

The PDT also ran a consequence analysis between the geometric mean t+1 model and the direct survey t+1 models (Table 8). Not surprising the t+1 assumption has consequential effects if the truth is closer to the t+1 geometric metric mean recruitment and catch is taken based on recruitment from the direct survey estimate. This would result in overfishing (F_{MSY}=0.46) from 2013 through 2015 (lower left box). The risk of continued overfishing is not fully captured in the projections or the consequence analysis.

The PDT also developed a constant catch scenario within the geometric mean model. The constant catch was based on the catch at 75%Fmsy in 2014 (342 mt). This was an attempt to stabilize the catch over the three years period with minimal biological effects within the projections. This would result in a slight increase in the catch and F in 2013 and a decrease in the catch and F in 2015. However if the 2010 year-class is stronger than the geometric mean then this constant ABC may become a larger constraint on the fishery in 2014 relative to the current ABCs which are increasing with time.

Tables

Fishing Mortality	**1**	**2**	**3**	**4**
Catches	Current	Updated Catch	Updated Catch	Updated Catch
Assumption	Recruitment-Geo-mean	Recruitment-Geo-mean	Recruitment-Direct estimate t+1	Constant Catch-2014 level
2011	0.50	0.51	0.50	0.51
2012	0.74	0.72	0.66	0.72
2013	0.35	0.35	0.35	0.42
2014	0.35	0.35	0.35	0.36
2015	0.35	0.35	0.35	0.26

Table 4: Projected fishing mortality of GOM haddock from 2011-2015. Projections 1-3 assume 75%Fmsy from 2013-2015 and projection 4 is based on a constant ABC.

SSB	**1**	**2**	**3**	**4**
Catches	Current	Updated Catch	Updated Catch	Updated Catch
Assumption	Recruitment-Geo-mean	Recruitment-Geo-mean	Recruitment-Direct estimate t+1	Constant Catch-2014 level
2011	2127	2122	2168	2122
2012	1700	1702	2043	1702
2013	1686	1688	2990	1674
2014	2227	2229	4170	2237
2015	3023	3024	4991	3070

Table 5: Projected SSB of GOM haddock from 2011-2015. Projections 1-3 assume 75%Fmsy from 2013-2015 and projection 4 is based on a constant ABC.

ABCs	**1**	**2**	**3**	**4**
Catches	Current	Updated Catch	Updated Catch	Updated Catch
Assumption	Recruitment-Geo-mean	Recruitment-Geo-mean	Recruitment-Direct estimate t+1	Constant Catch-2014 level
2013	290	290	388	342
2014	341	342	544	342
2015	435	435	823	342

Table 6: Projected ABCs of GOM haddock from 2011-2015. Projections 1-3 assume 75%Fmsy from 2013-2015 and projection 4 is based on a constant ABC.

OFLs	**1**	**2**	**3**	**4**
Catches	Current	Updated Catch	Updated Catch	Updated Catch
Assumption	Recruitment-Geo-mean	Recruitment-Geo-mean	Recruitment-Direct estimate t+1	Constant Catch-2014 level
2013	371	371	501	371
2014	440	440	705	425
2015	561	561	1,063	546

Table 7: Projected OFLs of GOM haddock from 2011-2015. Projections 1-3 assume 75%Fmsy from 2013-2015 and projection 4 is based on a constant ABC.

			"True" State of Nature							
			Geo Mean				Direct Estimate			
Assessment Model	Year	Catch	F	SSB	Prob. F> FMSY	Prob. SSB< SSBMSY	F	SSB	Prob. F> FMSY	Prob SSB< ½ SSBMSY
Geo Mean	2012	708	0.723	1.702	0.802	0.804	0.66	2.043	0.762	0.667
	2013	290	0.345	1.689	0.316	0.817	0.250	3.023	0.141	0.354
	2014	342	0.344	2.283	0.300	0.558	0.200	4.336	0.083	0.175
	2015	435	0.334	3.089	0.297	0.346	0.159	5.401	0.070	0.104
Direct Estimate	2012	708	0.723	1.702	0.802	0.804	0.66	2.043	0.667	0.762
	2013	388	0.484	1.660	0.532	0.823	0.345	2.998	0.360	0.312
	2014	544	0.631	2.140	0.699	0.602	0.341	4.197	0.201	0.319
	2015	823	0.817	2.716	0.808	0.442	0.340	5.031	0.152	0.353

Table 8: Consequence table for catches estimated from different GOM haddock T+1 age-1 assumptions. The catches in the top half of the table are based on 75% of F_{MSY} catches using 2012 groundfish update geometric mean assumption for t+1. The bottom half of the table is based on 75% of F_{MSY} catches using the direct estimate of the t+1 age 1 recruitment from the NEFSC spring Survey.

Figures

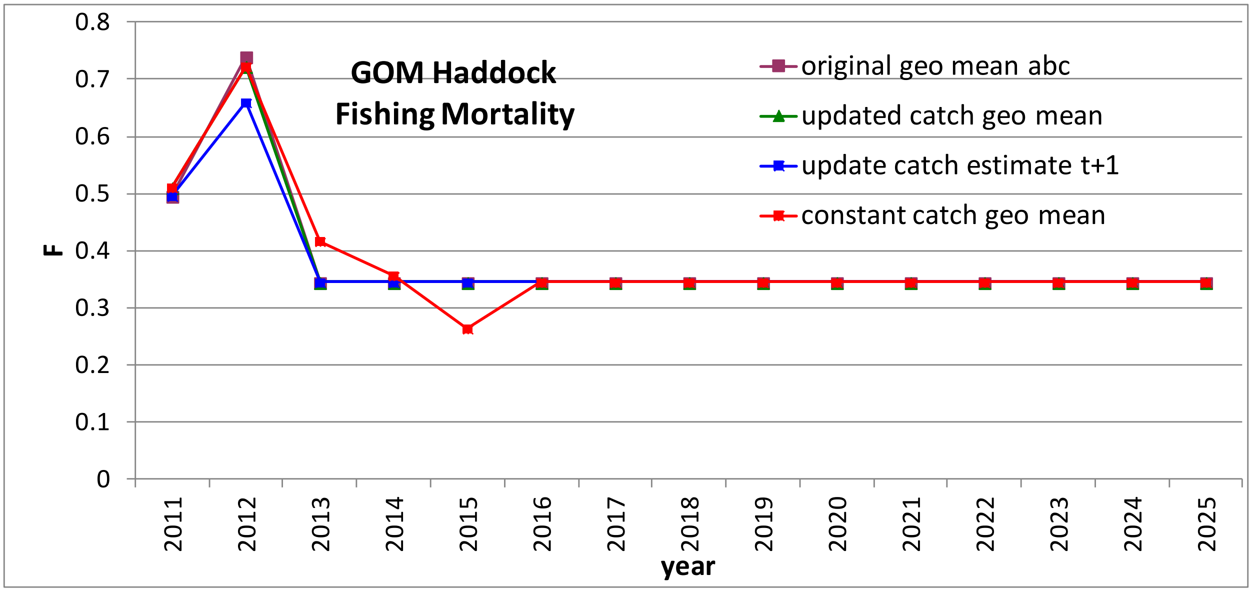


Figure 18: Projected fishing mortality of GOM haddock from 2011-2025. Projections 1-3 assume 75%Fmsy from 2013-2015 and projection 4 is based on a constant ABC. 2011 and 2012 are bridge year catch assumptions and F's after 2015 are assumed to be at 75%Fmsy.

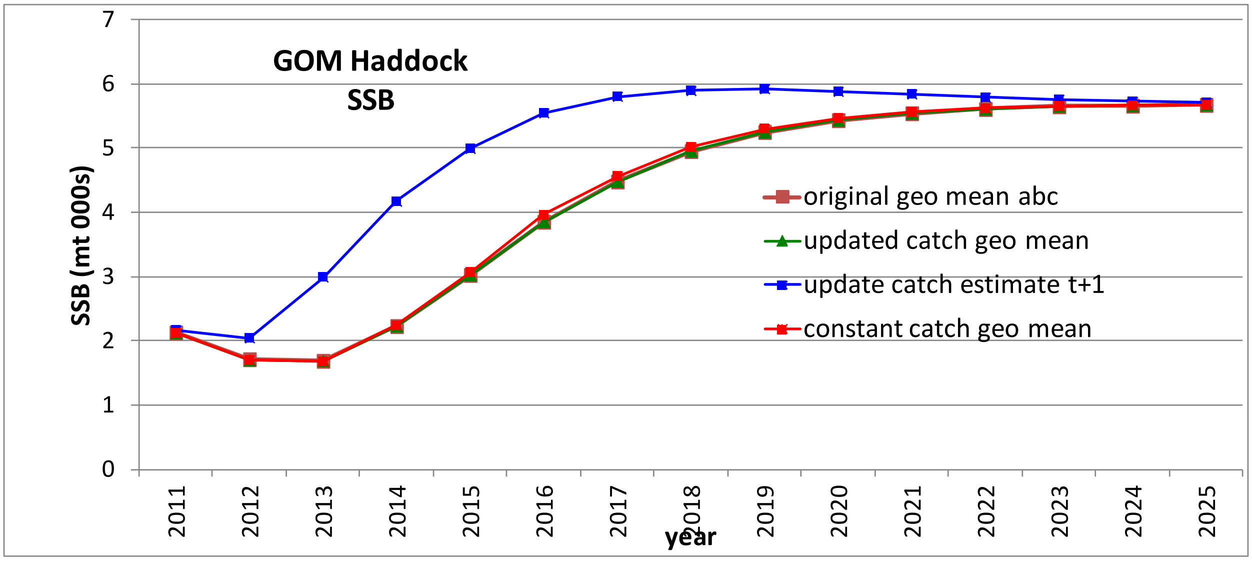


Figure 19: Projected SSB of GOM haddock from 2011-2025. Projections 1-3 assume 75%Fmsy from 2013-2015 and projection 4 is based on a constant ABC. 2011 and 2012 are bridge year catch assumptions and F's after 2015 are assumed to be at 75%Fmsy.

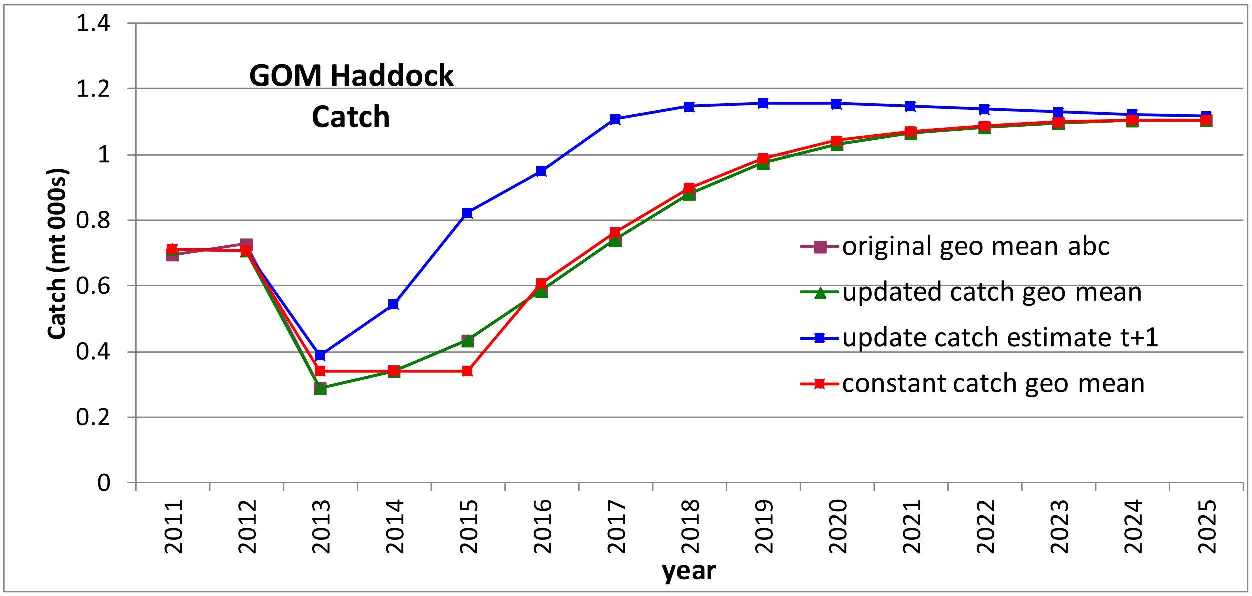


Figure 20: Projected catch of GOM haddock from 2011-2025. Projections 1-3 assume 75%Fmsy from 2013-2015 and projection 4 is based on a constant ABC. 2011 and 2012 are bridge year catch assumptions and F's after 2015 are assumed to be at 75%Fmsy.

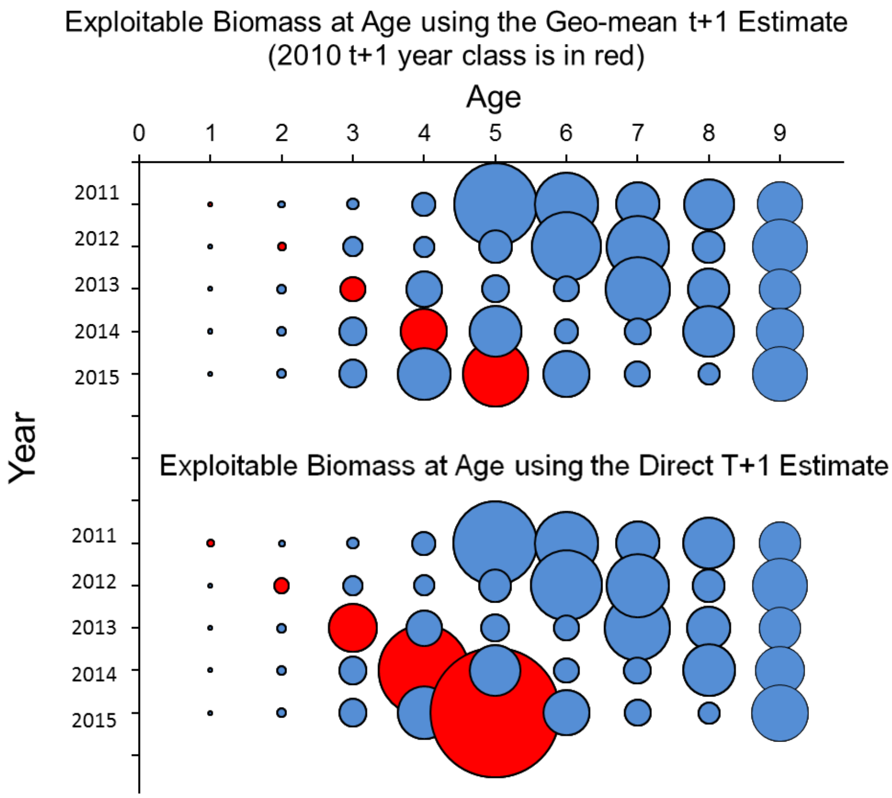


Figure 21: Exploitable biomass-at-age comparison between the geometric mean assumption and direct t+1 models fishing at 75%Fmsy. The influence of the t+1 assumption on the projections can be seen with 2010 year-class in red.

6. PDT Consensus Statement

Based on the review of recent survey information, comparison of t+1 estimates, and consequence analysis (Sections 3-5), the PDT recommends no change to the current 2013-2015 ABCs/OFLs until the next assessment is available.

The current ABCs/OFLs are almost identical to the ABCs/OFLs that incorporate updated catches for 2011 and 2012 (within 1 mt).

The PDT developed ABCs/OFLs using the direct age-1 estimate from the NEFSC spring survey for year t+1 (2011), which resulted in a modest increase from the current ABCs/OFLs. The potential increase in the ABCs/OFLs is heavily reliant on this t+1 age-1 estimate (2010 year-class). For the geometric mean projection, 5% of the exploitable biomass comes from the single t+1 2010 year-class in 2013, 18% in 2014 and 31% in 2015. For the direct estimate projection, 18% of the exploitable biomass comes from the single t+1 2010 year-class in 2013, 46% in 2014 and 63% in 2015.

The 2012 assessment indicated the stock was approaching an overfished condition with a projected biomass dropping below $1/2B_{MSY}$ in 2011. Very high bridge year F's (over 0.7 in both 2011 and 2012) were estimated in the 2012 Groundfish Update ABC projections. The high exploitation rate, along with poor year-classes estimated from 2007 to 2008, resulted in substantial declines in projected SSB.

In addition, evidence from the surveys suggests caution in the use of the direct estimate of the t+1 group. The PDT conducted a retrospective analysis of estimates of t+1 age 1 abundance for the direct estimate and the geometric mean approach in comparison to the VPA model estimates. Estimates using the geometric mean approach were more precise and less biased than the direct estimate approach and therefore those estimates perform better. There was some evidence in the updated NEFSC spring and fall surveys and in the recent cohort tracking through observer size distributions that the 2010 year-class is of a moderate size. However, without an updated assessment and given the poor performance of the spring age 1 index in predicting the size of the t+1 year-class the PDT was unable to produce a better estimate of the size this t+1 2010 year-class used in the projections.

The PDT's consequence analysis suggests that selecting the direct estimate rather than the geometric mean may lead to overly optimistic OFLs and increase the risk of overfishing of the stock if the 2010 year-class is not four times the size of the geometric mean estimate. Furthermore by using the direct estimate of the t+1 group instead of the geometric mean estimate, these projections do not follow the advice from the peer review of the recent stock assessment (e.g., the geometric mean could help counter the effects of the observed retrospective pattern seen in 2012 Groundfish Updates).

The PDT provided the constant catch approach as another alternative to provide contrast, but ultimately did not recommend those ABCs/OFLs because of their deviation from the default control rule, reducing the uncertainty buffer between the ABCs and OFLs in 2013 relative to the current ABCs and OFLs and increasing the buffer in 2015 respectively.

Lastly, these analyses consider short-term risks, and the PDT has not quantified long-term risks/implications to the GOM haddock stock of increasing ABCs/OFLs.