

Rose v rho

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11/21/2019

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Comparison of Rose and Rho-adjusted Approaches

This document compares two ways to address stock assessments exhibiting retrospective problems in terms of stock status and catch advice. The Rose approach uses an ensemble of models that change the input data to remove the retrospective problem in different ways. It requires a fair amount of computing time to explore many options. The rho-adjusted approach modifies the terminal year estimates based on the Mohn's rho values. It has the challenge of a discontinuity at the end of the time series. This document walks the reader through two examples using Georges Bank Yellowtail Flounder and White Hake. These examples are provided for demonstration purposes only and should not be considered to provide guidance on the assessment of either stock.

Georges Bank Yellowtail Flounder Example

Background

The Georges Bank yellowtail flounder (GBYT) stock has been plagued by a strong retrospective pattern for many years. In 2014 a benchmark assessment was conducted that rejected the analytical modeling (then in VPA) in favor of an index-based approach due to the strong retrospective pattern. The data from the current index-based assessment was input to a statistical catch at age model (ASAP) for this demonstration and still exhibits a strong retrospective pattern with a 5 year Mohn's rho for spawning stock biomass of 2.14.

This assessment uses data from 1973-2018 for ages 1-6+ with three surveys providing tuning information. Recent survey values have been near or at time series lows. Recent quotas are well below historical catch amounts (hundreds of tons compared to tens of thousands of tons) with discards in the scallop fishery contributing a major source of the catch (discards were greater than landings in two recent years). This stock has not responded to recent low catches and continues to decline despite low quotas being set. Both missing catch and increased natural mortality have been explored previously as an explanation for the strong retrospective patterns in this stock assessment. However, the magnitude of the missing catch or amount of change required in M needed to remove the retrospective pattern was considered too large by review panels. The rho-adjustment approach was used in years prior to the VPA being rejected.

Removing the GBYT retro

There are an infinite number of ways to remove a retrospective pattern by changing the input data. This demonstration focuses on a limited set of combinations. Either the catch or natural mortality rate is increased in recent years. The change from original to modified values can happen suddenly from one year to the next

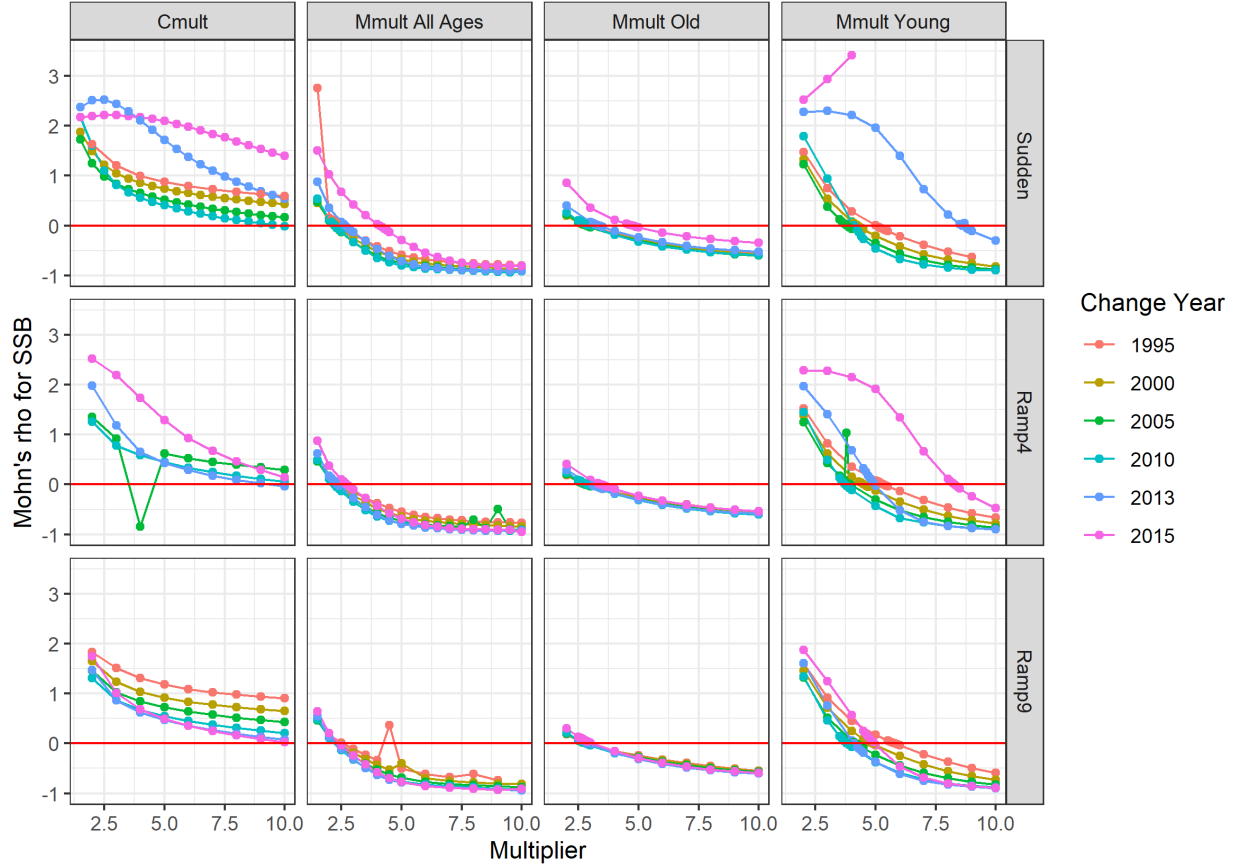


Figure 1: Examination of ways to remove the retrospective pattern

or with a linear ramp of 4 or 9 years. When natural mortality is modified, the increase can occur across all ages, only young ages (ages 1-3 in this case), or only old ages (ages 4-6+) in this case. The timing of the change was examined for years 1995, 2000, 2005, 2010, 2013, and 2015 being the first year of fully changed catch or natural mortality. The catch or natural mortality was modified by multiplication across all ages for catch or according the age range in the natural mortality scenario. This resulted in a total of 12 scenarios with 6 change years as possible ways to remove the retrospective pattern. For each scenario, a range of multipliers was applied to find the multiplier (to the nearest 0.1) that removed the retrospective pattern. Just over one thousand ASAP runs were conducted when searching for the multipliers that removed the retrospective pattern.

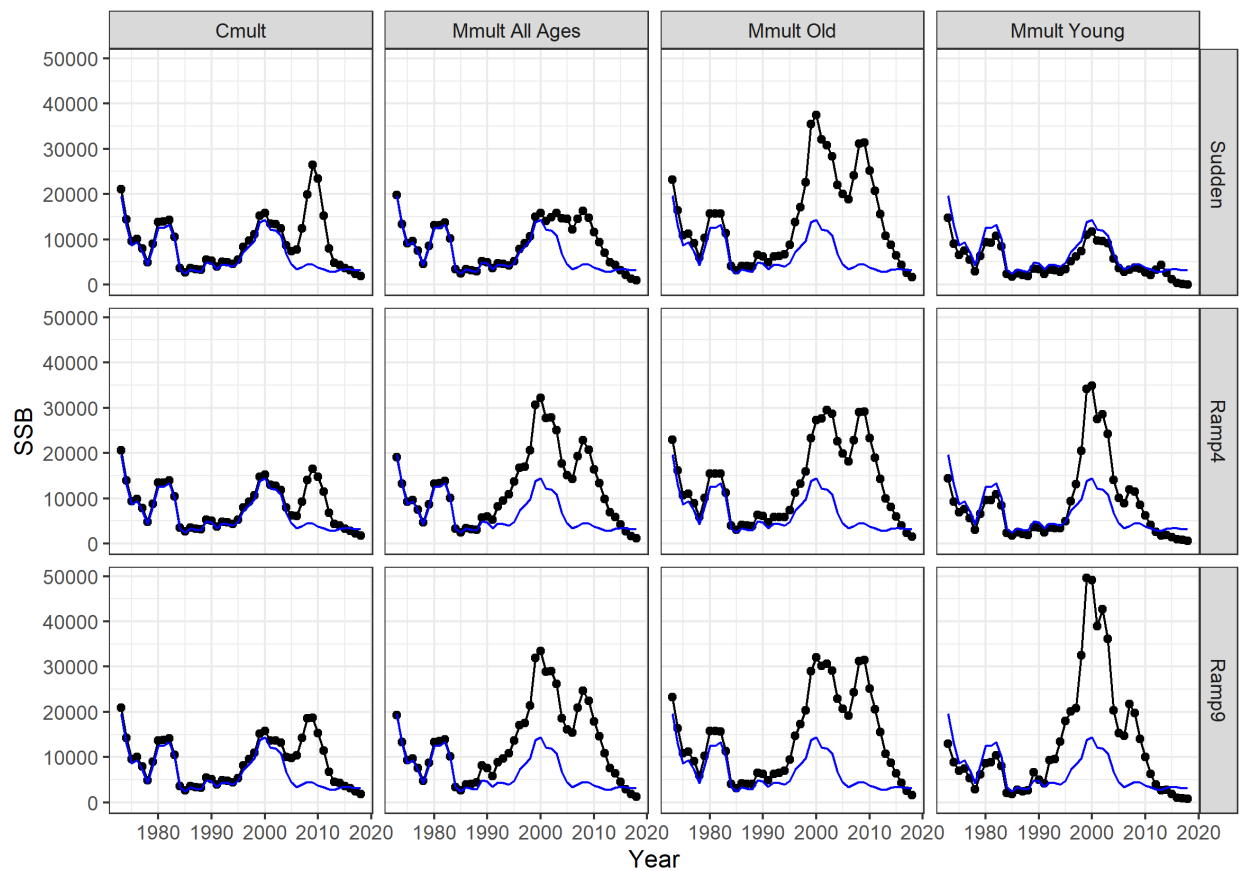
The plot shows that for most scenarios and change years, it was possible to find a multiplier less than 10 that removed the retrospective pattern ($ssbrho = 0$). However, there were some combinations that were unable to reduce the retrospective pattern sufficiently (e.g., many of the Cmult cases). There were also the occasional “blips” in the pattern of Mohn’s rho for spawning stock biomass as the multiplier changed (e.g., Cmult-Ramp4-2005) due to one or more of the peels producing a dramatically different estimate of SSB. This means an automated system of finding a multiplier may not work well. Instead, an iterative approach was used with an initial large step size for the multipliers examined that was further refined.

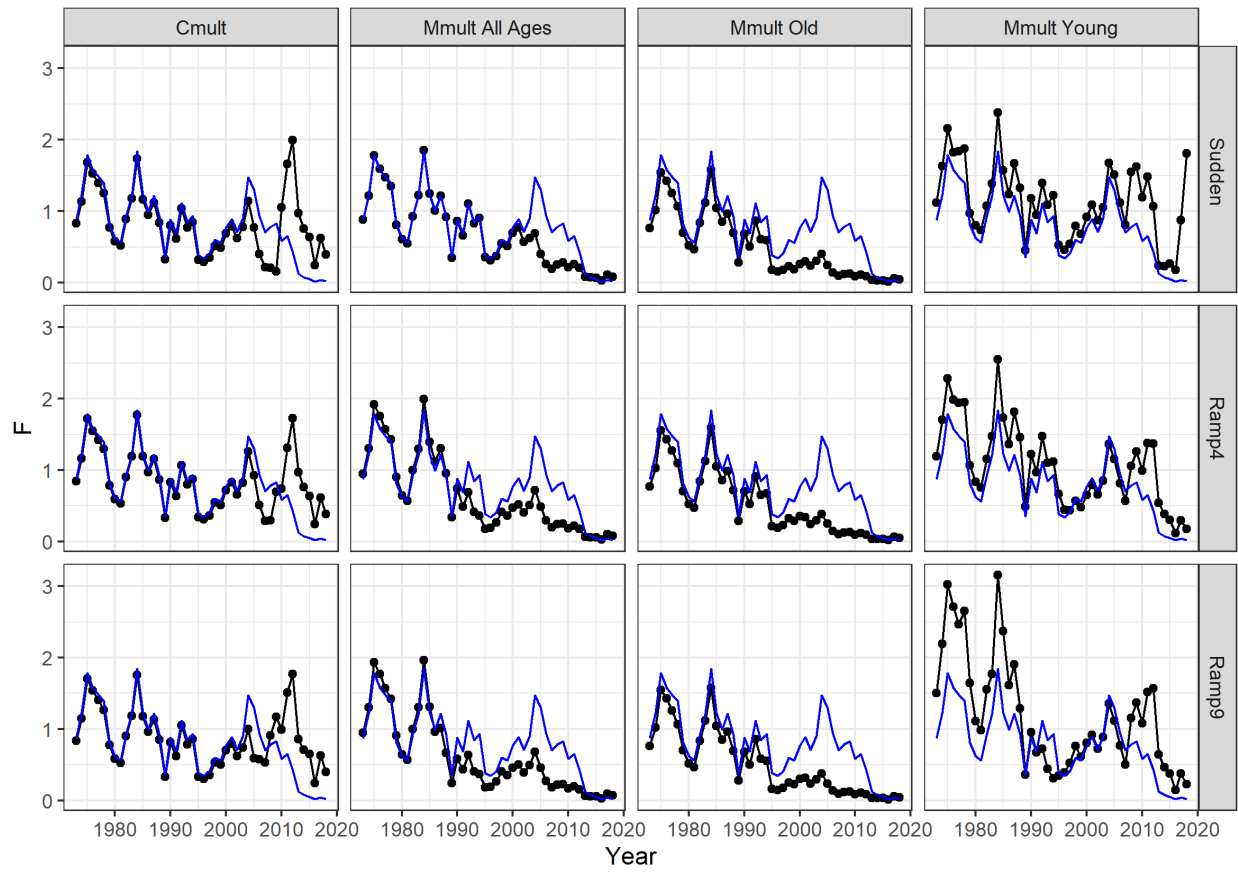
To allow the greatest diversity of models in the Rose approach, the change year with the lowest absolute value of Mohn’s rho for SSB for each scenario was selected as shown below.

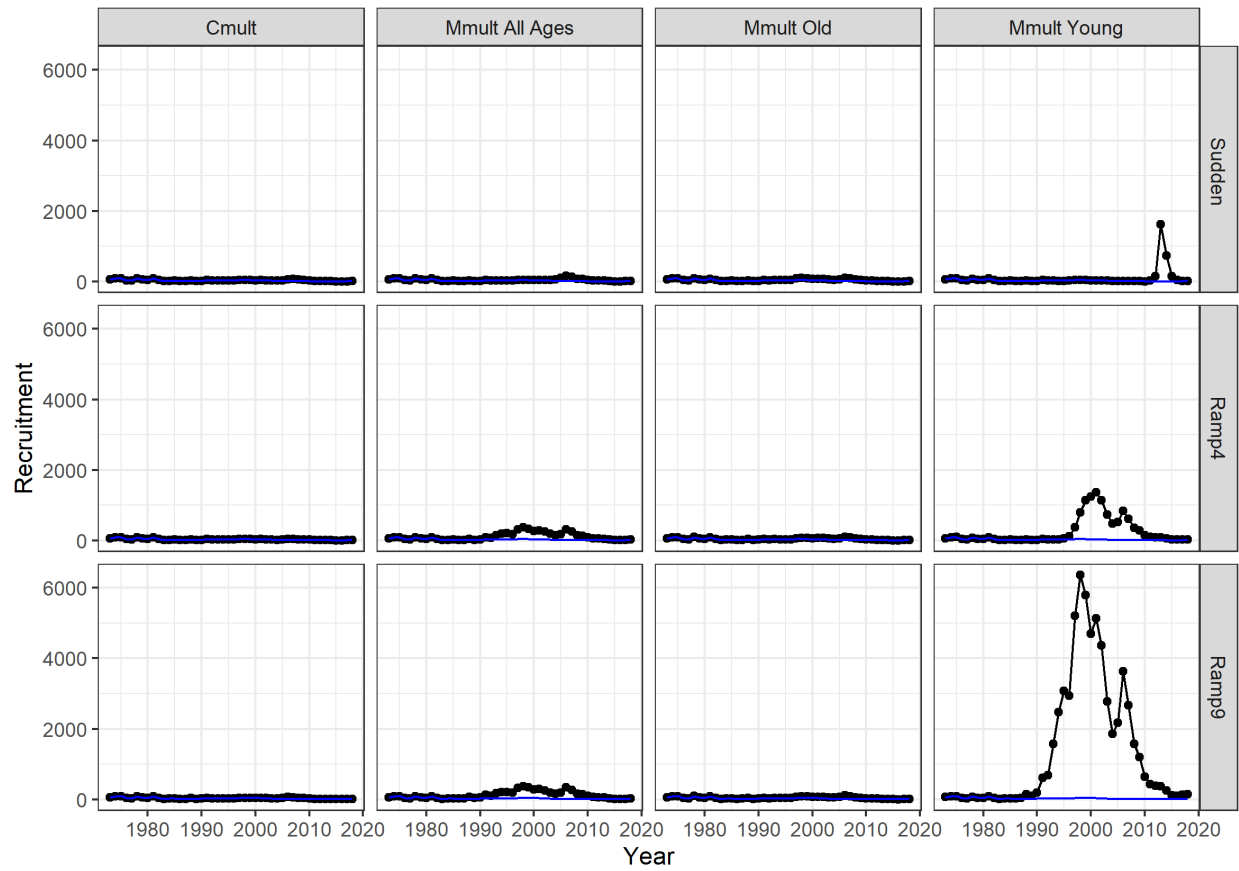
##	scenario	change.year	ramp	cmult	mmult	ssbrho
## 1	Sudden Cmults	2010	0	10	1.0	-0.013028268
## 2	Ramp4 Cmults	2013	4	9	1.0	0.022195777

## 3	Ramp9 Cmults	2015	9	10	1.0	0.026836550
## 4	Sudden Mmults	2005	0	1	2.2	0.003792029
## 5	Ramp4 Mmults	1995	4	1	2.5	-0.000568356
## 6	Ramp9 Mmults	1995	9	1	2.5	0.016738500
## 7	Old Sudden Mmults	2000	0	1	2.8	0.002620500
## 8	Old Ramp4 Mmults	2005	4	1	2.8	-0.002240719
## 9	Old Ramp9 Mmults	2005	9	1	2.8	0.000721171
## 10	Young Sudden Mmults	2013	0	1	8.6	0.000652003
## 11	Young Ramp4 Mmults	2000	4	1	4.5	0.003387530
## 12	Young Ramp9 Mmults	1995	9	1	5.8	-0.000370662

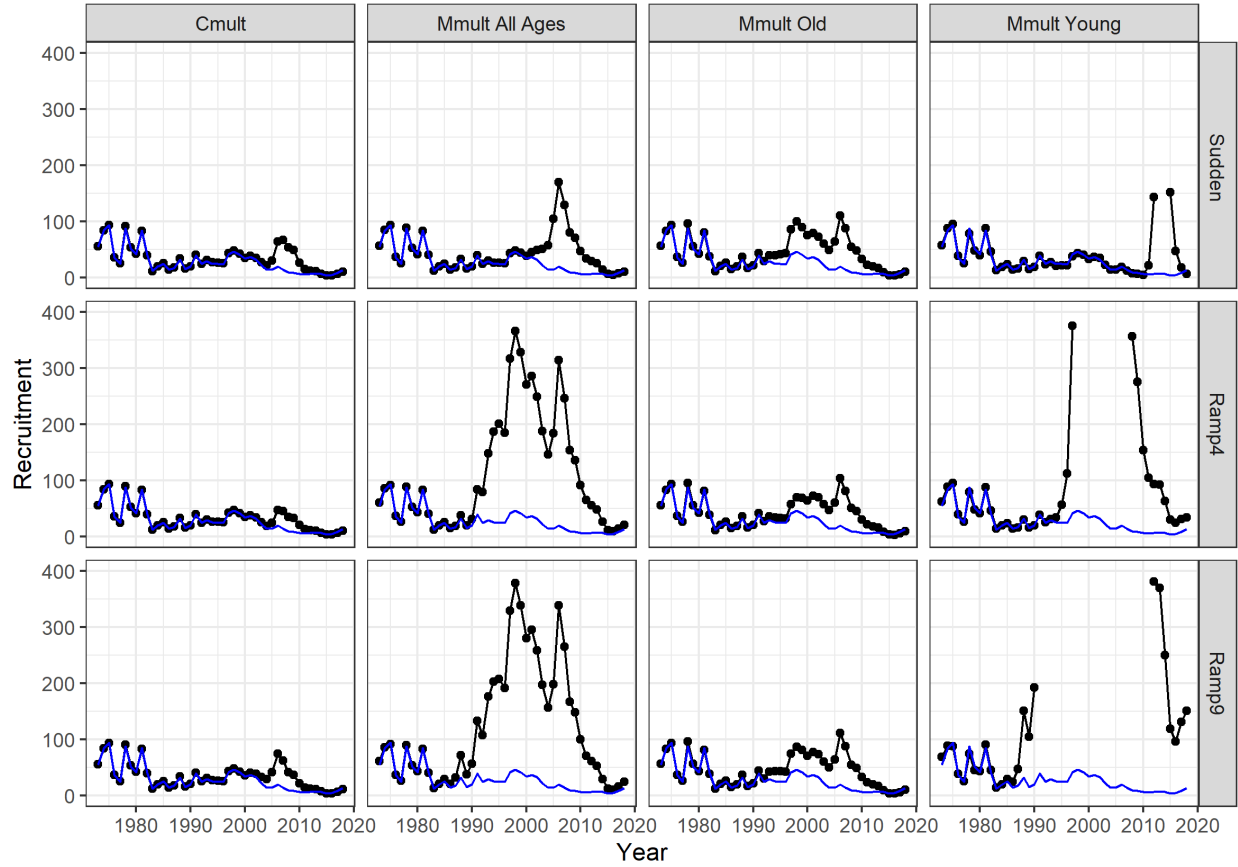
These 12 scenarios all removed the retrospective pattern, but produced quite different estimates of SSB, F , and recruitemnt. In the plots below, the units are SSB in metric tons, F is the mean fishing mortality rate on ages 5-6+, and Recruitment in millions of fish. The solid blue line in each plot is the base case run.







The natural mortality multipliers applied to young ages produced much higher recruitment estimates than any of the other scenarios. Limiting the range of recruitments plotted allows the other scenarios to be compared to the base case.



Of course, a Mohn's rho for SSB of zero is not the only diagnostic that should be considered in the Rose approach. Fits to the indices, parameter estimates at bounds or unbelievable values, fits to age composition data, etc. should all be considered. The table below provides a link to a pdf showing the model fits and results for each scenario. These can be compared to the base run.

Ramp	Cmult	Mmult All Ages	Mmult Old	Mmult Young
Sudden	1	4	7	10
Ramp4	2	5	8	11
Ramp9	3	6	9	12

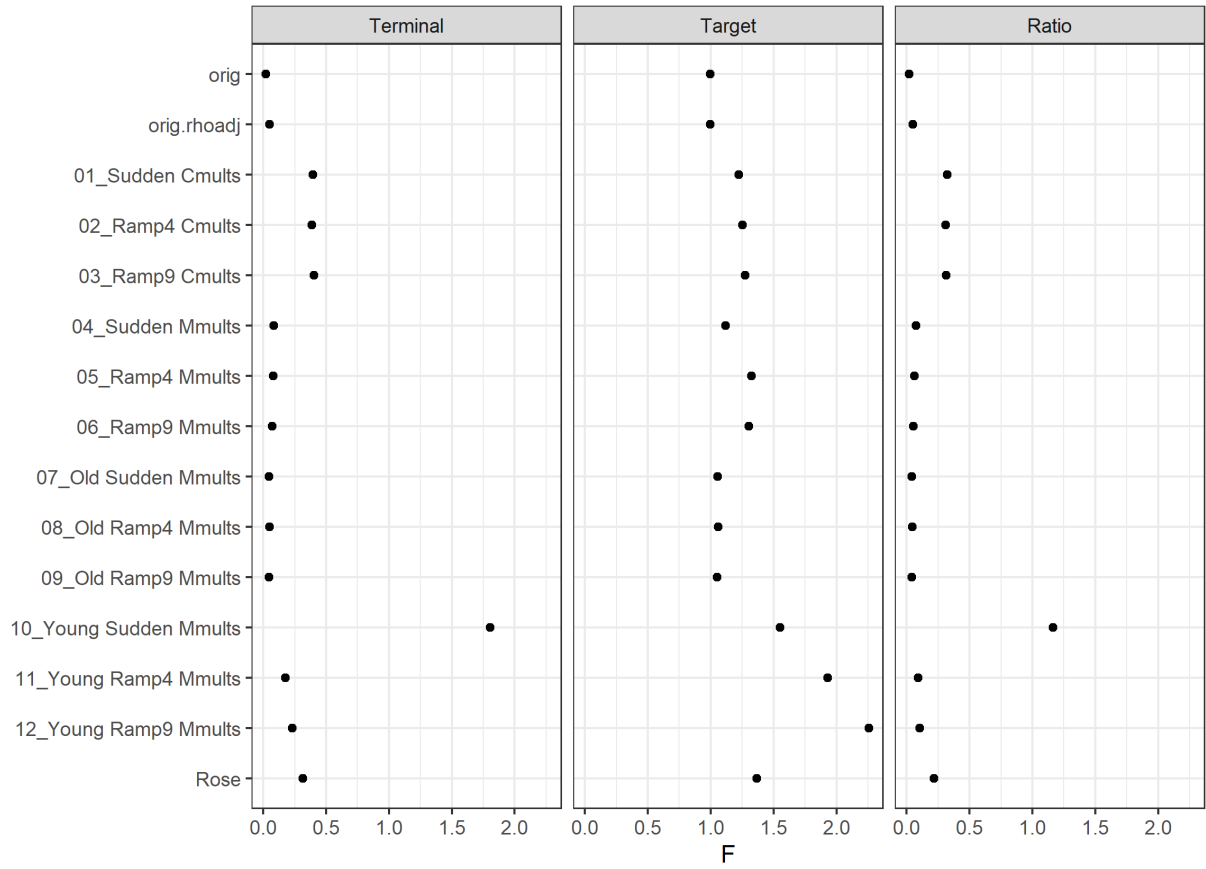
Despite some troubling diagnostics for some scenarios, all 12 scenarios were kept for this demonstration. Actual application of the Rose approach would spend a lot of time evaluating which scenarios had good enough diagnostics to be considered in the ensemble approach. This consideration would be done before the catch advice was calculated to prevent picking scenarios to include based on the catch advice.

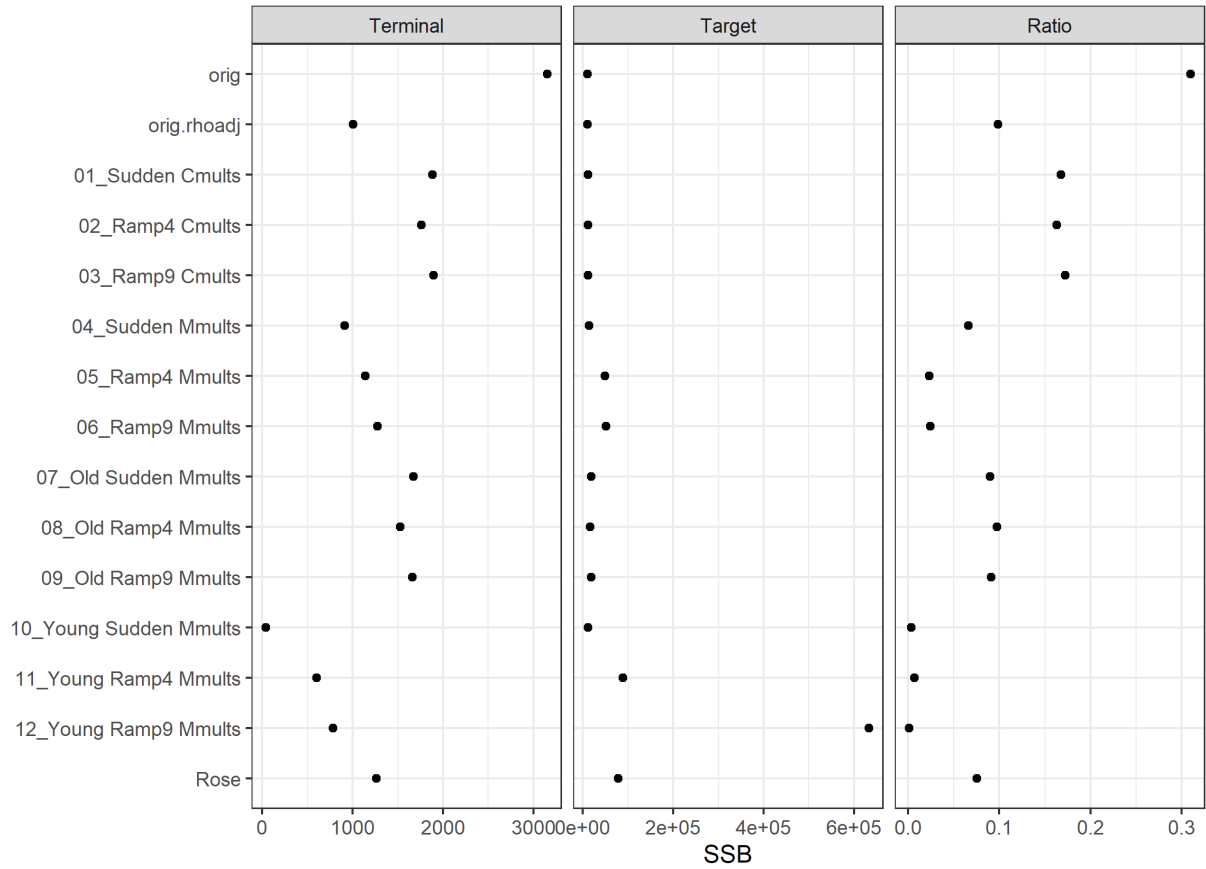
GBYT Reference Points and Status

For the sake of simplicity, F40%SPR (the F that reduces spawning stock biomass per recruit to 40% of unexploited) was selected as the fishing mortality reference point. Of note, the natural mortality rate used in the calculation of F40% was the original value of 0.4, not a value at the end of the time series with M multipliers. This is because the time periods associated with the change in M are too short for the fish population to have evolved characteristics associated with this new M (see Legault and Palmer 2016 for more details). The weights and maturity at age were the same across all scenarios, only the fishery selectivity differed. The most recent time block (2008-2018) was used for the fishery selectivity for each run. Due to

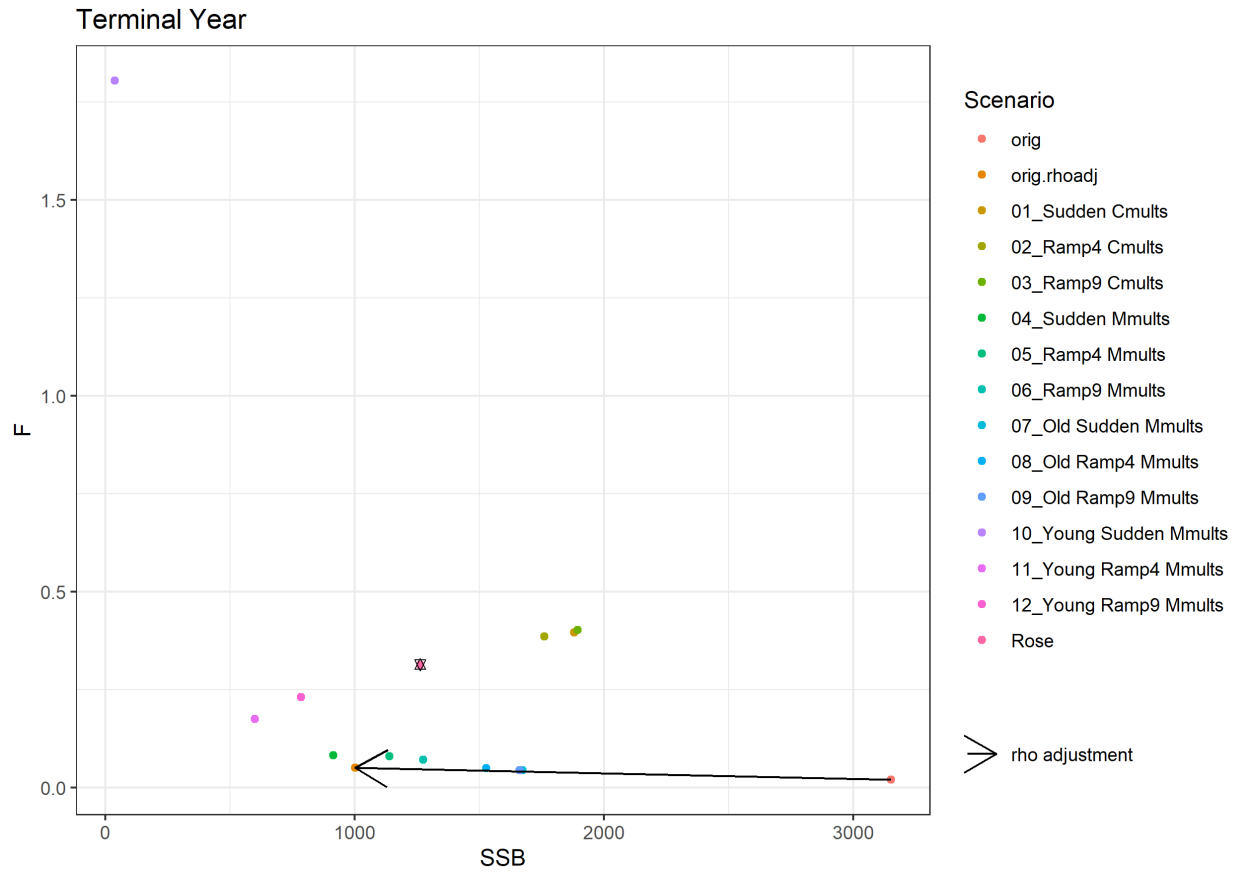
the relatively high M of 0.4 and the selectivity being to the right of the maturity ogive for all runs, the F40 values were quite high. As seen above, most runs estimated a much lower F value in the terminal year of the assessment, resulting in the F status being well below 1. However, there is one scenario (Young Sudden Mmults) that has a terminal year F of nearly 2 that is above the target F for that scenario. This one scenario has a strong influence on the Rose estimates. The terminal year SSB was always well below the target SSB, resulting in ratios well below 0.5 (the overfished definition in the US is typically half of SSBmsy or an SSBmsy proxy). For GBYT, the Rose status is the same as the rho-adjusted status with both estimating higher F ratios and lower SSB ratios compared to the original run. The changes in F and SSB ratios were greater for the Rose approach compared to the rho-adjusted approach for GBYT.

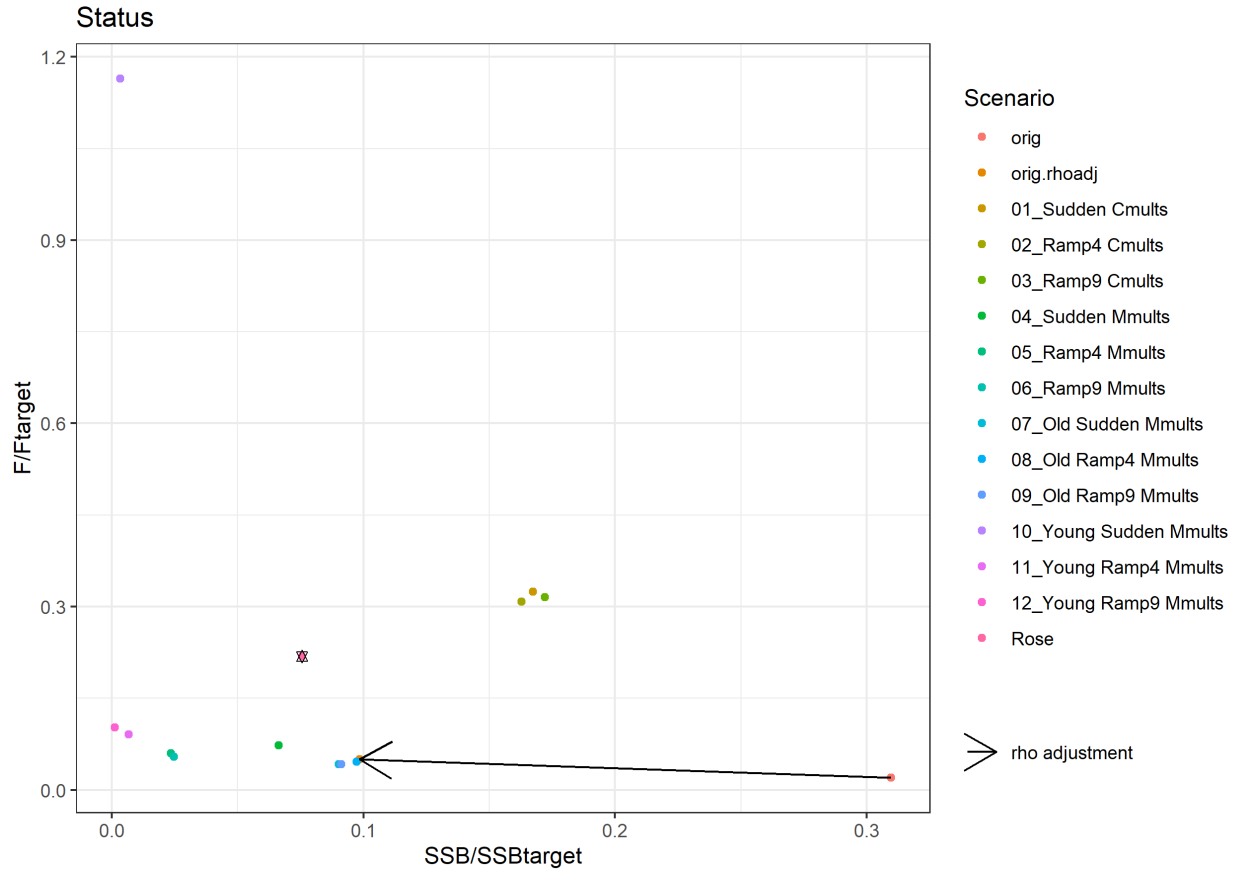
##	Scenario	F_Terminal	F_Target	F_Ratio	SSB_Terminal
## 1	orig	0.020	0.997	0.020	3153
## 2	orig.rhoadj	0.050	0.997	0.051	1003
## 3	01_Sudden Cmults	0.396	1.222	0.324	1881
## 4	02_Ramp4 Cmults	0.386	1.255	0.308	1762
## 5	03_Ramp9 Cmults	0.402	1.275	0.315	1895
## 6	04_Sudden Mmults	0.082	1.119	0.073	914
## 7	05_Ramp4 Mmults	0.079	1.324	0.060	1140
## 8	06_Ramp9 Mmults	0.071	1.303	0.054	1275
## 9	07_Old Sudden Mmults	0.044	1.056	0.042	1674
## 10	08_Old Ramp4 Mmults	0.049	1.060	0.046	1528
## 11	09_Old Ramp9 Mmults	0.045	1.053	0.042	1662
## 12	10_Young Sudden Mmults	1.806	1.550	1.165	39
## 13	11_Young Ramp4 Mmults	0.175	1.931	0.091	601
## 14	12_Young Ramp9 Mmults	0.231	2.259	0.102	785
## 15	Rose	0.314	1.367	0.219	1263
##	SSB_Target	SSB_Ratio			
## 1	10177	0.310			
## 2	10177	0.099			
## 3	11239	0.167			
## 4	10817	0.163			
## 5	11011	0.172			
## 6	13782	0.066			
## 7	48716	0.023			
## 8	51689	0.025			
## 9	18566	0.090			
## 10	15712	0.097			
## 11	18227	0.091			
## 12	11942	0.003			
## 13	88845	0.007			
## 14	632838	0.001			
## 15	77782	0.076			





The Rose estimates are highlighted with a star symbol in the following three plots.





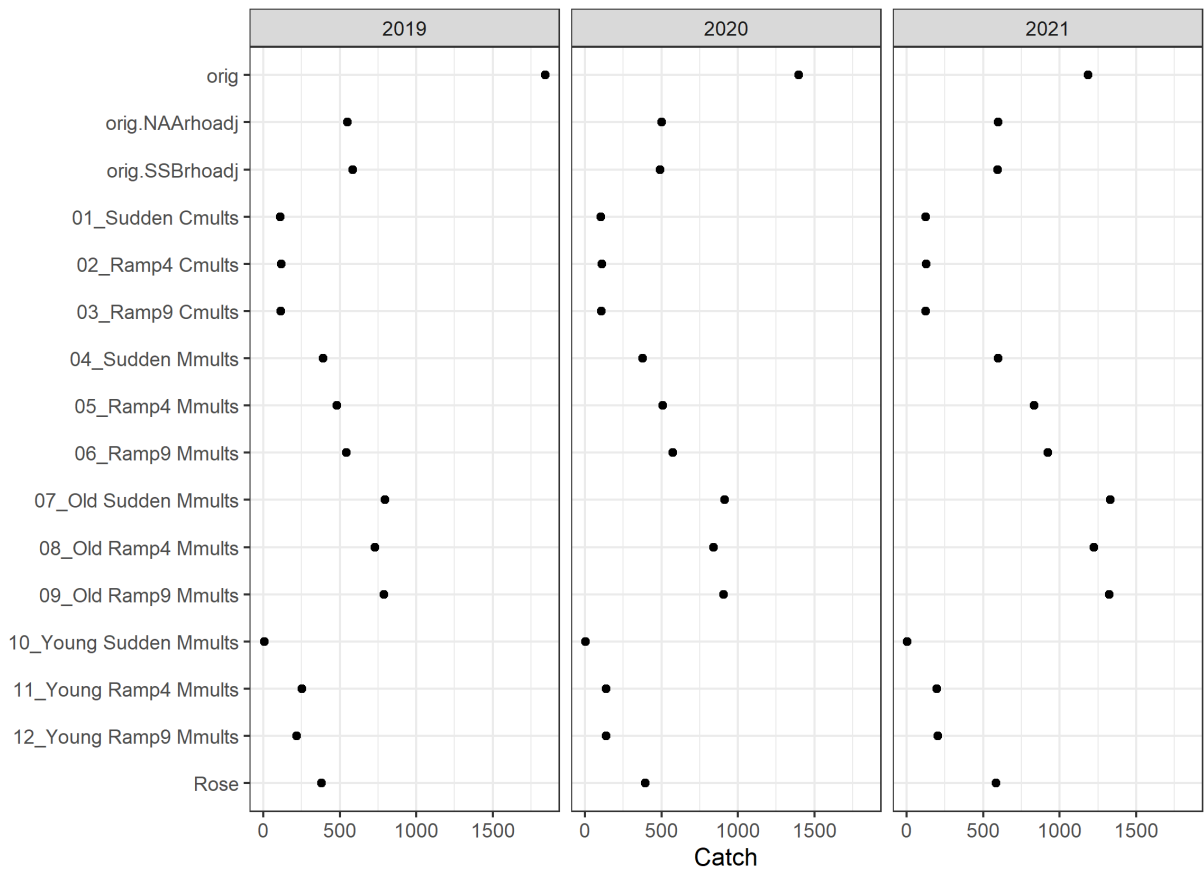
GBYT Catch Advice

Catch advice was based on applying the target F for each scenario for three years. Two approaches were used to adjust the terminal year plus one numbers at age for the rho-adjusted catch advice. One case applied the Mohn's rho for SSB to all ages while the other case used the age-specific Mohn's rho values to adjust the numbers at age. The adjustment was calculated as $N_{adj} = N_{orig} / (1 + \rho)$. The Rose scenarios that used catch multipliers had the output catch divided by the catch multipliers because this missing catch in the assessment would not be expected to be suddenly available to the fishery in terms of reported catch. The Rose scenarios that used M multipliers continued the M from the terminal year in the assessment because there is no reason to expect the natural mortality rate to suddenly return to its original value in the projections. If the M was decreased in the projections, there would be "bonus" amount of fish suddenly available to the fishery as catch and to help rebuilding.

The catch table and plot below shows the Rose approach providing lower catch advice than either rho-adjusted approach for GBYT in all three years.

##	Scenario	X2019	X2020	X2021
## 1	orig	1843	1398	1187
## 2	orig.SSBrhoadj	586	491	595
## 3	orig.NAArhoadj	549	500	600
## 4	01_Sudden Cmults	111	105	122
## 5	02_Ramp4 Cmults	117	110	127
## 6	03_Ramp9 Cmults	113	106	123
## 7	04_Sudden Mmults	392	375	599
## 8	05_Ramp4 Mmults	482	508	832

## 9	06_Ramp9 Mmults	542	572	922
## 10	07_Old Sudden Mmults	797	914	1331
## 11	08_Old Ramp4 Mmults	729	840	1224
## 12	09_Old Ramp9 Mmults	790	908	1324
## 13	10_Young Sudden Mmults	6	3	3
## 14	11_Young Ramp4 Mmults	252	139	197
## 15	12_Young Ramp9 Mmults	218	137	204
## 16	Rose	379	393	584



White Hake example

Background

The white hake (WH) stock assessment was recently updated as part of a mangement track (local lingo meaning not a benchmark assessment). The stock exhibited a strong retrospective pattern based on 7 peels with Mohn's rho for SSB of 0.31. While strong, this is a much smaller retrospective pattern than the GBYT example above. Using the ICES standard of 5 peels, the Mohn's rho for SSB is 0.24, which still results in a strong retrospective pattern.

This assessment uses data from 1963-2018 for ages 1-9+ with two surveys providing tuning information. Recent survey values have been near the medians of the time series. Recent quotas are below historical catch amounts (low thousands of tons compared to high thousands of thousands of tons). This stock has been slowly increasing in abundance in responded to recent low catches. There has not been a reason suggested for this retrospective pattern. The rho-adjustment approach has been used in recent years to determine

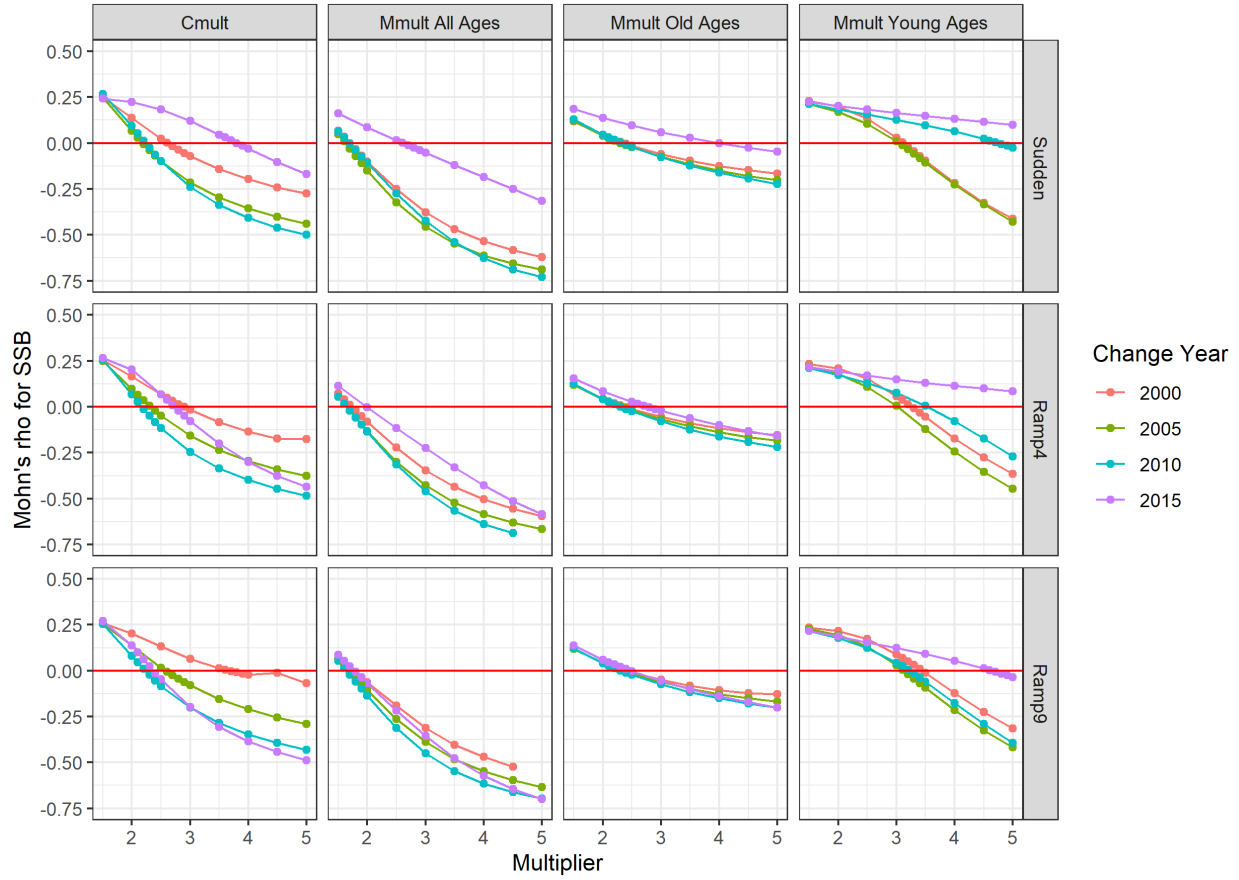


Figure 2: Examination of ways to remove the retrospective pattern

stock status and catch advice (based on a 7 year peel). This example uses a 5 year peel for consistency with the standard in ICES.

Removing the White Hake retro

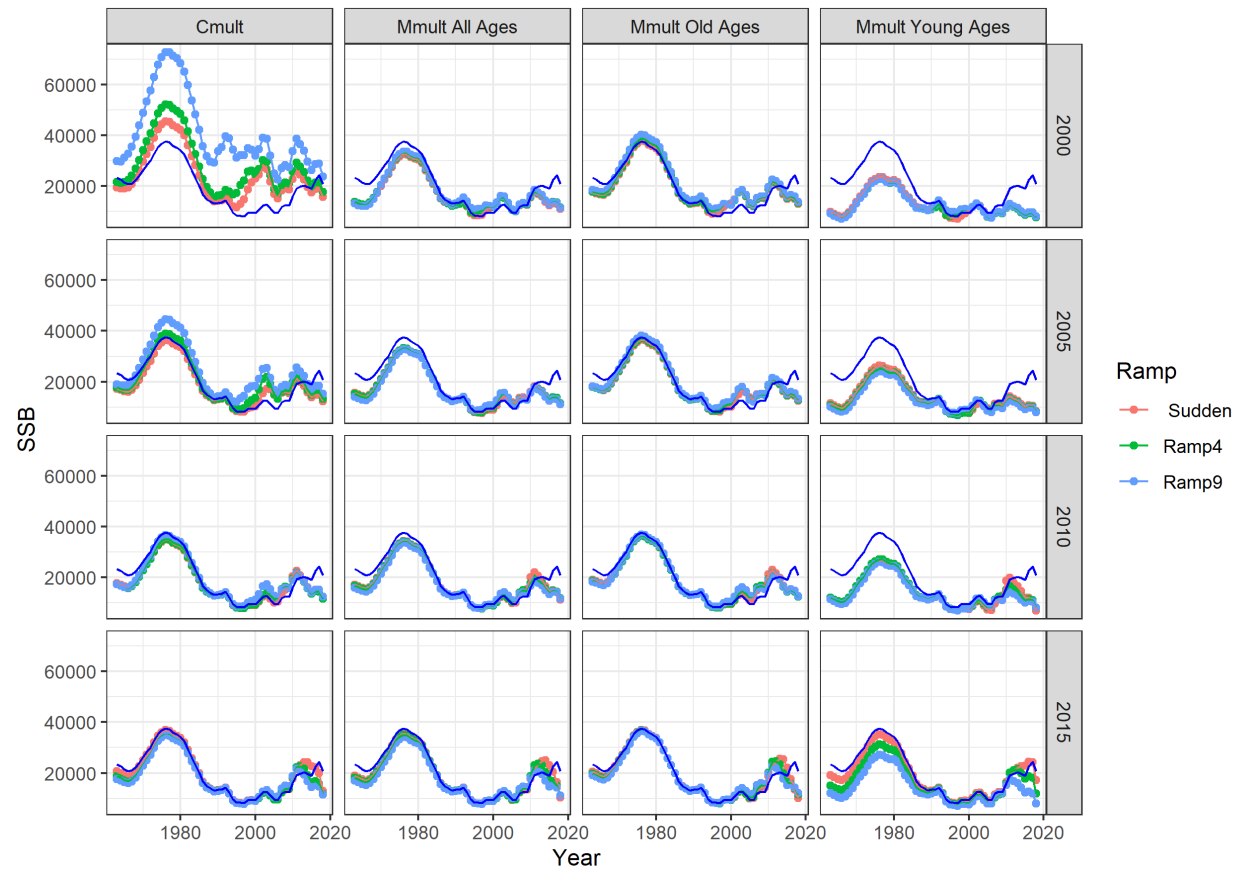
For white hake, a systematic approach to removing the retrospective pattern was also applied. Either the catch or natural mortality rate is increased in recent years. The change from original to modified values can happen suddenly from one year to the next or with a linear ramp of 4 or 9 years. When natural mortality is modified, the increase can occur across all ages, only young ages (ages 1-4 in this case), or only old ages (ages 6-9+ in this case). The timing of the change was examined for years 2000, 2005, 2010, and 2015 being the first year of fully changed catch or natural mortality. The catch or natural mortality was modified by multiplication across all ages for catch or according the age range in the natural mortality scenario. This resulted in a total of 12 scenarios with 4 change years as possible ways to remove the retrospective pattern. For each scenario, a range of multipliers was applied to find the multiplier (to the nearest 0.1) that removed the retrospective pattern. A total of 555 ASAP runs were done to find these best multipliers for the 48 combinations.

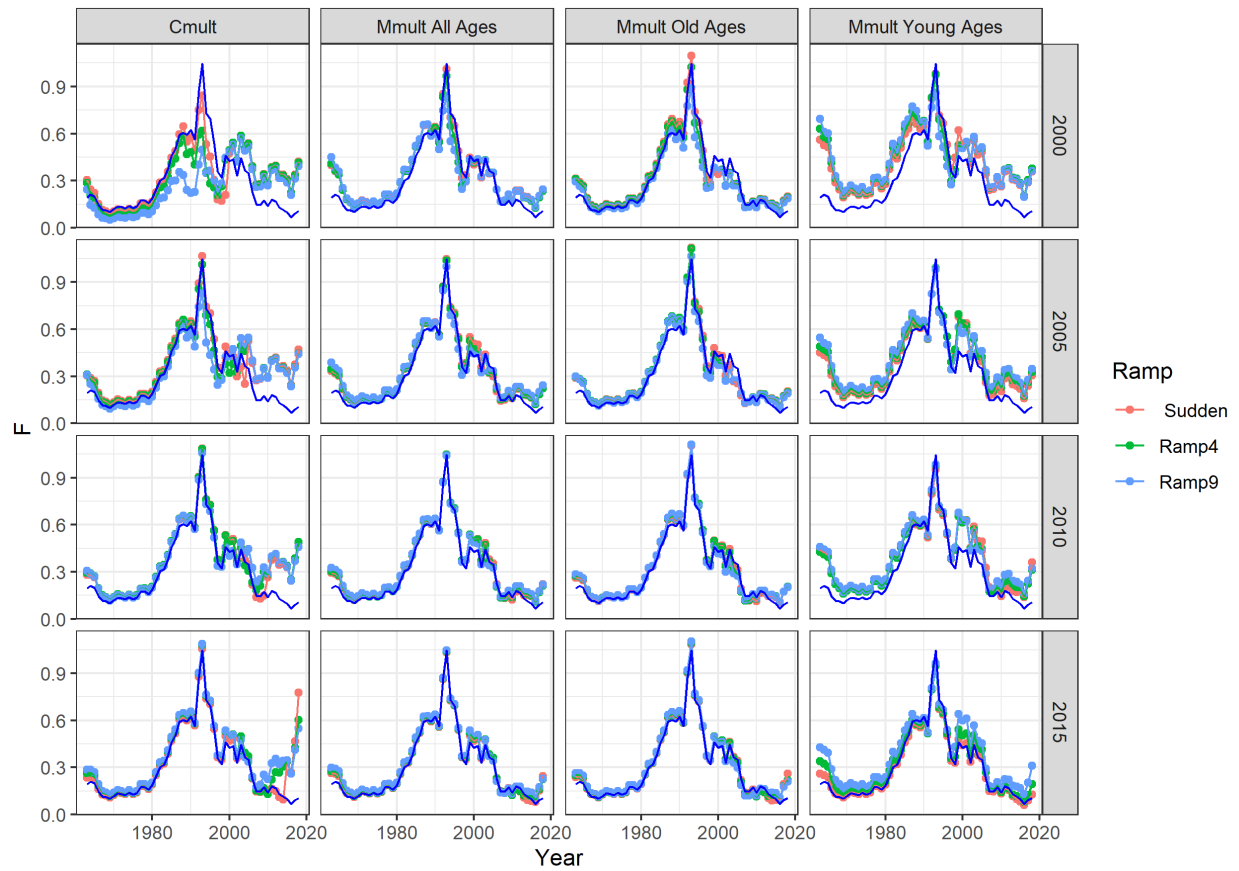
The plot shows that for all scenarios and change years, it was possible to find a multiplier less than 5 that removed the retrospective pattern (ssbrho within -0.013 to 0.100) as shown below.

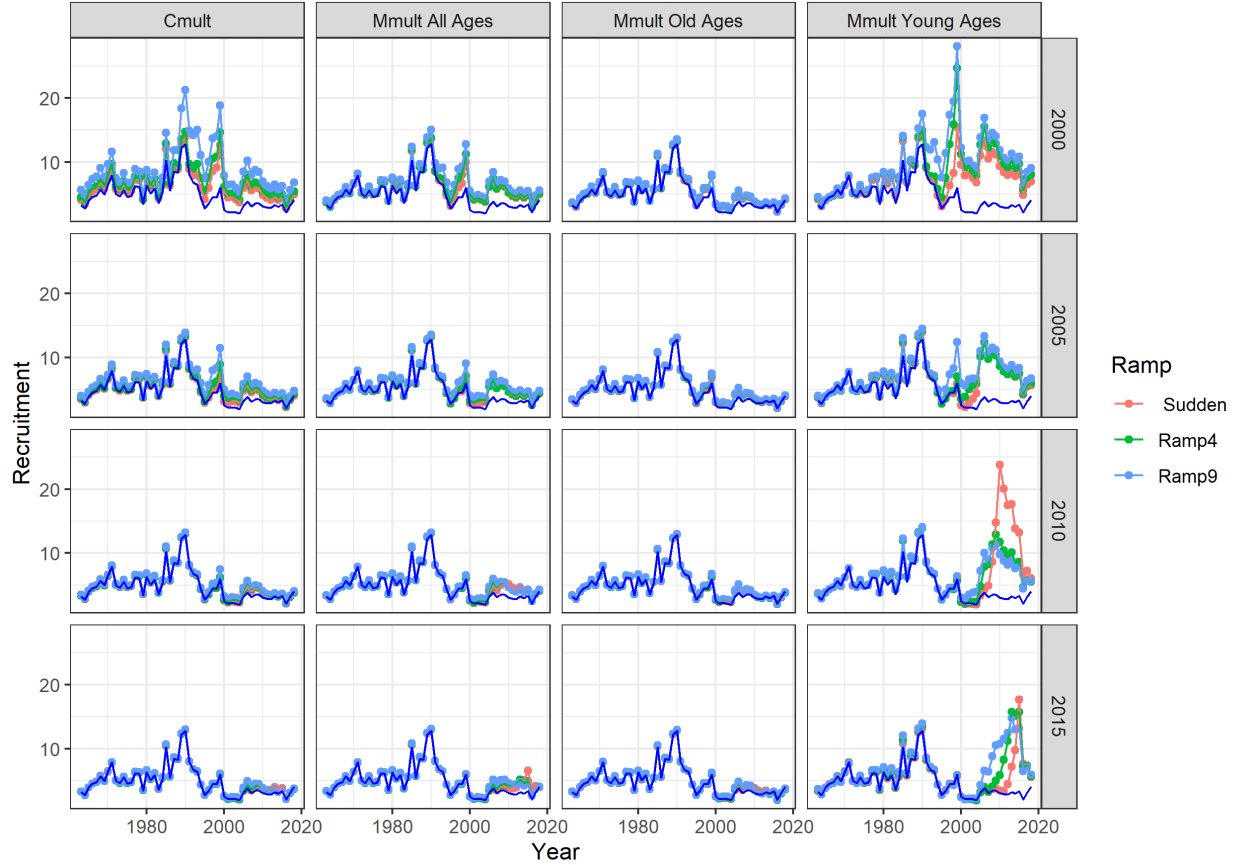
##	scenario	change.year	ramp	cmult	mmult	ssbrho
## 1	Sudden Cmults	2000	0	2.6	1.0	2.031043e-03

## 2	Sudden Cmults	2005	0	2.2	1.0	-5.749937e-03
## 3	Sudden Cmults	2010	0	2.2	1.0	1.263940e-02
## 4	Sudden Cmults	2015	0	3.8	1.0	-7.381923e-04
## 5	Ramp4 Cmults	2000	4	2.9	1.0	-3.714917e-04
## 6	Ramp4 Cmults	2005	4	2.3	1.0	5.353923e-03
## 7	Ramp4 Cmults	2010	4	2.2	1.0	-1.286194e-02
## 8	Ramp4 Cmults	2015	4	2.7	1.0	8.507758e-03
## 9	Ramp9 Cmults	2000	9	3.7	1.0	-2.507874e-03
## 10	Ramp9 Cmults	2005	9	2.6	1.0	-5.248440e-03
## 11	Ramp9 Cmults	2010	9	2.2	1.0	9.342529e-03
## 12	Ramp9 Cmults	2015	9	2.4	1.0	-1.311846e-02
## 13	Sudden Mmults	2000	0	1.0	1.7	-8.902172e-04
## 14	Sudden Mmults	2005	0	1.0	1.6	8.972259e-03
## 15	Sudden Mmults	2010	0	1.0	1.7	-4.247748e-03
## 16	Sudden Mmults	2015	0	1.0	2.6	1.866134e-03
## 17	Ramp4 Mmults	2000	4	1.0	1.7	1.120698e-02
## 18	Ramp4 Mmults	2005	4	1.0	1.6	1.736520e-02
## 19	Ramp4 Mmults	2010	4	1.0	1.6	1.567103e-02
## 20	Ramp4 Mmults	2015	4	1.0	2.0	-2.630471e-03
## 21	Ramp9 Mmults	2000	9	1.0	1.8	-7.365206e-03
## 22	Ramp9 Mmults	2005	9	1.0	1.7	-5.623246e-03
## 23	Ramp9 Mmults	2010	9	1.0	1.6	1.596233e-02
## 24	Ramp9 Mmults	2015	9	1.0	1.8	-7.179721e-03
## 25	Old Sudden Mmults	2000	0	1.0	2.4	-5.152670e-03
## 26	Old Sudden Mmults	2005	0	1.0	2.3	4.763059e-05
## 27	Old Sudden Mmults	2010	0	1.0	2.3	3.841934e-03
## 28	Old Sudden Mmults	2015	0	1.0	4.0	-9.001123e-04
## 29	Old Ramp4 Mmults	2000	4	1.0	2.4	-2.067572e-03
## 30	Old Ramp4 Mmults	2005	4	1.0	2.3	2.691638e-03
## 31	Old Ramp4 Mmults	2010	4	1.0	2.3	-3.449542e-04
## 32	Old Ramp4 Mmults	2015	4	1.0	2.8	-2.998194e-03
## 33	Old Ramp9 Mmults	2000	9	1.0	2.4	-4.300485e-04
## 34	Old Ramp9 Mmults	2005	9	1.0	2.3	5.002606e-03
## 35	Old Ramp9 Mmults	2010	9	1.0	2.3	3.334432e-04
## 36	Old Ramp9 Mmults	2015	9	1.0	2.5	-2.511824e-03
## 37	Young Sudden Mmults	2000	0	1.0	3.1	4.331702e-03
## 38	Young Sudden Mmults	2005	0	1.0	3.0	8.995993e-03
## 39	Young Sudden Mmults	2010	0	1.0	4.7	4.105428e-03
## 40	Young Sudden Mmults	2015	0	1.0	5.0	1.000542e-01
## 41	Young Ramp4 Mmults	2000	4	1.0	3.3	-7.746503e-03
## 42	Young Ramp4 Mmults	2005	4	1.0	3.0	5.469336e-03
## 43	Young Ramp4 Mmults	2010	4	1.0	3.5	6.017076e-03
## 44	Young Ramp4 Mmults	2015	4	1.0	5.0	8.554970e-02
## 45	Young Ramp9 Mmults	2000	9	1.0	3.4	1.018337e-02
## 46	Young Ramp9 Mmults	2005	9	1.0	3.1	5.570539e-03
## 47	Young Ramp9 Mmults	2010	9	1.0	3.2	5.156175e-03
## 48	Young Ramp9 Mmults	2015	9	1.0	4.6	2.712598e-03

Since the original retrospective pattern was not as strong for white hake as it was for GBYT, the estimates of SSB, F, and recruitemnt did not vary as much. In the plots below, the units are SSB in metric tons, F is the mean fishing mortality rate on ages 6-9+, and Recruitment in millions of fish. The solid blue line in each plot is the base case run.







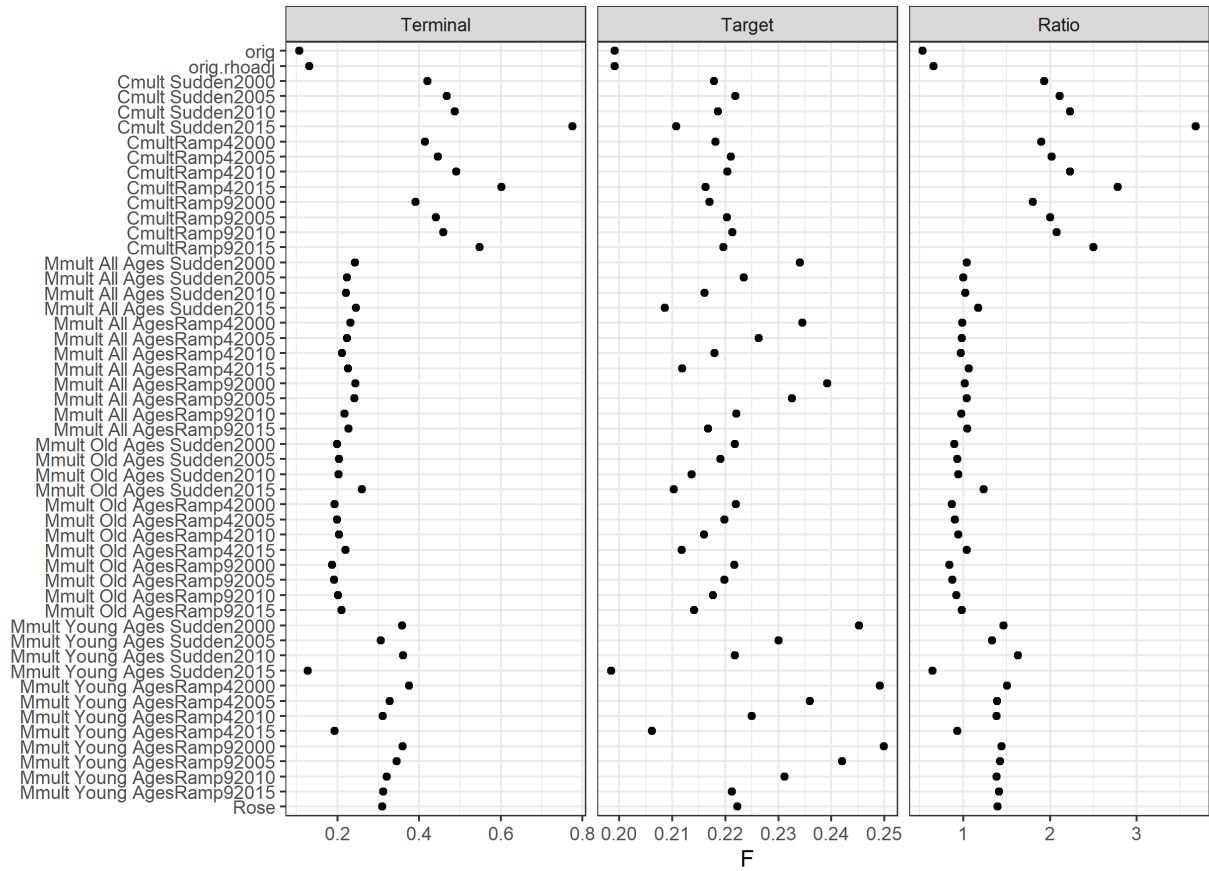
Of course, a Mohn's rho for SSB of zero is not the only diagnostic that should be considered in the Rose approach. Fits to the indices, parameter estimates at bounds or unbelievable values, fits to age composition data, etc. should all be considered. The 48 pdf files for the best runs can be found in the White-Hake/Rose/saved directory with (hopefully) informative filenames. These can be compared to the base run. For this example, all 48 runs were included in the Rose approach without consideration of other diagnostics.

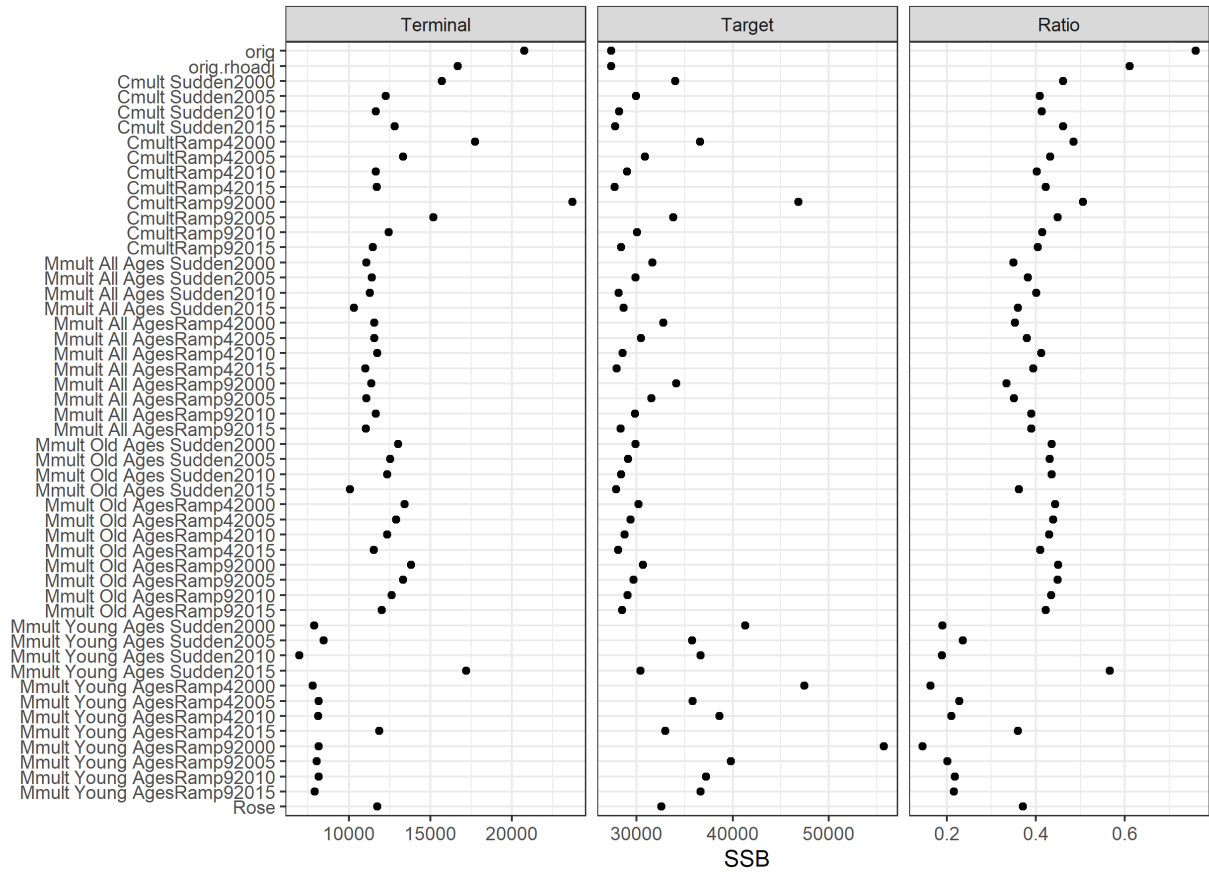
White Hake Reference Points and Status

For the sake of simplicity, F40%SPR (the F that reduces spawning stock biomass per recruit to 40% of unexploited) was selected as the fishing mortality reference point. Of note, the natural mortality rate used in the calculation of F40% was the original value of 0.2, not a value at the end of the time series with M multipliers. This is for the same reason noted above for GBYT. The weights and maturity at age were the same across all scenarios, only the fishery selectivity differed. The most recent time block (2008-2018) was used for the fishery selectivity for each run. The terminal year F is well below the target for the original run and the rho-adjusted run while most of the Rose scenarios and the Rose value are above 1. The rho-adjustment moves the F and F ratio in the same direction as the Rose approach, but not as far. The terminal year SSB is reduced by the rho adjustment but has a ratio that is above 0.5 while most of the Rose scenarios and the Rose value for the SSB ratio are below 0.5. Patterns can be seen within the groups of four change years for each scenario with more recent change years having lower F and SSB targets but inconsistent patterns for terminal year F and SSB, causing the ratios to not follow strong patterns. These patterns in F targets can only be caused by changes in the selectivity of the fishery over time because the other inputs to the F40%SPR calculation are the same. The patterns in SSB targets can also be impacted by the recruitment estimates in the recent 10 years, which vary among the scenarios quite a bit (see plots above). For white hake, the rho-adjustment moved the F and SSB in the direction of the Rose estimates, but not as far as the Rose estimates, which is the same as in the GBYT example above.

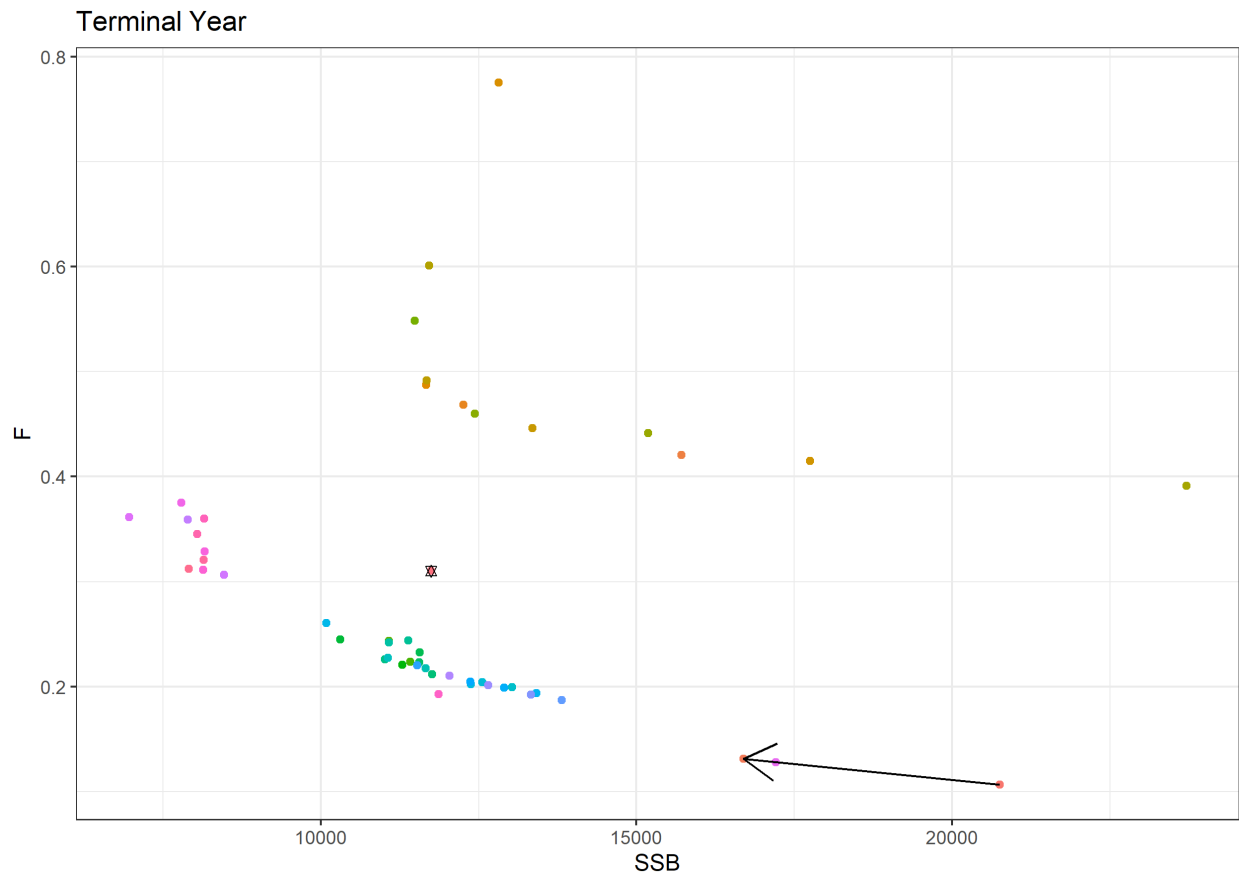
##	Scenario	F_Terminal	F_Target	F_Ratio	SSB_Terminal
## 1	orig	0.107	0.199	0.535	20757
## 2	orig.rhoadj	0.131	0.199	0.658	16692
## 3	Cmult Sudden2000	0.421	0.218	1.931	15710
## 4	Cmult Sudden2005	0.468	0.222	2.111	12255
## 5	Cmult Sudden2010	0.488	0.219	2.230	11667
## 6	Cmult Sudden2015	0.775	0.211	3.679	12815
## 7	CmultRamp42000	0.415	0.218	1.902	17747
## 8	CmultRamp42005	0.446	0.221	2.018	13348
## 9	CmultRamp42010	0.491	0.220	2.230	11674
## 10	CmultRamp42015	0.601	0.216	2.779	11713
## 11	CmultRamp92000	0.391	0.217	1.803	23716
## 12	CmultRamp92005	0.441	0.220	2.003	15183
## 13	CmultRamp92010	0.460	0.221	2.077	12440
## 14	CmultRamp92015	0.549	0.220	2.497	11483
## 15	Mmult All Ages Sudden2000	0.243	0.234	1.040	11077
## 16	Mmult All Ages Sudden2005	0.224	0.223	1.001	11420
## 17	Mmult All Ages Sudden2010	0.221	0.216	1.022	11293
## 18	Mmult All Ages Sudden2015	0.245	0.209	1.174	10304
## 19	Mmult All AgesRamp42000	0.233	0.235	0.992	11568
## 20	Mmult All AgesRamp42005	0.223	0.226	0.986	11561
## 21	Mmult All AgesRamp42010	0.212	0.218	0.972	11765
## 22	Mmult All AgesRamp42015	0.226	0.212	1.066	11018
## 23	Mmult All AgesRamp92000	0.244	0.239	1.019	11388
## 24	Mmult All AgesRamp92005	0.242	0.233	1.040	11075
## 25	Mmult All AgesRamp92010	0.217	0.222	0.979	11657
## 26	Mmult All AgesRamp92015	0.227	0.217	1.049	11064
## 27	Mmult Old Ages Sudden2000	0.200	0.222	0.900	13026
## 28	Mmult Old Ages Sudden2005	0.204	0.219	0.931	12556
## 29	Mmult Old Ages Sudden2010	0.202	0.214	0.948	12373
## 30	Mmult Old Ages Sudden2015	0.260	0.210	1.238	10083
## 31	Mmult Old AgesRamp42000	0.194	0.222	0.872	13414
## 32	Mmult Old AgesRamp42005	0.199	0.220	0.905	12900
## 33	Mmult Old AgesRamp42010	0.205	0.216	0.947	12366
## 34	Mmult Old AgesRamp42015	0.220	0.212	1.039	11526
## 35	Mmult Old AgesRamp92000	0.187	0.222	0.845	13816
## 36	Mmult Old AgesRamp92005	0.192	0.220	0.874	13327
## 37	Mmult Old AgesRamp92010	0.201	0.218	0.924	12649
## 38	Mmult Old AgesRamp92015	0.210	0.214	0.983	12034
## 39	Mmult Young Ages Sudden2000	0.359	0.245	1.463	7893
## 40	Mmult Young Ages Sudden2005	0.307	0.230	1.333	8463
## 41	Mmult Young Ages Sudden2010	0.361	0.222	1.630	6961
## 42	Mmult Young Ages Sudden2015	0.128	0.198	0.645	17206
## 43	Mmult Young AgesRamp42000	0.375	0.249	1.506	7787
## 44	Mmult Young AgesRamp42005	0.329	0.236	1.393	8159
## 45	Mmult Young AgesRamp42010	0.311	0.225	1.384	8137
## 46	Mmult Young AgesRamp42015	0.193	0.206	0.935	11868
## 47	Mmult Young AgesRamp92000	0.360	0.250	1.440	8149
## 48	Mmult Young AgesRamp92005	0.345	0.242	1.426	8044
## 49	Mmult Young AgesRamp92010	0.321	0.231	1.387	8143
## 50	Mmult Young AgesRamp92015	0.312	0.221	1.411	7907
## 51	Rose	0.310	0.222	1.395	11744
##	SSB_Target SSB_Ratio				
## 1	27330	0.759			

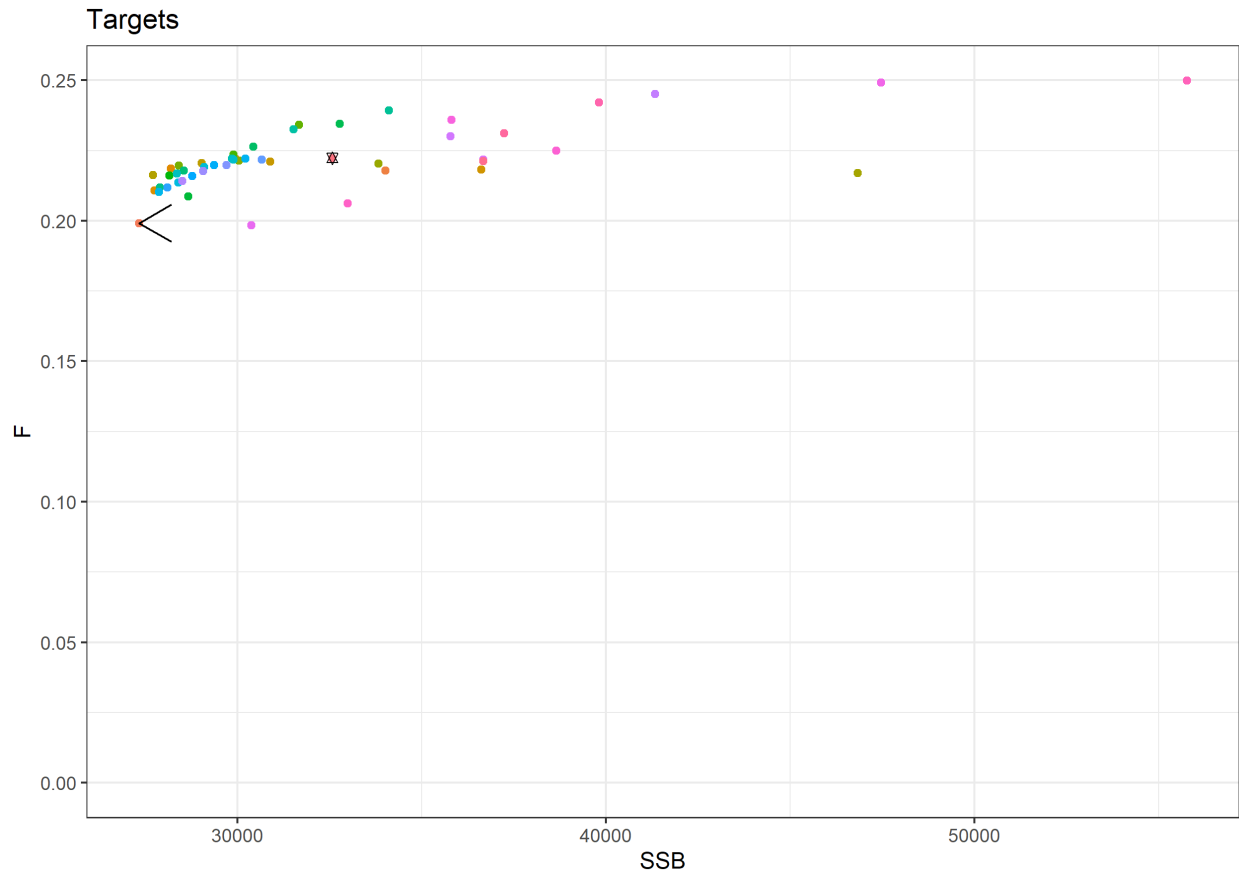
## 2	27330	0.611
## 3	34012	0.462
## 4	29962	0.409
## 5	28194	0.414
## 6	27756	0.462
## 7	36613	0.485
## 8	30889	0.432
## 9	29032	0.402
## 10	27707	0.423
## 11	46838	0.506
## 12	33821	0.449
## 13	30037	0.414
## 14	28407	0.404
## 15	31671	0.350
## 16	29887	0.382
## 17	28152	0.401
## 18	28662	0.360
## 19	32775	0.353
## 20	30432	0.380
## 21	28547	0.412
## 22	27901	0.395
## 23	34111	0.334
## 24	31523	0.351
## 25	29854	0.390
## 26	28351	0.390
## 27	29887	0.436
## 28	29093	0.432
## 29	28395	0.436
## 30	27868	0.362
## 31	30213	0.444
## 32	29370	0.439
## 33	28772	0.430
## 34	28102	0.410
## 35	30665	0.451
## 36	29700	0.449
## 37	29073	0.435
## 38	28499	0.422
## 39	41327	0.191
## 40	35787	0.236
## 41	36676	0.190
## 42	30384	0.566
## 43	47471	0.164
## 44	35814	0.228
## 45	38653	0.211
## 46	32989	0.360
## 47	55768	0.146
## 48	39813	0.202
## 49	37233	0.219
## 50	36670	0.216
## 51	32570	0.372

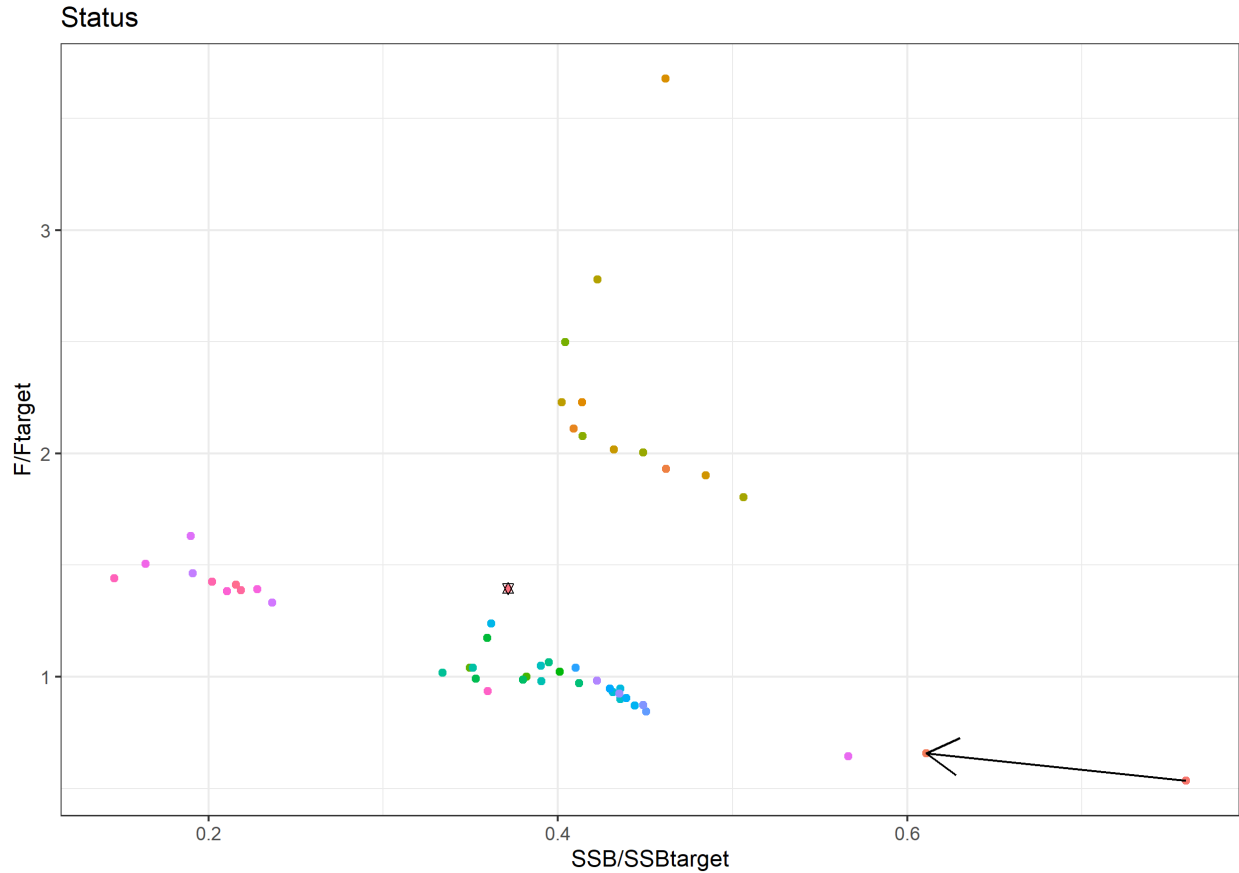




The Rose estimates are highlighted with a star symbol in the following three plots.







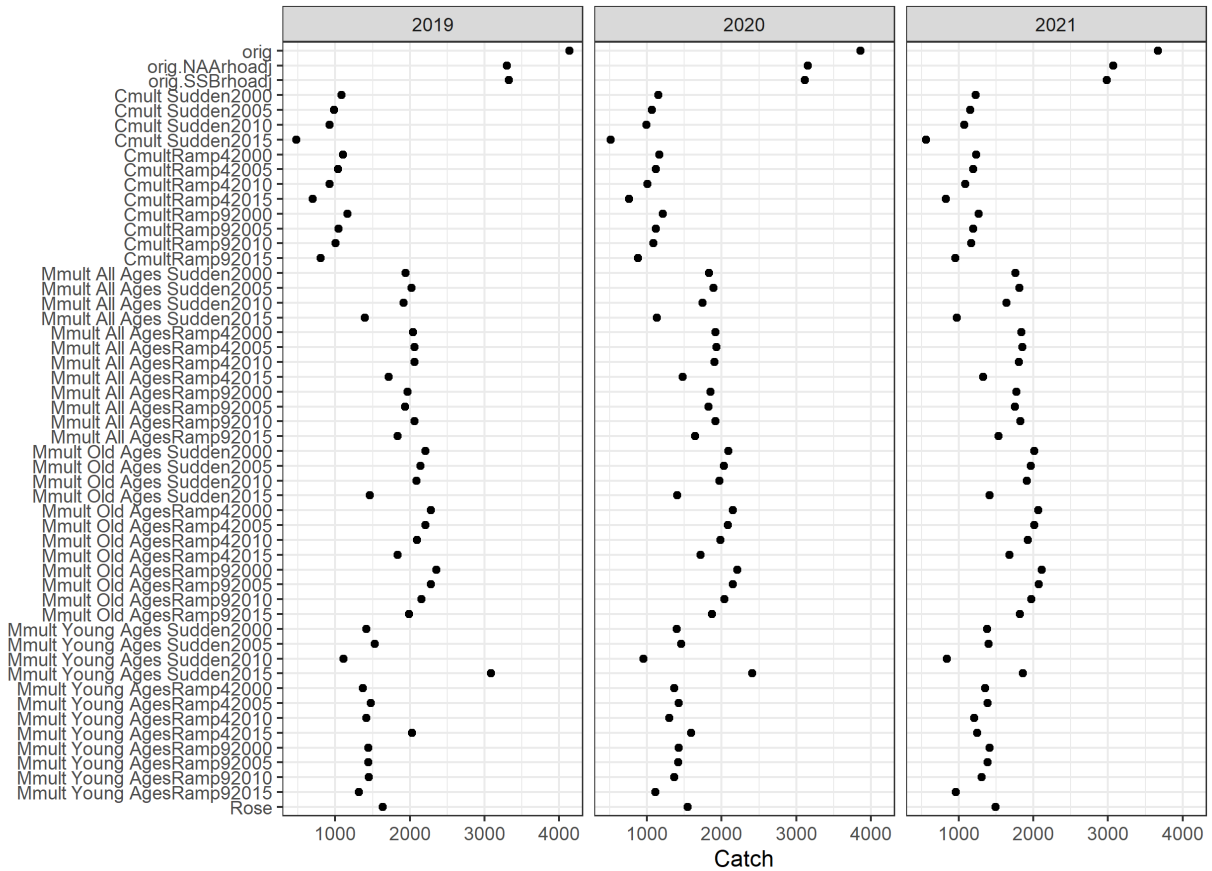
White Hake Catch Advice

Catch advice was based on applying the target F for each scenario for three years. Two approaches were used to adjust the terminal year plus one numbers at age for the rho-adjusted catch advice. One case applied the Mohn's rho for SSB to all ages while the other case used the age-specific Mohn's rho values to adjust the numbers at age. The adjustment was calculated as $N_{adj} = N_{orig} / (1 + \rho)$. The Rose scenarios that used catch multipliers had the output catch divided by the catch multipliers because this missing catch in the assessment would not be expected to be suddenly available to the fishery in terms of reported catch. The Rose scenarios that used M multipliers continued the M from the terminal year in the assessment because there is no reason to expect the natural mortality rate to suddenly return to its original value in the projections. If the M was decreased in the projections, there would be "bonus" amount of fish suddenly available to the fishery as catch and to help rebuilding.

The catch table and plot below shows the Rose approach providing lower catch advice than either rho-adjusted approach for white hake in all three years. This is the same result as for GBYT above.

##	Scenario	X2019	X2020	X2021
## 1	orig	4137	3863	3672
## 2	orig.SSBrhoadj	3327	3116	2985
## 3	orig.NAArhoadj	3298	3156	3069
## 4	Cmult Sudden2000	1085	1153	1226
## 5	Cmult Sudden2005	987	1068	1152
## 6	Cmult Sudden2010	921	992	1071
## 7	Cmult Sudden2015	476	514	563
## 8	CmultRamp42000	1102	1165	1233

## 9		CmultRamp42005	1038	1116	1196
## 10		CmultRamp42010	925	1004	1088
## 11		CmultRamp42015	698	756	825
## 12		CmultRamp92000	1161	1211	1266
## 13		CmultRamp92005	1044	1118	1194
## 14		CmultRamp92010	1005	1084	1167
## 15		CmultRamp92015	805	877	956
## 16	Mmult All Ages Sudden2000		1941	1832	1762
## 17	Mmult All Ages Sudden2005		2022	1892	1810
## 18	Mmult All Ages Sudden2010		1917	1744	1639
## 19	Mmult All Ages Sudden2015		1397	1132	971
## 20	Mmult All AgesRamp42000		2041	1919	1840
## 21	Mmult All AgesRamp42005		2060	1933	1851
## 22	Mmult All AgesRamp42010		2065	1905	1806
## 23	Mmult All AgesRamp42015		1718	1478	1328
## 24	Mmult All AgesRamp92000		1969	1851	1774
## 25	Mmult All AgesRamp92005		1937	1824	1751
## 26	Mmult All AgesRamp92010		2062	1919	1828
## 27	Mmult All AgesRamp92015		1833	1646	1530
## 28	Mmult Old Ages Sudden2000		2211	2088	2013
## 29	Mmult Old Ages Sudden2005		2143	2028	1966
## 30	Mmult Old Ages Sudden2010		2091	1969	1913
## 31	Mmult Old Ages Sudden2015		1460	1403	1413
## 32	Mmult Old AgesRamp42000		2281	2148	2063
## 33	Mmult Old AgesRamp42005		2207	2085	2014
## 34	Mmult Old AgesRamp42010		2098	1983	1927
## 35	Mmult Old AgesRamp42015		1833	1719	1681
## 36	Mmult Old AgesRamp92000		2353	2207	2115
## 37	Mmult Old AgesRamp92005		2285	2151	2070
## 38	Mmult Old AgesRamp92010		2155	2036	1971
## 39	Mmult Old AgesRamp92015		1987	1870	1821
## 40	Mmult Young Ages Sudden2000		1414	1397	1382
## 41	Mmult Young Ages Sudden2005		1530	1456	1400
## 42	Mmult Young Ages Sudden2010		1110	952	844
## 43	Mmult Young Ages Sudden2015		3084	2409	1862
## 44	Mmult Young AgesRamp42000		1372	1364	1355
## 45	Mmult Young AgesRamp42005		1474	1426	1388
## 46	Mmult Young AgesRamp42010		1418	1296	1210
## 47	Mmult Young AgesRamp42015		2027	1589	1250
## 48	Mmult Young AgesRamp92000		1441	1427	1413
## 49	Mmult Young AgesRamp92005		1446	1416	1390
## 50	Mmult Young AgesRamp92010		1450	1368	1306
## 51	Mmult Young AgesRamp92015		1316	1112	957
## 52		Rose	1633	1542	1491



Food for thought

In both stocks, the rho-adjusted approach and Rose approach the F status point was increased and the SSB status point was decreased relative to the original run. The change due to the Rose approach was greater than from the rho-adjusted approach in both cases. Similarly, in both stocks the catch advice provided by both approaches as lower than the original run and the catch advice from the Rose approach was lower than the catch advice provided by the rho-adjustment.

As seen in the GBYT example, the Rose approach can be influenced by one scenario that is quite different from the others. This influence could be reduced by using some other measure of central tendency of the scenarios, such as the median or a trimmed mean. It would be better to make this decision before applying the Rose approach to eliminate any concern about basing the decision on the results.

The rho-adjusted approach does not impact the reference points in these examples because only the terminal year is adjusted. There is not a standard approach used to link the terminal year adjusted values back to the rest of the time series, resulting in a sudden discontinuity in the time series. This is one of the major concerns expressed with using the rho-adjusted approach. Another concern is that rho-adjusting the terminal year F and N does not necessarily result in the same catch that was originally predicted.

Approach	Pros	Cons
Rose	All models in ensemble have no retro	Long run times
Rose	Addresses model structure uncertainty	Potential stacking the deck
Rho	Easy and quick to compute	Discontinuity in time series
Rho	Does not require identifying source of retro	Ad hoc adjustment