Plan B approaches for summer flounder in the unlikely situation that the analytical model is rejected

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Introduction

During the SAW/SARC 66 benchmark assessment of summer flounder a number of analytical models are being prepared and evaluated. In the unlikely situation that none of them are deemed acceptable by the CIE review panel, a simpler approach is required that can be evaluated quickly and easily, known locally as the Plan B. Plan B approaches typically rely on only aggregate catch and index information. There are currently two main approaches used in this region, referred to here as Survey Smoothing and Survey Expansion. Survey Smoothing is based on making changes to recent catch amounts based on the directional change of surveys, meaning that increasing surveys should allow more catch while decreasing surveys should have reduced catch. This approach has two computational varieties. One is known as PlanBsmooth and has been used for Georges Bank cod (Northeast Fisheries Science Center 2015, 2017b) and monkfish (Richards 2016). The other is known as FSD, an acronym of first second derivatives, and has been used for halibut (Rago 2017). The second approach, Survey Expansion, is to expand survey biomass to a population estimate including a catchability estimate and applying an exploitation rate based on recent catch dived by expanded survey to determine catch advice. This approach has been used for witch flounder (Northeast Fisheries Science Center 2017a, 2017b) and Georges Bank yellowtail flounder (Legault and McCurdy 2018).

These simple approaches can be computed quickly, but have a number of assumptions and can produce different catch advice depending on exactly how they are implemented. This working paper describes the application of the three methods (PlanBsmooth, FSD, and survey expansion) to summer flounder for a number of scenarios and poses a number of questions to the working group for how best to configure the Plan B for summer flounder.

Data

Catch and survey values were collected from the working paper provided by Mark Terceiro for the September 2018 working group meeting, from the working paper provided by Tim Miller et al. for the meeting, or from personal communication with Mark Terceiro. The catch data have two time series corresponding to the old MRFSS/MRIP data and the new MRFSS/MRIP data (Table 1). The working group will have to determine which catch series is most appropriate to use in Plan B. The survey data are aggregate biomass values from the Northeast Fisheries Science Center (NEFSC) spring and fall surveys, the Massachusetts Department of Marine Fisheries (MADMF) spring and fall surveys, and the Northeast Area Monitoring and Assessment Program (NEAMAP) spring and fall surveys (Table 2, Figure 1). There are of course many other surveys available for this stock, but these were the only ones with aggregate biomass indices readily available. The working group will need to determine which of these indices to use in the survey smoothing approach and whether any additional surveys should be included. The NEFSC fall 2017 survey did not operate in the southern portion of the overall survey area, so no index is available for that year. The NEAMAP spring 2018 survey value was not available when this working paper was developed. If this index is included in the final Plan B approach, the NEAMAP spring 2018 value should be added to the analysis. The NEFSC data expanded to population biomass with survey catchability was taken from the Miller et al. (2018) working paper developed for this meeting (Table 3). Note that only years 2009-2016 are presented in this working paper, so estimates for spring 2017 and 2018 were computed using the ratio of the spring survey biomass (kg/tow) in these years to that in 2016 (Table 2). If this approach is selected by the working group, estimates for spring 2017 and spring 2018 generated using similar methods to the rest of the time series should replace these calculated values. The fall 2017 NEFSC survey did not occur in the majority of the fluke area, so is left as missing and the fall 2018 NEFSC survey has not occurred yet, so is also left as missing. The data, R code, and output are available at https://github.com/cmlegault/PlanB_summer_flounder.

Methods

The three Plan B methods are easiest to understand through worked examples. Citations for additional details about the methods are provided for the interested reader in the Introduction section.

Survey Smoothing

Both survey smoothing methods, PlanBsmooth and FSD, rely on identifying one or more indices that reflects the recent change in the population to estimate a multiplier. This multiplier is applied to recent catch (or quota in some cases) to produce catch advice for upcoming year(s). There is no actual projection or population dynamics involved. To demonstrate the dependence of results on choice of surveys, seven cases were examined for all combinations of the NEFSC, MADMF, and NEAMAP surveys (Table 4). When a survey program was included, both the spring and fall survey were included. In the Georges Bank cod application of PlanBsmooth, the fall survey is brought forward one year (meaning the fall 2017 value is combined with the 2018 spring values from other surveys). The impact of whether the fall surveys were shifted or not and whether the surveys were rescaled before being combined or not created four sources of survey data for use in the estimation. The four sources of survey data times the seven cases of survey combinations times the two estimators results in 56 possible multipliers. These multipliers were applied to recent three year average of either the old or new catch data to produce distributions of catch advice.

The two methods, PlanBsmooth and FSD, treat multiple indices differently. PlanBsmooth combines the index values within a year to produce a single time series of index values to estimate the recent change, while FSD treats each index separately to estimate the recent change and averages the estimates of first and second derivatives, its measure of recent change, to produce the multiplier. The recent change in PlanBsmooth is defined as three years, while recent change in FSD is defined as five years. Additional differences can most clearly be seen through a worked example using just the NEFSC spring data.

The PlanBsmooth calculations are available as an R package (https://github.com/cmlegault/PlanBsmooth). For the NEFSC spring data, first a loess smooth is fit through the observations on regular scale. A linear regression is applied to the log of the predicted values for the most recent three years. Note that sometimes the loess prediction can become negative on normal scale, creating a missing value for the regression of the log predicted values and producing a warning message. The multiplier is computed as the exponent of the slope of the three point regression. Figure 2 shows the standard plot produced by the PlanBsmooth R package for the NEFSC spring survey.

There are some details to note about the PlanBsmooth method. There are defaults for the amount of smoothing used in the loess fit that come from Georges Bank cod (a smooth of 0.3 for a time series of 33 years). Changing the amount of smoothing in the loess fit will produce different multipliers. This aspect was not evaluated in this working paper, the default smoothing was used in all cases. The amount of smoothing is recalculated depending on the number of years available to produce the same amount of smoothing no matter how many years of data were available.

Since variability at the end of the time series is expected with any type of smoother and a loess fit is applied as part of PlanBsmooth, there is the possibility of a retrospective pattern emerging. So a retrospective analysis is part of the PlanBsmooth R package. For the NEFSC spring data example, it shows no consistent bias across seven peels with a low Mohn's rho value (Figure 3). However, despite the low Mohn's rho, the updating of previous multipliers can be quite large, as seen by comparing the 2017 multiplier from peel 0 with the 2017 multiplier from peel 1 (Figure 4). This difference was computed for all 28 combinations of source and case for the PlanBsmooth estimator and denoted deltamult2017. Comparing the 2018 multiplier from peel 0 with the 2017 multiplier from peel 1 provides an indication of the stability of the multiplier from one year to the next and was denoted deltamult2018. In the 28 combinations of source and case examined, a five peel Mohn's rho instead of the default seven peels was computed to save time.

The FSD method does not include any sort of model fitting, such as a loess smooth, and therefore cannot exhibit a retrospective pattern. The FSD approach conducts two regressions on the log of recent survey values. The first regression is for the most recent five years and the second regression is for years t-5 to t-1 where t denotes the most recent year. So for the NEFSC spring data example, where the most recent year is 2018, the first regression is for years 2014-2018 and the second regression is for years 2013-2017 (Figure 5). If there was more than one survey, the mean of the slopes of the regressions would be computed. Since there is only one, the average slope (first derivative) is the slope from the first regression and the delta slope (second derivative) is the slope from 2014-2018 minus the slope from 2013-2017. The multiplier is then calculated as exp(Kp * average slope + Kd * delta slope), where Kp and Kd default to values of 0.75 and 0.50, respectively. Alternative values of Kd and Kp will produce different multipliers, but this aspect was not evaluated in this working paper. See Rago (2018) for details on why these defaults are reasonable. The stability of the FSD multiplier was computed similar to

PlanBsmooth by estimating the multiplier for end year 2018 and subtracting the multiplier for end year 2017, denoted deltamult2018.

Survey Expansion

The survey expansion approach relies on having one or more indices that can be expanded to estimate the population biomass directly. This can be accomplished using the following equation $B = I (A/a) / q$ where B is the population biomass estimate, I is the stratified mean survey index in kg/tow, A is the survey area, a is the area of a single tow, and q is the survey catchability. Experimental work has produced estimates of survey catchability for a number of flatfish in this region (Miller et al. 2018). In both the witch flounder and Georges Bank yellowtail flounder applications of this approach, the fall survey is shifted ahead one year so that fall 2017 is combined with spring 2018 to create an estimate for 2018. Both the shifted and original data are used to create an estimate of the population biomass by taking the mean of the two surveys (Figure 6).

Relative exploitation rates for each year can be computed by dividing the catch in metric tons by the population biomass in that year. This is done for both the old and new catch data with the average of the spring and fall surveys and with the average of the spring and fall shifted surveys. Applying the mean of the relative exploitation rate observed during this period is one way to generate the catch advice for the upcoming year.

Results

Survey Smoothing

The mean catches from 2015-2017 for the old and new catch time series are 7,185.33 mt and 11,301.67 mt, respectively.

The multipliers from the 56 combinations of source, case, and estimator ranged from 0.8465 to 1.3589 with mean and median of 1.0857 and 1.0876, respectively (Table 5). There did not appear to be a consistent trend for the multipliers across estimators or source, but the MADMF surveys tended to result in higher multipliers while the NEAMAP surveys tended to result in lower estimators (Figure 7).

The range of catch advice from applying the multipliers to the mean catches is quite high, but depends more on the catch data used than on the choices made about source, case, or estimator (Figure 8).

The PlanBsmooth biomass retrospectives were all quite small (Figure 9), but the change in multiplier for 2017 when one year of data was added could be quite large (Figure 10). Both the PlanBsmooth and FSD methods were relatively stable, with multipliers generally changing less than 10% from 2017 to 2018, although PlanBsmooth did have some changes approaching 30% (Figure 11).

Survey Expansion

Relative exploitation rates were similar whether the fall data were shifted or not, but were quite different depending on whether the old or new catch data were used (Tables 6-7). This translated into larger differences in catch advice depending on the catch time series than on whether the fall data were shifted or not (Table 8). Since the fall 2017 NEFSC survey did not cover the main part of summer flounder habitat, it was not included in this analysis and thus the fall shifted and original survey expansions are identical for 2018.

Discussion

The two Survey Smoothing methods multipliers are quite similar for the NEFSC spring data example (1.074 from PlanBsmooth and 1.053 from FSD) and for the 28 combinations of source and case for summer flounder (Table 5). An R shiny app was developed to compare PlanBsmooth and FSD for simulated data (https://github.com/cmlegault/PlanBsmooth_Shiny_tester) and found quite similar catch advice produced by the two methods across a wide range of situations. There does not appear to be any consistent difference between the two methods nor any strong basis to prefer one approach over the other. Both methods are easy to compute and rely on a number of structural assumptions and settings to derive catch advice. The FSD method has a stronger theoretical underpinning than the PlanBsmooth method, but both methods appear to similarly estimate changes in survey biomass across a wide range of situations.

Selecting the appropriate exploitation rate for use in the Survey Expansion approach is the most challenging aspect of this approach. Since this approach is only used when the analytical assessment is rejected, it is difficult to generate the exploitation rate from model results that were rejected, for example, yield per recruit or spawning potential ratios using selectivity estimates from the analytical model. This can be done in situations where the analytical model is accepted by computing the exploitation rate (catch/survey) for accepted model results when the fishing mortality reference point, for example, F40% is applied. The Georges Bank yellowtail flounder application uses the quota instead of the catch when computing the mean historical exploitation rate. This approach was not considered in this working paper.

The lack of biological reference points for both Plan B approaches described in this working paper makes it challenging to determine stock status. Since neither approach is based on population dynamics, and neither approach allows projections, any biological reference points would have to be created in an ad hoc manner. If either approach is used because the analytical assessment was rejected, then caution should be used before assuming that standard approaches to estimating biological reference points are appropriate because the analytical model would have worked in these situations.

Questions for Working Group

1. Which approach, Survey Smoothing or Survey Expansion, is preferred for summer flounder?
2. If Survey Smoothing is preferred, which method, PlanBsmooth or FSD is preferred?
3. If Survey Expansion is preferred, what exploitation is appropriate?
4. Should fall surveys be shifted ahead one year?
5. How should missing survey information, e.g. NEFSC fall 2017, be treated?
6. How should surveys be selected for inclusion in Plan B?
7. Which catch time series should be used in Plan B?

References

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Table 1. Two time series of catch in metric tons for summer flounder. The old and new refer to how the recreational catch is estimated in MRFSS/MRIP.

Year	Old.Catch	New.Catch
1982	18847	21408
1983	26291	30425
1984	25934	30470
1985	20357	26264
1986	20741	24837
1987	18222	23577
1988	21564	24598
1989	10041	11231
1990	7621	9028
1991	10421	12914
1992	13213	15985
1993	11246	13347
1994	12965	15016
1995	10955	12482
1996	12351	14734
1997	10650	13867
1998	12007	17079
1999	10917	15138
2000	14996	20146
2001	11819	15695
2002	11853	16473
2003	13670	19224
2004	15495	20958
2005	15049	19293
2006	13406	17868
2007	11873	14773
2008	10184	12909
2009	10392	14307
2010	10940	15408
2011	12399	17487
2012	10340	16163
2013	10668	17483
2014	10107	15275
2015	8333	12498
2016	7784	11796
2017	5439	9611

Table 2. Aggregate biomass indices for summer flounder.

Year	NEFSC Fall	NEFSC Spring	MADMF Fall	MADMF Spring	NEAMAP Fall	NEAMAP Spring
1967	1.25					
1968	1	0.16				
1969	0.61	0.16				
1970	0.13	0.09				
1971	0.27	0.28				
1972	0.27	0.21				
1973	0.63	0.54				
1974	1.86	1.26				
1975	2.48	1.61				
1976	0.85	2				
1977	1.75	1.74				
1978	0.4	1.4	0.91	1.26		
1979	0.94	0.35	0.28	0.64		
1980	0.57	0.78	0.74	0.62		
1981	0.72	0.8	0.67	1.11		
1982	0.9	1.11	1.55	1.44		
1983	0.47	0.53	0.94	1.16		
1984	0.65	0.38	0.9	0.41		
1985	0.87	1.2	1.84	0.97		
1986	0.45	0.82	2.35	0.92		
1987	0.28	0.38	1.27	0.54		
1988	0.11	0.68	0.87	0.81		
1989	0.08	0.24	0.49	0.43		
1990	0.19	0.27	0.13	0.31		
1991	0.17	0.35	0.94	0.06		
1992	0.49	0.46	0.98	0.57		
1993	0.04	0.48	1.15	0.57		
1994	0.35	0.46	1.88	1.84		
1995	0.83	0.46	0.98	1.16		
1996	0.45	0.67	1.86	0.73		
1997	0.92	0.61	1.96	1.27		
1998	1.58	0.76	0.85	1.58		
1999	1.66	1.01	1.47	1.84		
2000	1.82	1.7	4.03	2.83		
2001	1.55	2.16	2.1	1.93		
2002	1.4	2.29	3.05	2.07		
2003	1.93	2.42	3.1	2.04		
2004	3.06	2.43	1.77	0.84		
2005	1.83	1.59	4.62	2.15		

Year	NEFSC Fall	NEFSC Spring	MADMF Fall	MADMF Spring	NEAMAP Fall	NEAMAP Spring
2006	1.79	1.34	4.01	2.91		
2007	2.45	3.17	1.46	1.64	2.62	
2008	1.62	1.38	1.41	0.67	1.69	1.9
2009	2.63	1.17	1.24	1.08	2.44	1.49
2010	1.37	1.57	1.41	0.84	1.99	1.27
2011	2.69	1.61	2.06	0.83	1.5	1.64
2012	1.77	1.63	1.04	0.73	1.82	0.77
2013	1.61	1.48	0.62	0.62	0.63	0.81
2014	2.18	1.21	1.25	0.53	0.86	0.92
2015	1.63	1.54	2.47	0.35	0.77	0.97
2016	2.06	0.94	2.33	1.62	0.64	0.84
2017		0.82	2.48	2.06	0.65	0.46
2018		1.53		1.66		

Table 3. Estimated biomass (metric tons) from expanding the NEFSC survey conducted with the Bigelow (from Miller et al. 2018).

Year	Fall	Spring
2009	36689	25954
2010	17927	34024
2011	37913	34248
2012	28991	31838
2013	26004	31025
2014	29004	24955
2015	26977	34713
2016	23978	17186

Table 4. The seven cases of survey combinations examined in the Survey Smoothing analyses. An "X" indicates that the spring and fall surveys from that program were used in that Case.

Case	NEFSC	MADMF	NEAMAP
1	X		
2		X	
3			X
4	X	X	
5	X		X
6		X	X
7	X	X	X

Table 5. Estimated multipliers from the two Survey Smoothing approaches, PlanBsmooth and FSD, for four sources of indices and seven combinations of surveys.

Source	Case	FSD	PlanBsmooth
Original	1	0.996873	0.965238
Original	2	1.228083	1.078961
Original	3	0.846521	0.931026
Original	4	1.106455	1.037128
Original	5	0.918626	1.101490
Original	6	1.019607	1.173949
Original	7	1.011972	1.099894
Original Rescaled	1	0.996873	1.053011
Original Rescaled	2	1.228083	1.232816
Original Rescaled	3	0.846521	0.921980
Original Rescaled	4	1.106455	1.173563
Original Rescaled	5	0.918626	1.142971
Original Rescaled	6	1.019607	1.358936
Original Rescaled	7	1.011972	1.235815
Fall Shifted	1	1.046996	1.004684
Fall Shifted	2	1.353703	1.268745
Fall Shifted	3	0.927081	0.919106
Fall Shifted	4	1.190513	1.162511
Fall Shifted	5	0.985216	0.977260
Fall Shifted	6	1.120264	1.226411
Fall Shifted	7	1.095289	1.144622
Fall Shifted Rescaled	1	1.046996	1.079818
Fall Shifted Rescaled	2	1.353703	1.275619
Fall Shifted Rescaled	3	0.927081	0.853345
Fall Shifted Rescaled	4	1.190513	1.235555
Fall Shifted Rescaled	5	0.985216	0.999672
Fall Shifted Rescaled	6	1.120264	1.244758
Fall Shifted Rescaled	7	1.095289	1.203151

Table 6. Exploitation rates (catch/survey) using the old and new MRFSS/MRIP data where avg is the average of NEFSC spring and fall survey expanded estimates of biomass.

Year	avg	Old.Catch	New.Catch	F.old	F.new
2009	31321.5	10392	14307	0.332	0.457
2010	25975.5	10940	15408	0.421	0.593
2011	36080.5	12399	17487	0.344	0.485
2012	30414.5	10340	16163	0.340	0.531
2013	28514.5	10668	17483	0.374	0.613
2014	26979.5	10107	15275	0.375	0.566
2015	30845.0	8333	12498	0.270	0.405
2016	20582.0	7784	11796	0.378	0.573
2017	14992.0	5439	9611	0.363	0.641
mean				0.355	0.541

Table 7. Exploitation rates (catch/survey) using the old and new MRFSS/MRIP data where avg is the average of NEFSC spring and fall shifted survey expanded estimates of biomass.

Year	avg	Old.Catch	New.Catch	F.old	F.new
2009	25954.0	10392	14307	0.400	0.551
2010	35356.5	10940	15408	0.309	0.436
2011	26087.5	12399	17487	0.475	0.670
2012	34875.5	10340	16163	0.296	0.463
2013	30008.0	10668	17483	0.356	0.583
2014	25479.5	10107	15275	0.397	0.600
2015	31858.5	8333	12498	0.262	0.392
2016	22081.5	7784	11796	0.353	0.534
2017	19485.0	5439	9611	0.279	0.493
mean				0.347	0.525

Table 8. Catch advice (metric tons) for 2019 from survey expansion approach using four exploitation rates.

	Mean F.old Avg	Mean F.new Avg	Mean F.old Avg Shifted	Mean F.new Avg Shifted
Biomass 2018	0.355	0.541	0.347	0.525
27973	9935	15120	9719	14679

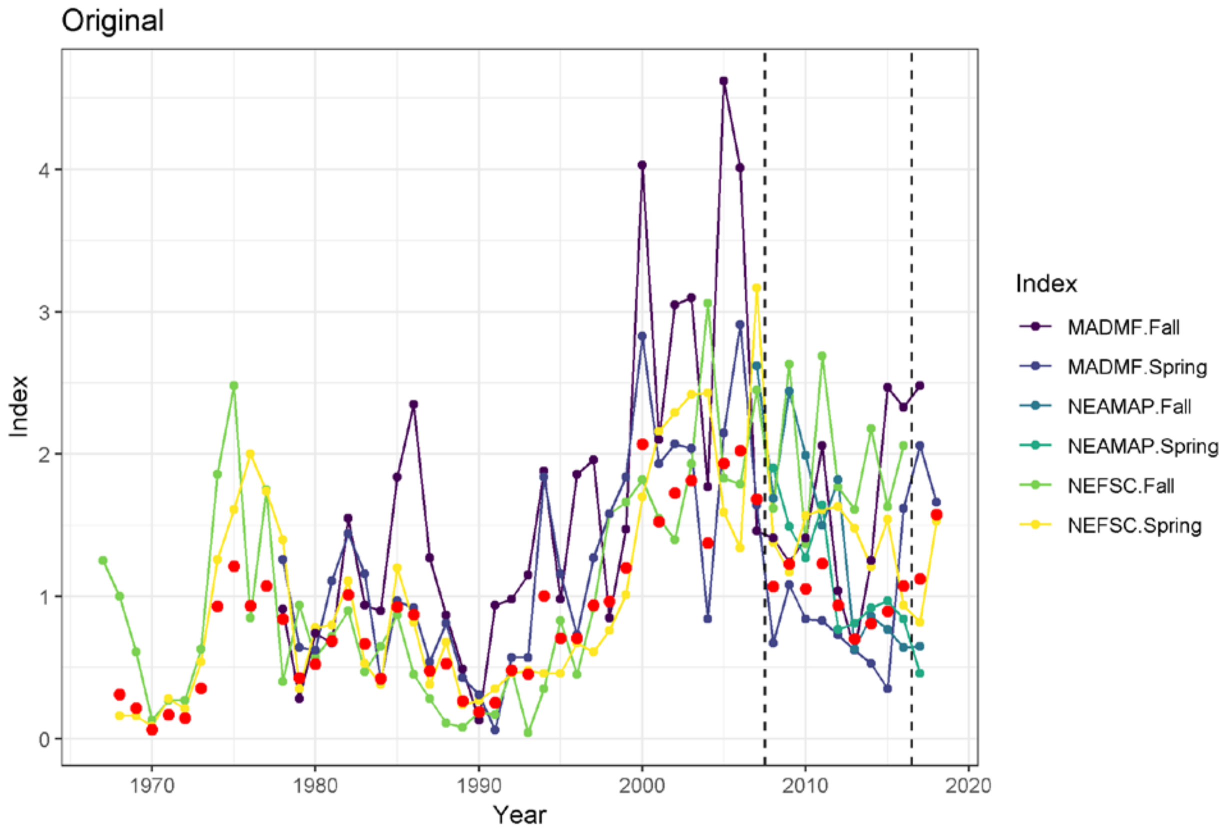

Figure 1a. Survey index time series from three programs with two seasons each. The red dots indicate the average of the survey index values in that year. Vertical lines denote the range of years used to standardize the time series, if used.

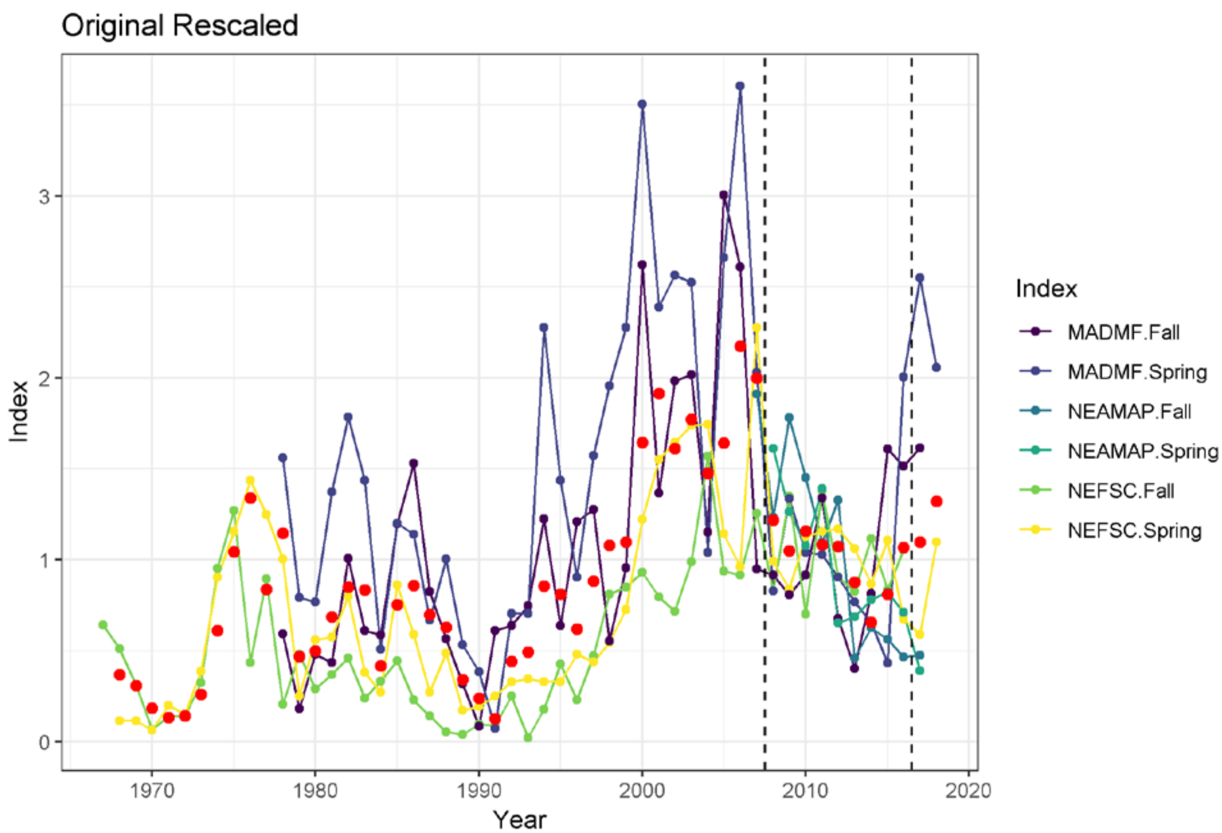

Figure 1b. Same as Figure 1a except each index has been rescaled to have mean one for years 2008-2016.

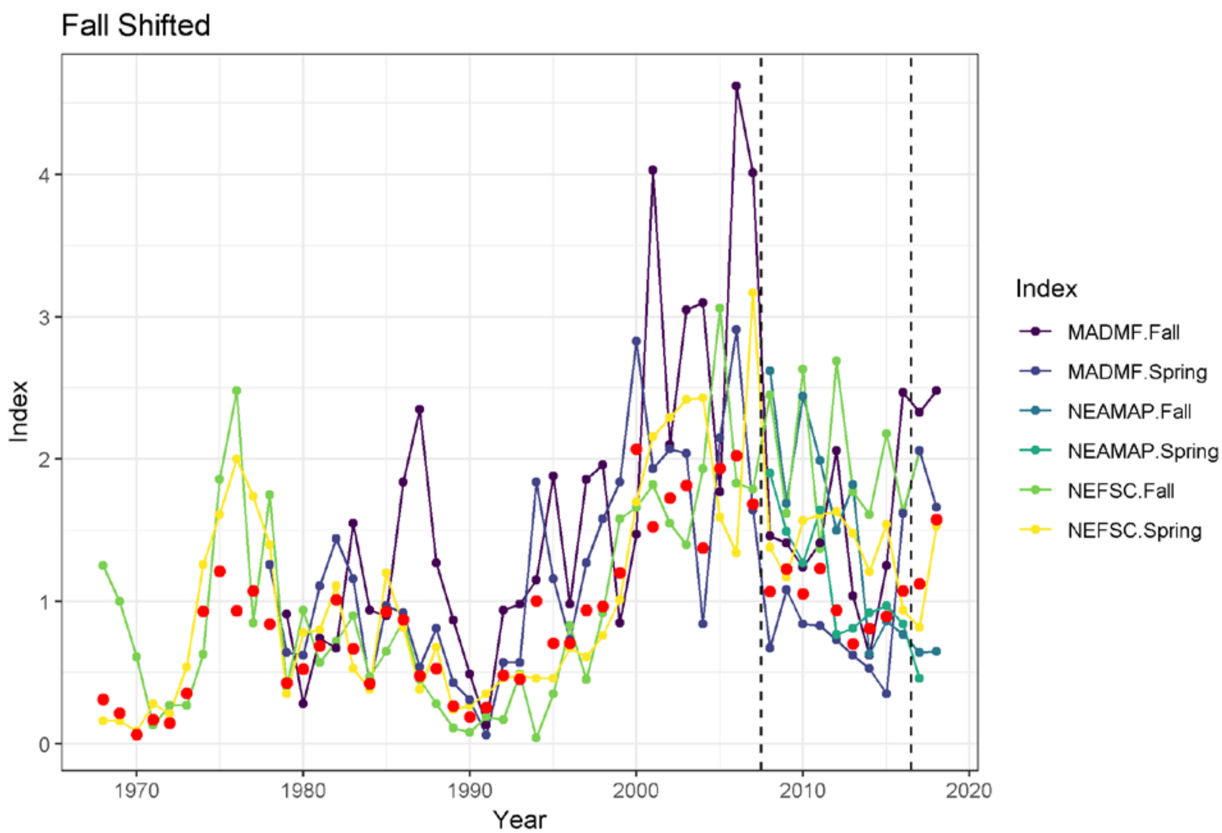

Figure 1c. Same as Figure 1a except the three fall indices have been shifted forward one year.

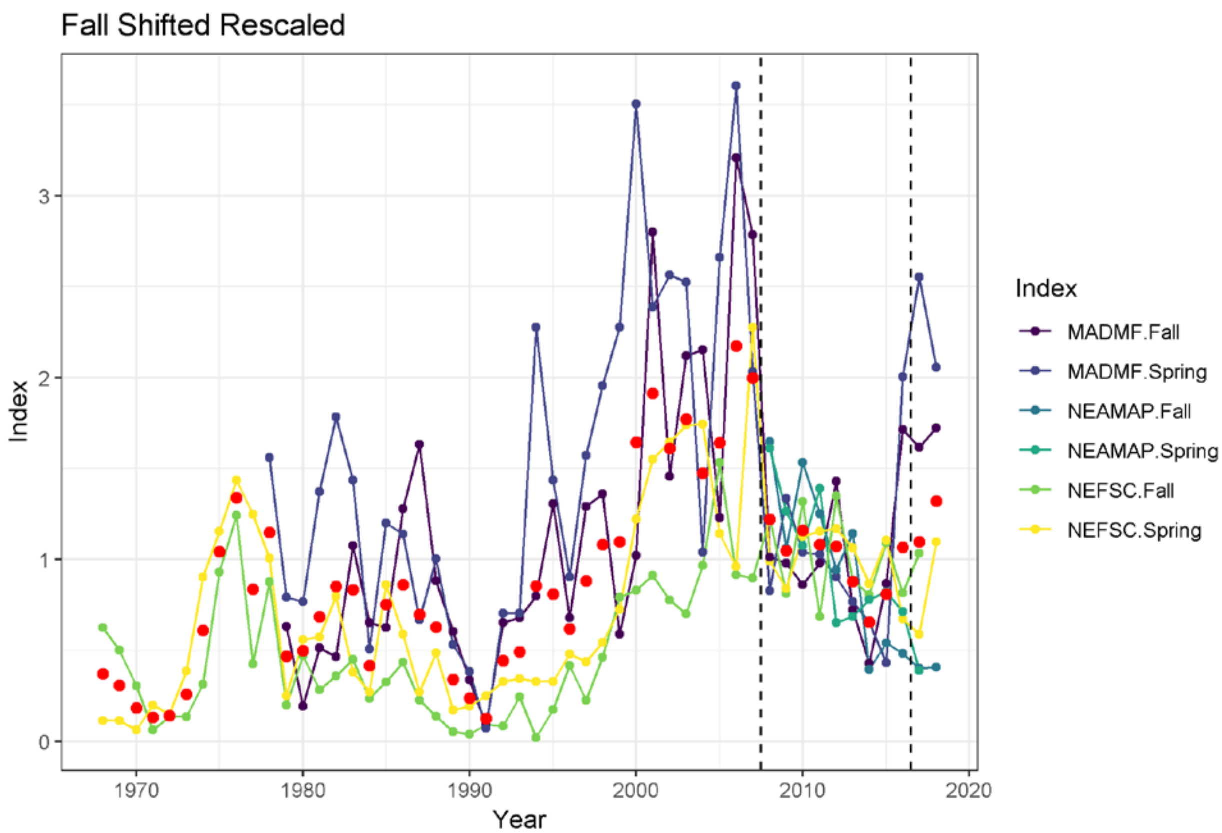

Figure 1d. Same as Figure 1a except the three fall series have been shifted forward one year and the time series have been standardized to have mean one for years 2008-2016.

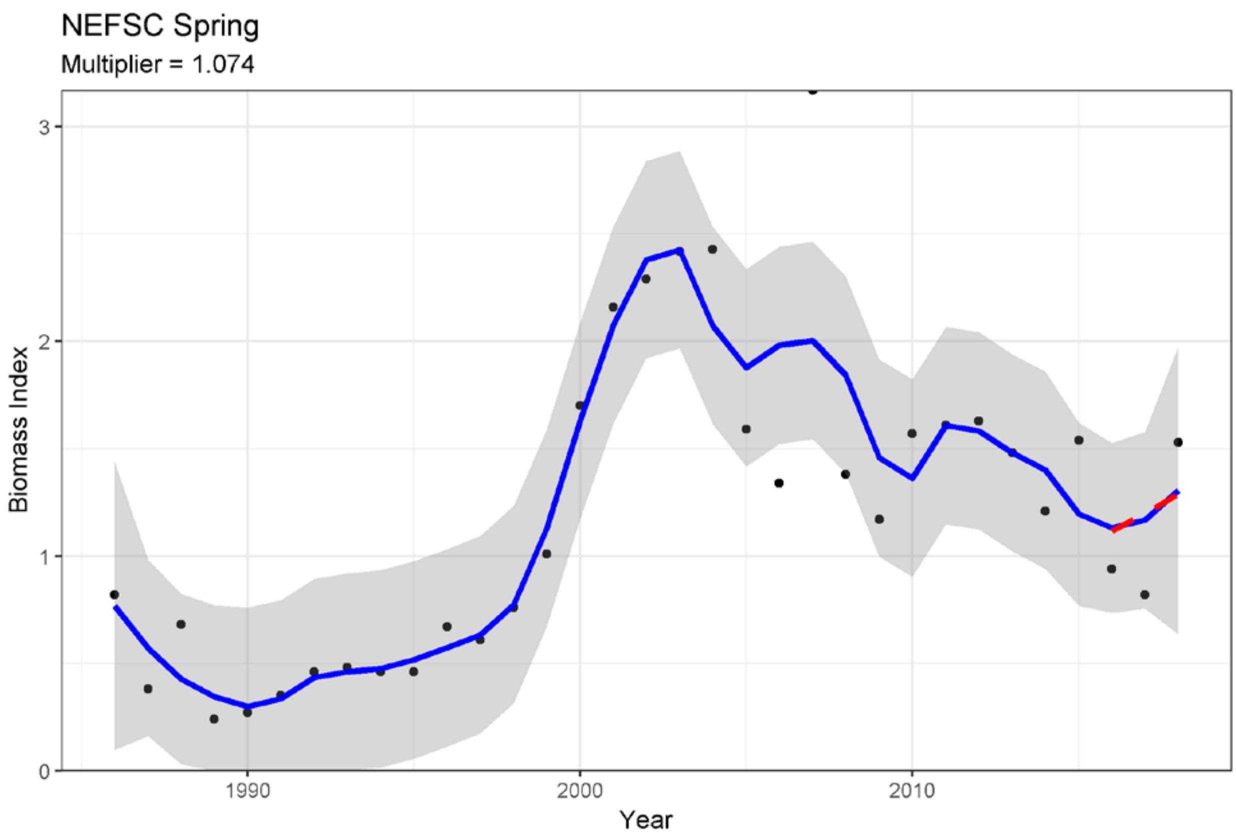

Figure 2. Standard plot produced by PlanBsmooth R package for NEFSC spring data. The filled circles are the biomass index values, the blue line is the loess smooth, the light blue shaded region denotes the 95% confidence interval for the loess smooth, the red dashed line is the regression of the log of the predicted values for the most recent three years on log scale converted back to regular scale. The Multiplier in the caption is used to adjust the recent three year catch. In this case, the multiplier of 1.074 indicates that catch could increase by 7.4% relative to the mean of the catch that occurred during 2015 – 2017.

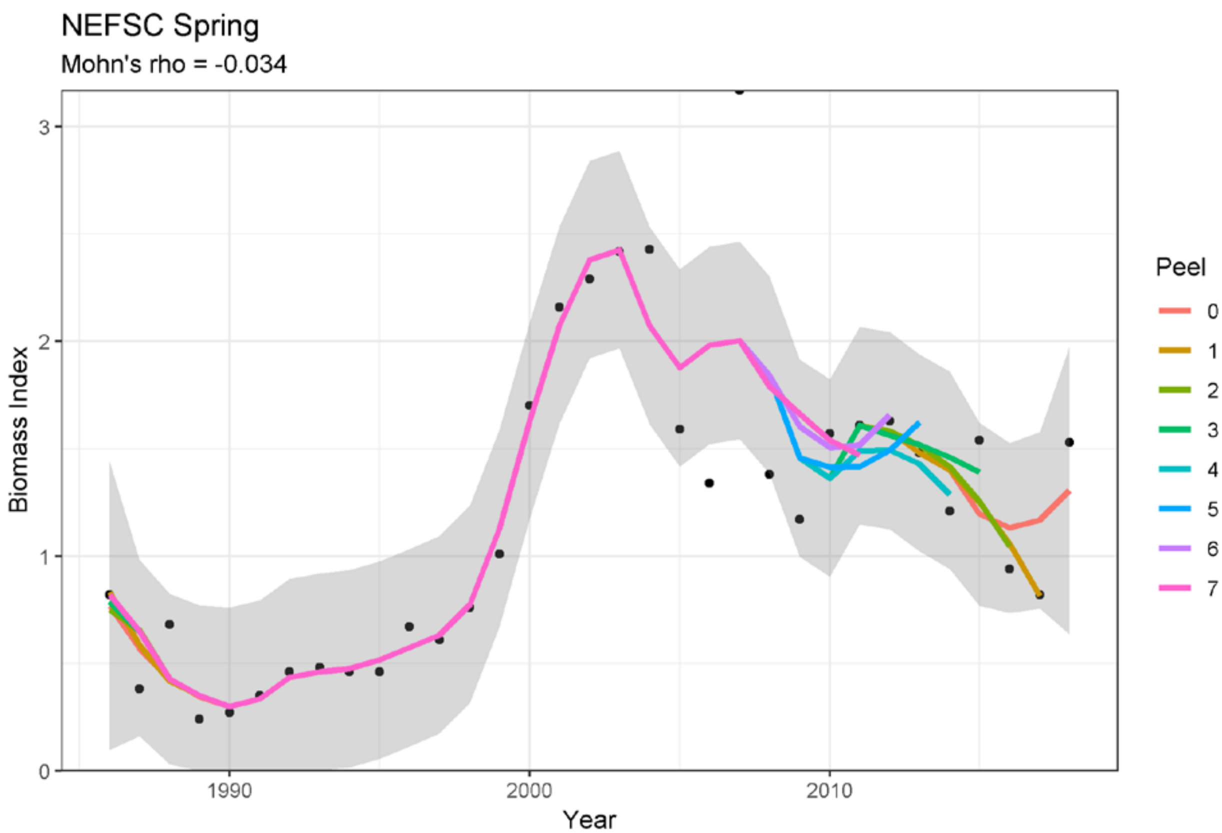

Figure 3. Standard biomass index retrospective plot produced by PlanBsmooth R package for NEFSC spring data. Peel indicates the number of years of data removed from the recent end of the time series, with peel = 0 denoting the loess fit to all years of data. The gray shaded region is the 95% confidence interval from the full time series loess fit for comparison with the peels. The Mohn's rho value in the caption is computed as the average relative difference between the last point in each peel and the corresponding biomass in the full time series loess fit.

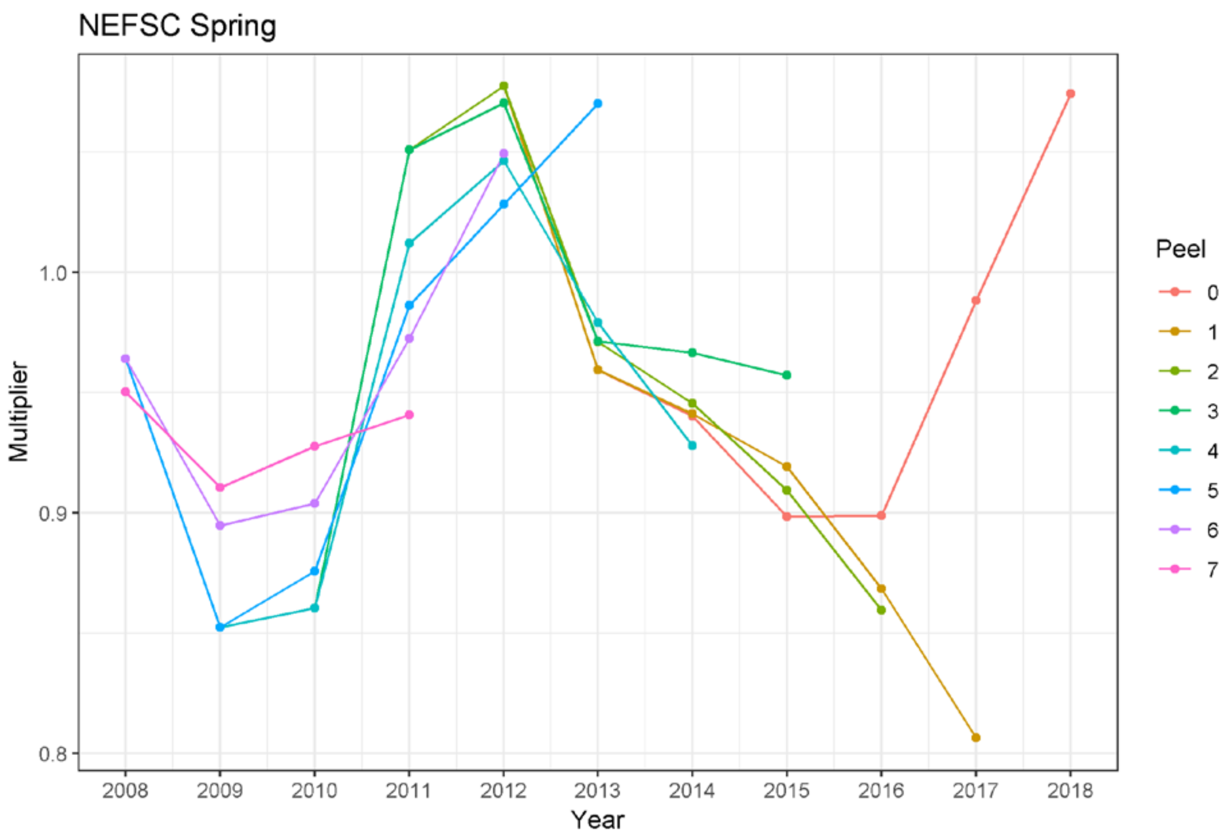

Figure 4. Standard multiplier retrospective plot produced by PlanBsmooth R package for NEFSC spring data. Peel indicates the number of years of data removed from the recent end of the time series, with peel = 0 denoting the loess fit to all years of data.

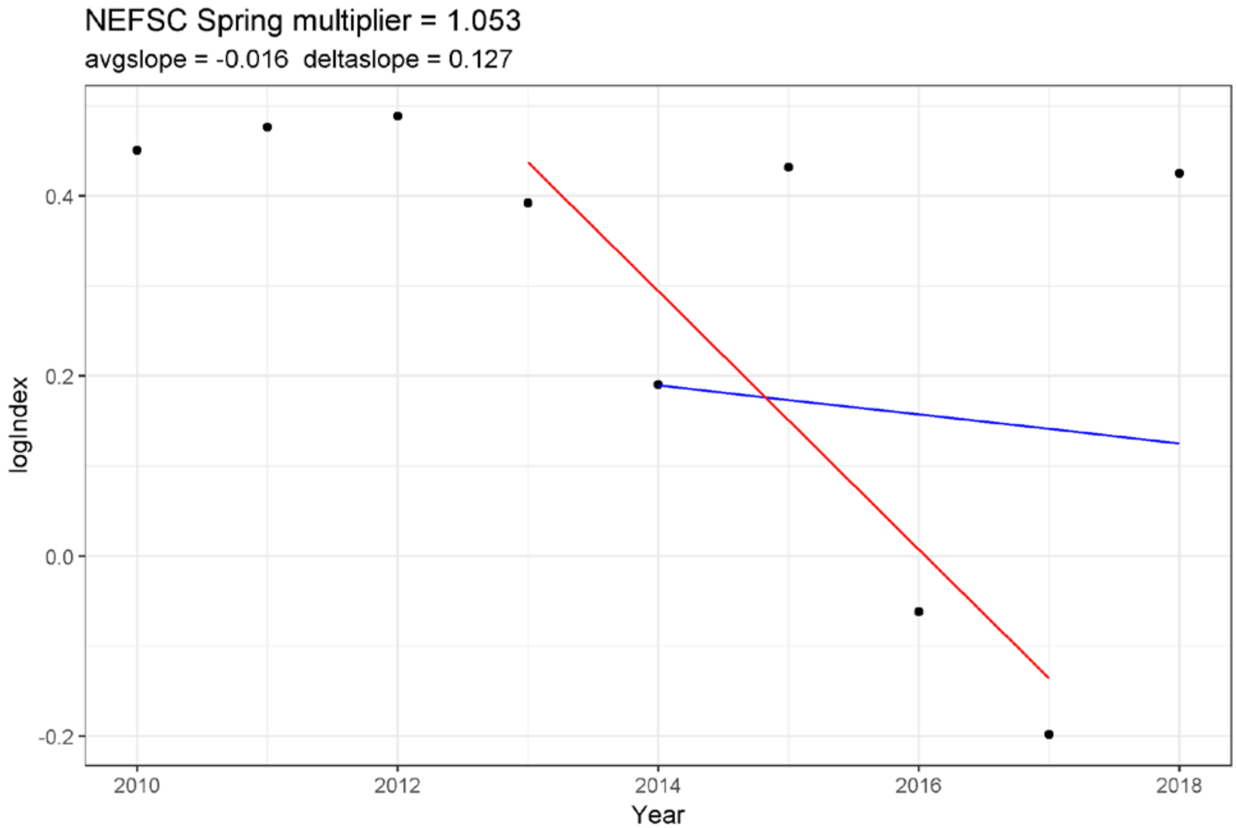

Figure 5. Demonstration plot of how FSD method works for NEFSC spring data. The blue line is the regression of the log of the biomass index from years 2014-2018 and the red line is the regression of the log of the biomass index from years 2013-2018. The multiplier is calculated as exp(0.75 * avgslope + 0.50 * deltaslope).

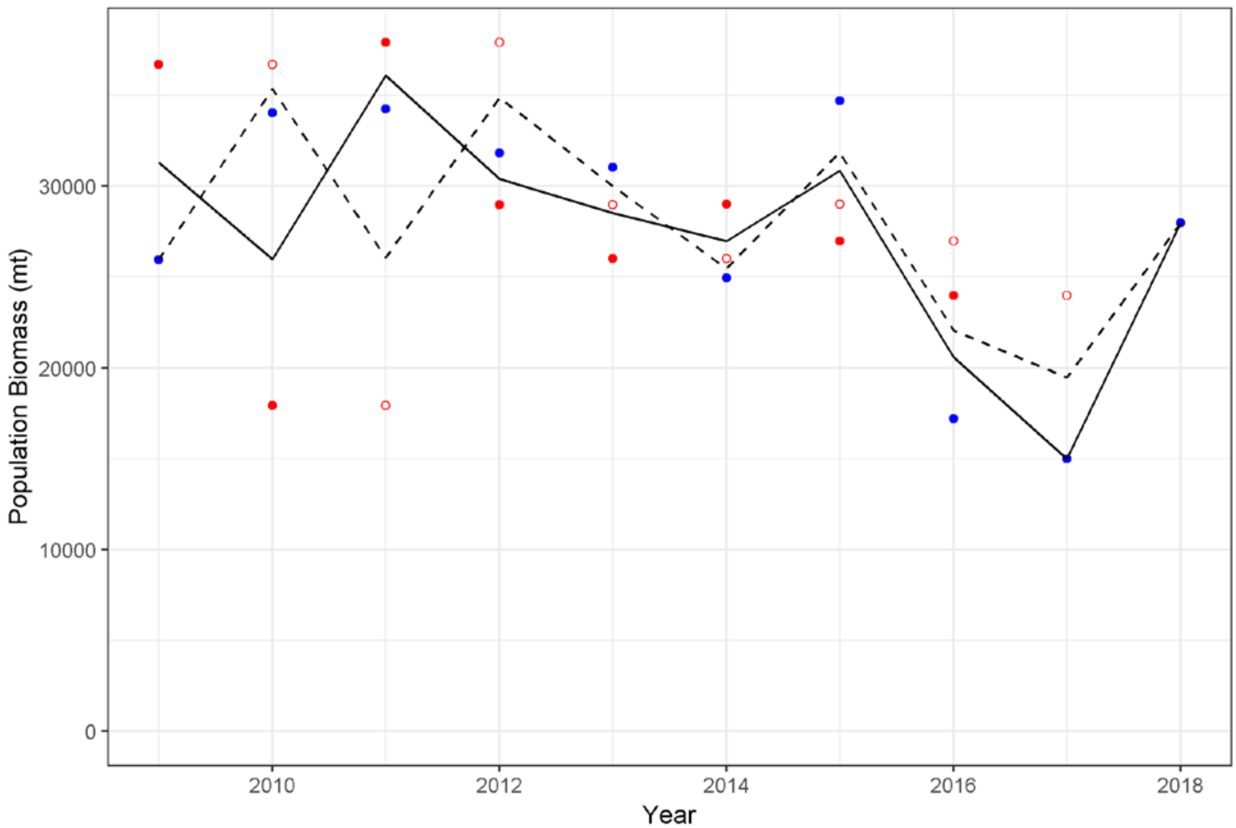

Figure 6. Population biomass (metric tons) used in survey expansion approach. The filled blue circles are from the NEFSC spring survey, the filled red circles are from the NEFSC fall survey, and the open red circles are the shifted fall survey values. The solid line shows the average of the spring and fall surveys, while the dashed line shows the average of the spring and fall shifted surveys.

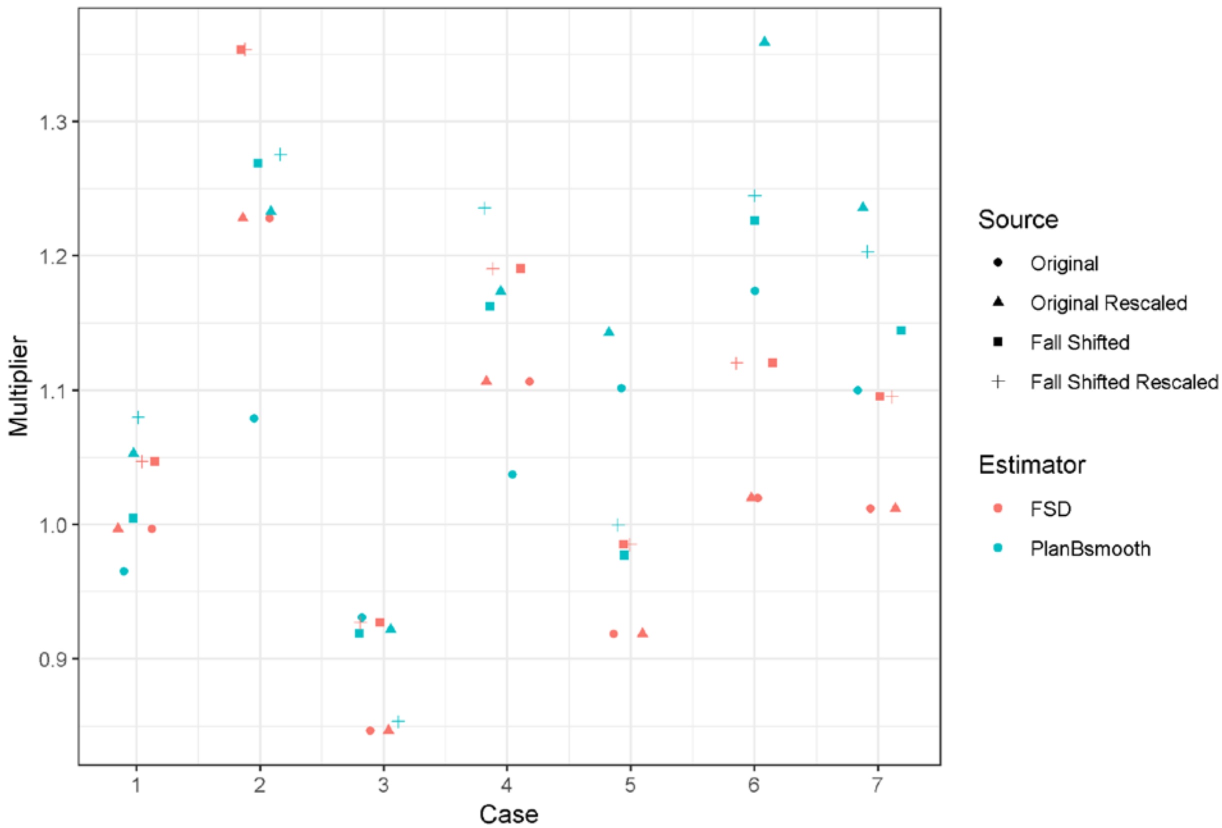

Figure 7. Survey Smoothing multipliers from tow estimators, four sources of indices, and seven cases of survey combinations.

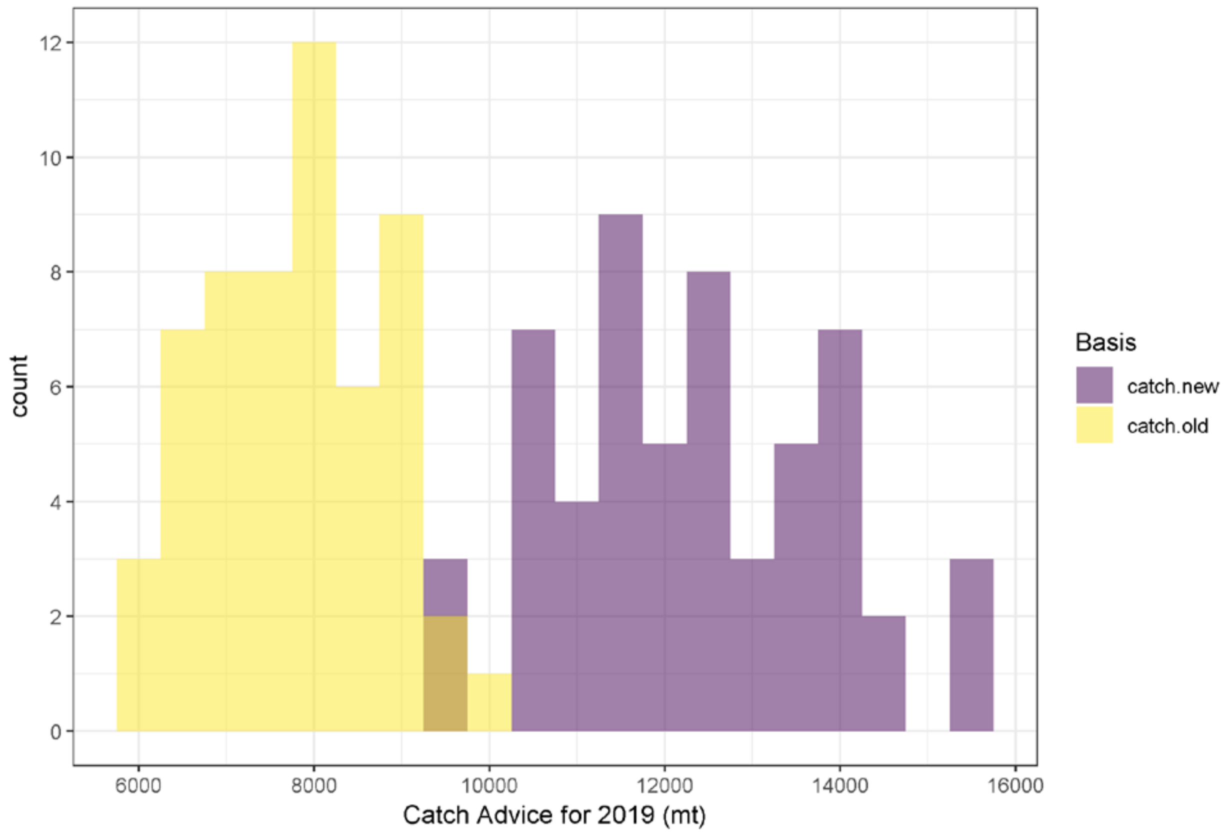

Figure 8. Distribution of catch advice from the 56 combinations of Survey Smoothing estimator, sources of indices, and survey combinations for two values of mean recent catch, old and new MRFSS/MRIP data.

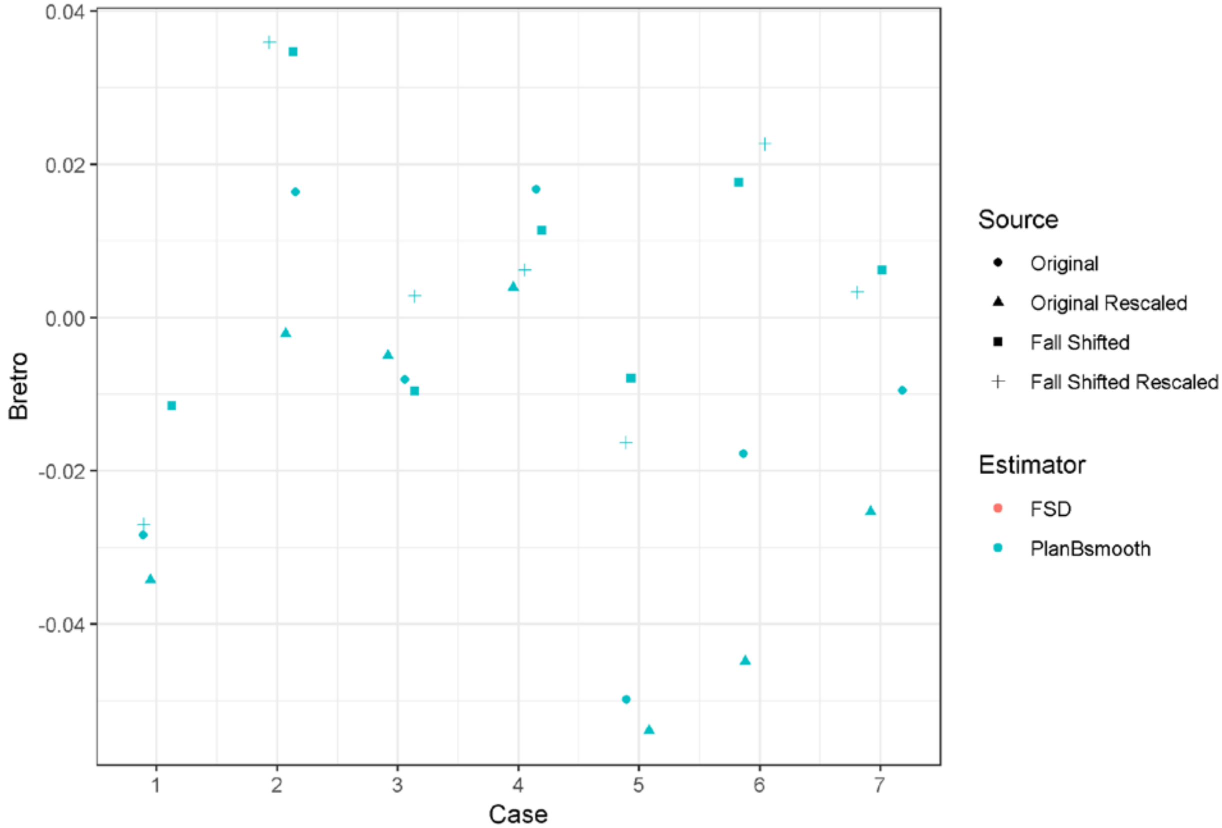

Figure 9. Mohn’s rho for biomass from five peels for two estimators, four sources of indices, and seven cases of survey combinations. Note the FSD Mohn’s rho are all zero by construction, so are not shown in this plot.

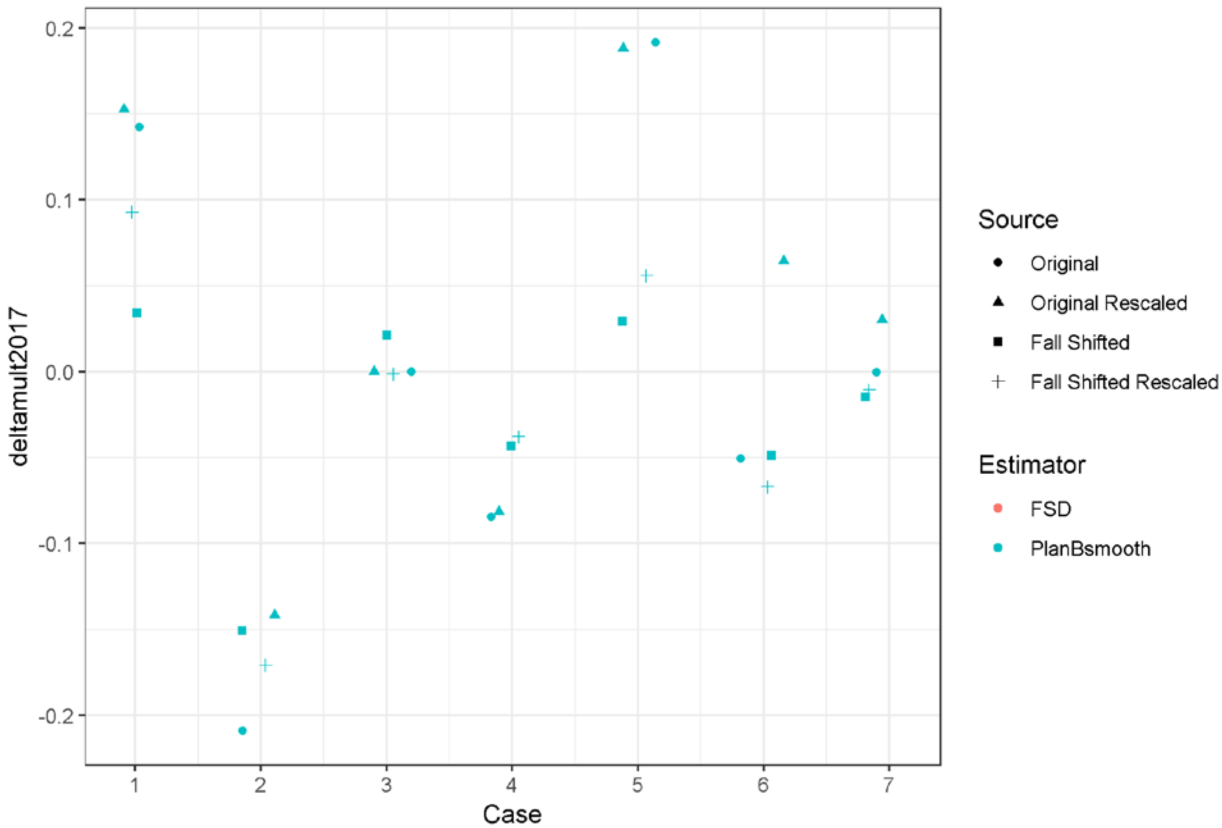

Figure 10. Difference between the 2017 multiplier estimated from the time series ending in 2018 and estimated from the time series ending in 2017 for two estimators, four sources of survey indices, and seven cases of survey combinations. The FSD values are all zero by construction, so are not shown on this plot.

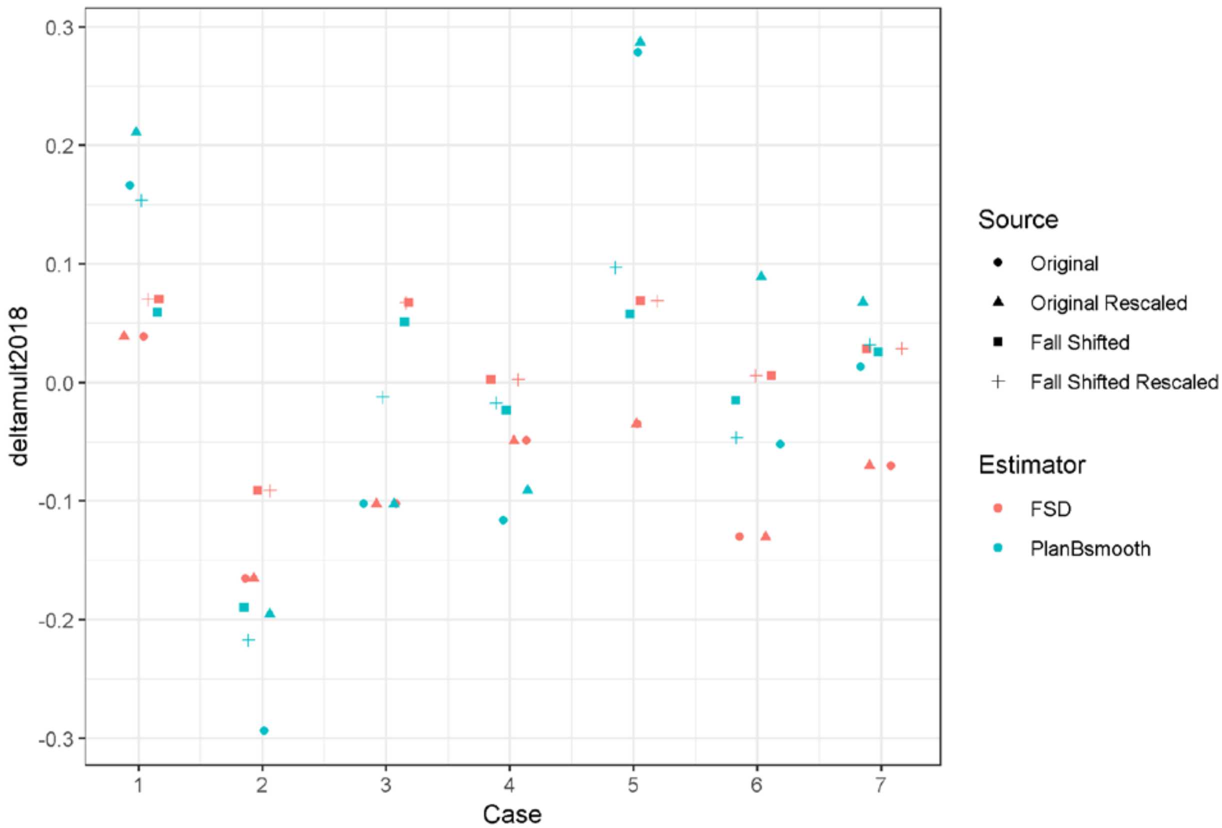

Figure 11. Difference in the terminal year multipliers estimated from time series ending in 2018 and time series ending in 2017 for two estimators, four sources of survey indices, and seven cases of survey combinations.