

# ISmooth performance

## 1 Premise

The purpose of this analysis is to evaluate the application of the ISmooth (previously known as PlanBSmooth) approach for bluefish. Performance is quantified relative to the historical ABCs that were set using the results of the ASAP model (and subject to any deviations in the harvest control rule that were implemented by the SSC).

More information on the ISmooth approach can be found on [Chris Legault's ISmooth GitHub page](#). In general, this approach applies recent trends in an index or indices to recent dead catch to generate advice. There are two steps in the process. The model calculates an average of normalized indices, applies a loess smooth, fits a linear model to the final three years of (logged) smoothed data and extracts the slope of the fit. The results are then applied to recent dead catch levels. In this case, the previous three years of catch are averaged and the ISmooth exponentiated slope (the multiplier) is multiplied by that average to generate the advice.

### 1.1 A note on timing and the management procedure

For the purposes of this analysis, there are three “notable years” which should be differentiated. The “terminal year” refers to the final year of the ISmooth index data and also the terminal year of the three years of dead catch that are averaged. The “assessment year” occurs in the year following the terminal year and is the hypothetical year where the analysis takes place. The “management year” is the year the advice is compiled for. So if the assessment year is 2021 then the PlanBSmooth function uses index data through 2020, catch information is 2018-2020 inclusive and the management year for which the advice is developed is 2022.

### 1.2 MRIP calibrations

An ABC and RHL are specified in every year. However, beginning in 2020 the ABC/RHL were set using newly calibrated MRIP data. In this study it was possible to calculate ABCs from 2020 on using catch data from the calibrated time series because those data are available for the entire MRIP time series. For management year 2019 it was also possible to calculate advice – “management year” 2019 was based on “assessment year” 2018 and thus used data from 2015 through “terminal year” 2017 – the last year of the uncalibrated time series. Thus it was possible to generate ISmooth-based advice for each year in the time series. The MRIP dead catch that was used in each year of this ISmooth analysis corresponded to the catch series (calibrated or uncalibrated) that was used to develop that year's advice.

### 1.3 A note on survey averaging

The default behavior when averaging across survey indices is to not calculate the average if any data are unavailable – that way the averages aren’t suddenly overweighted by particular surveys that do have available data. Missing data can occur over many years such as the Albatross index after 2008. Here missing data are allowed and will be ignored in the mean calculation. The implications are somewhat mitigated by the fact that each index is divided by its mean before averaging – that way at least the scales are the same. All the same, careful attention should be paid to results that include missing survey data, especially in years close to the terminal year.

### 1.4 A note on imputed data for missing years

In contrast to large swaths of missing years (i.e., when a survey did not exist), there are also localized missing years. This includes the Bigelow survey during 2017 and 2020 and the LISTs survey during 2010 and 2020. One approach that has been used in the past is to impute the missing values using a mean of the surrounding two years. This approach was used for some alternate model runs that were implemented but not discussed here; those versions of the indices did not produce results that altered the conclusions.

### 1.5 Index Based Working Group findings relative to ISmooth

The [Index Based Methods Working Group](#) (NEFSC) examined the performance of index methods in the context of temporal patterns in observation or process error that caused retrospective patterns; ISmooth was examined alongside a suite of other data poor approaches, some of which have recently been used to provide advice for stocks assessed by the NEFSC. In this section “Working Group” refers to the Index Based Methods Working Group. The Working Group devised a management strategy evaluation to test index based methods and compared the results to an age-structured integrated assessment model adjusted for retrospective errors. The data that fed into the annual assessments in the MSE were designed to effect a retrospective pattern with a Mohn’s Rho of approximately 0.5 for SSB in an age structured assessment. Note that these simulations were developed to emulate northeast groundfish populations and were not tested on stocks with different patterns of growth, longevity or productivity.

The group found that in the short term the ISmooth approach performed reasonably well relative to other methods, especially with respect to the level of SSB and constraining F; thus the method is reasonable to consider when stock status is of concern. When stock status was good this method tended to produce conservative catch advice leading to increased risk of foregone catch relative to some of the other index approaches; the Working Group found that the long-term median catch was below MSY. The ISmooth approach was relatively insensitive to whether the source of the retrospective error came from catch or natural mortality, so if an assessment was rejected due to retrospective error and the source was unknown ISmooth could be a reasonable choice to provide advice. Regardless, none of the index based methods outperformed (on average) the retrospectively adjusted results from the catch-at-age model over the long-term.

In the event of a failure of the primary age structured model ISmooth represents a reasonable choice. Its lack of reliance on assumptions regarding productivity or catchability mean that incorrect beliefs about these population characteristics will not pollute the catch advice; in addition the simplicity of the approach promotes a transparent management process. Further, as bluefish are currently in a rebuilding plan the stock status aligns with the finding relative to the ISmooth approach that the method is useful for stocks that are not overabundant relative to their SSB reference point. Note that the Working Group's findings that index approaches tend not to out-perform an age-structured model in the long-term even when there is considerable retrospective patterning means that the conditions where this model would be relied on are realistically limited to age-structured model convergence failure which appears unlikely at this time.

## 2 Methods

### 2.1 Index data

The index data (Fig. 1) include:

- MRIP CPUE index. The continuity index was used here since this was the index in use when the ABCs were developed.
- NEFSC Bigelow & Albatross fall stratified mean
- CT LISTS stratified mean

More indices are available (see other sections of the assessment documentation) but were not included in this analysis. Many of these indices and combinations of indices were examined but those findings did not differ dramatically from what is presented here. It is critical to include the MRIP CPUE index, as this has been an important driver of the assessment model in the past. The NEFSC Bigelow and Albatross surveys offer a broad geographic perspective so those indices were also included. The Connecticut Long Island Trawl Survey (fall) was also included as an example to show the sensitivity of this analysis to additional indices. Note that ultimately the working group decided against including the Connecticut survey in the proposed WHAM model.

All indices were abundance-based. Weight-based indices would be preferable as catch advice should reflect trends in biomass rather than numbers; however, the MRIP index was only available as a numbers-based metric so all indices here were abundance-based for consistency.

### 2.2 Combinations of indices

The combinations of indices that were tested were:

- MRIP index alone
- MRIP index and Bigelow stratified mean (when that survey came online)
- MRIP index, Albatross and Bigelow stratified means
- Albatross and Bigelow stratified means

- Connecticut Long Island Sound Trawl Survey
- MRIP index and Connecticut Long Island Trawl Survey

Other combinations were available (including combinations that integrate other surveys), but these were not included in this particular exercise. Note that each index is standardized to the time series mean and when multiple indices are included the average of the standardized indices is used.

### 2.3 Terminal years to test

The terminal year of data was used to derive alternative management advice (i.e., an ABC) two years in the future. The earliest management year tested was 2009 (which had a terminal year of data in 2007) and ABC advice was available for 2022 so the terminal years of data tested were 2007-2020.

### 2.4 Replicates over terminal years and index groups

Each combination of indices was crossed with each terminal year with an available historical ABC. This resulted in 84 different combinations of indices and terminal years (Table 1).

## 3 Results and Discussion

The multipliers estimated by the ISmooth approach varied according to the indices that were included in the analysis (Table 1, Fig. 2). The indices that included MRIP generally had lower variance; the NFMS Albatross/Bigelow alone and the Long Island Trawl Survey alone had greater swings in the multiplier over the time series.

According to this analysis, the ISmooth approach provided advice that was comparable to the historical ASAP-based ABCs. In general the retrospective advice estimated by the ISmooth model was correlated with the actual ASAP-derived ABCs that were recommended for management use by the SSC (Fig. 3). The exceptions – no matter the index combination – were the years 2020 and 2021, in which the ISmooth advice was notably higher than the recommended ABC. This was likely related to the 2019 assessment finding that bluefish were overfished which prompted the stock entering a rebuilding plan. In general, when MRIP is included in the suite of indices the fit is closer to the ABC (Fig. 3).

The correlation between ASAP-derived advice and retrospectively calculated ISmooth advice appears to be high. However, it is important to note that any year of ISmooth management advice is guided by three years of ABC that were developed by ASAP so they should be at least somewhat similar in scale. In addition, any differences in advice are not cumulative since the ISmooth approach was always based on recent ASAP-based catch advice (i.e., the last three years of harvest history) and never catch advice that was derived from the ISmooth approach. In an MSE framework these methods are unlikely to be as correlated since ASAP ABCs would not be “guiding” the ISmooth results.

The results of this analysis indicate that if an age-structured model were not available, the ISmooth approach can be expected to provide catch advice that is similar to what an age-structured model would have provided for the same year. The cumulative impact of sequential ISmooth ABCs could not be evaluated.

## 4 Tables

*Table 1: Study design and estimated multipliers calculated using the ISmooth approach for each combination of terminal year (last year of catch), model year and the management year for which the advice is calculated.*

Terminal Year	Model Year	Mgt Year	Indices Included	Est multiplier
2007	2008	2009	AlbStMean, BigStMean	0.786
2008	2009	2010	AlbStMean, BigStMean	0.663
2009	2010	2011	AlbStMean, BigStMean	1.245
2010	2011	2012	AlbStMean, BigStMean	1.433
2011	2012	2013	AlbStMean, BigStMean	1.188
2012	2013	2014	AlbStMean, BigStMean	0.843
2013	2014	2015	AlbStMean, BigStMean	0.970
2014	2015	2016	AlbStMean, BigStMean	0.722
2015	2016	2017	AlbStMean, BigStMean	0.478
2016	2017	2018	AlbStMean, BigStMean	0.414
2017	2018	2019	AlbStMean, BigStMean	0.280
2018	2019	2020	AlbStMean, BigStMean	1.267
2019	2020	2021	AlbStMean, BigStMean	1.403
2020	2021	2022	AlbStMean, BigStMean	1.403
2007	2008	2009	LISTSSStMean	1.006
2008	2009	2010	LISTSSStMean	0.791
2009	2010	2011	LISTSSStMean	0.750
2010	2011	2012	LISTSSStMean	0.684
2011	2012	2013	LISTSSStMean	0.823
2012	2013	2014	LISTSSStMean	1.265
2013	2014	2015	LISTSSStMean	0.950
2014	2015	2016	LISTSSStMean	1.120
2015	2016	2017	LISTSSStMean	1.004

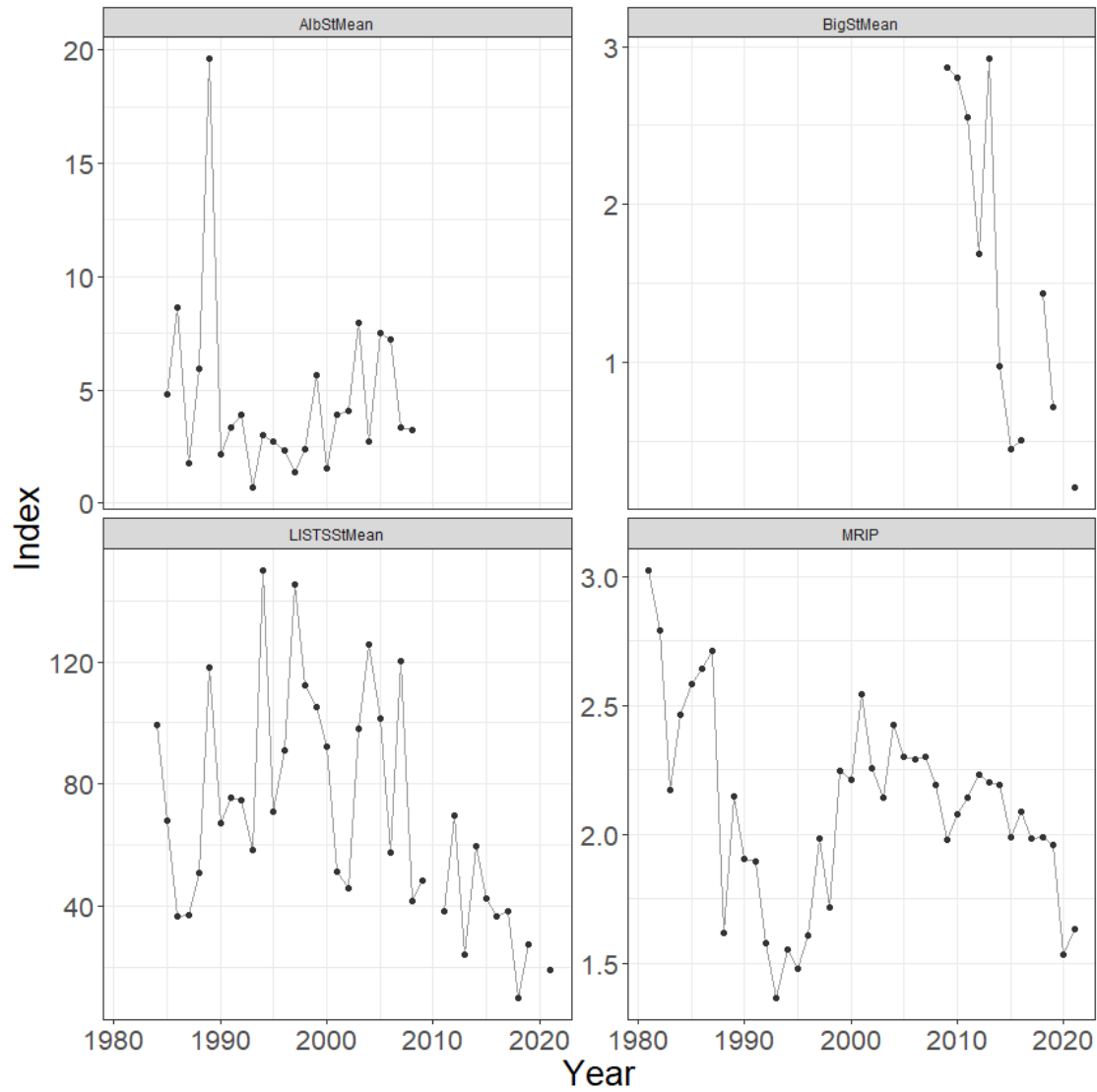
Terminal Year	Model Year	Mgt Year	Indices Included	Est multiplier
2016	2017	2018	LISTSStMean	0.914
2017	2018	2019	LISTSStMean	0.916
2018	2019	2020	LISTSStMean	0.633
2019	2020	2021	LISTSStMean	0.783
2020	2021	2022	LISTSStMean	0.762
2007	2008	2009	MRIP	0.999
2008	2009	2010	MRIP	0.973
2009	2010	2011	MRIP	0.939
2010	2011	2012	MRIP	0.961
2011	2012	2013	MRIP	0.998
2012	2013	2014	MRIP	1.035
2013	2014	2015	MRIP	1.035
2014	2015	2016	MRIP	1.015
2015	2016	2017	MRIP	0.962
2016	2017	2018	MRIP	0.968
2017	2018	2019	MRIP	0.969
2018	2019	2020	MRIP	0.984
2019	2020	2021	MRIP	0.991
2020	2021	2022	MRIP	0.913
2007	2008	2009	MRIP, AlbStMean, BigStMean	0.912
2008	2009	2010	MRIP, AlbStMean, BigStMean	0.842
2009	2010	2011	MRIP, AlbStMean, BigStMean	1.061
2010	2011	2012	MRIP, AlbStMean, BigStMean	1.121
2011	2012	2013	MRIP, AlbStMean, BigStMean	1.109
2012	2013	2014	MRIP, AlbStMean, BigStMean	0.972
2013	2014	2015	MRIP, AlbStMean, BigStMean	1.002

Terminal Year	Model Year	Mgt Year	Indices Included	Est multiplier
2014	2015	2016	MRIP, AlbStMean, BigStMean	0.849
2015	2016	2017	MRIP, AlbStMean, BigStMean	0.737
2016	2017	2018	MRIP, AlbStMean, BigStMean	0.762
2017	2018	2019	MRIP, AlbStMean, BigStMean	1.001
2018	2019	2020	MRIP, AlbStMean, BigStMean	1.146
2019	2020	2021	MRIP, AlbStMean, BigStMean	1.061
2020	2021	2022	MRIP, AlbStMean, BigStMean	0.960
2007	2008	2009	MRIP, BigStMean	0.999
2008	2009	2010	MRIP, BigStMean	0.973
2009	2010	2011	MRIP, BigStMean	1.103
2010	2011	2012	MRIP, BigStMean	1.108
2011	2012	2013	MRIP, BigStMean	1.058
2012	2013	2014	MRIP, BigStMean	0.933
2013	2014	2015	MRIP, BigStMean	1.000
2014	2015	2016	MRIP, BigStMean	0.860
2015	2016	2017	MRIP, BigStMean	0.741
2016	2017	2018	MRIP, BigStMean	0.762
2017	2018	2019	MRIP, BigStMean	1.001
2018	2019	2020	MRIP, BigStMean	1.146
2019	2020	2021	MRIP, BigStMean	1.061
2020	2021	2022	MRIP, BigStMean	0.960
2007	2008	2009	MRIP, LISTSSStMean	0.984
2008	2009	2010	MRIP, LISTSSStMean	0.860
2009	2010	2011	MRIP, LISTSSStMean	0.853
2010	2011	2012	MRIP, LISTSSStMean	0.955
2011	2012	2013	MRIP, LISTSSStMean	0.944

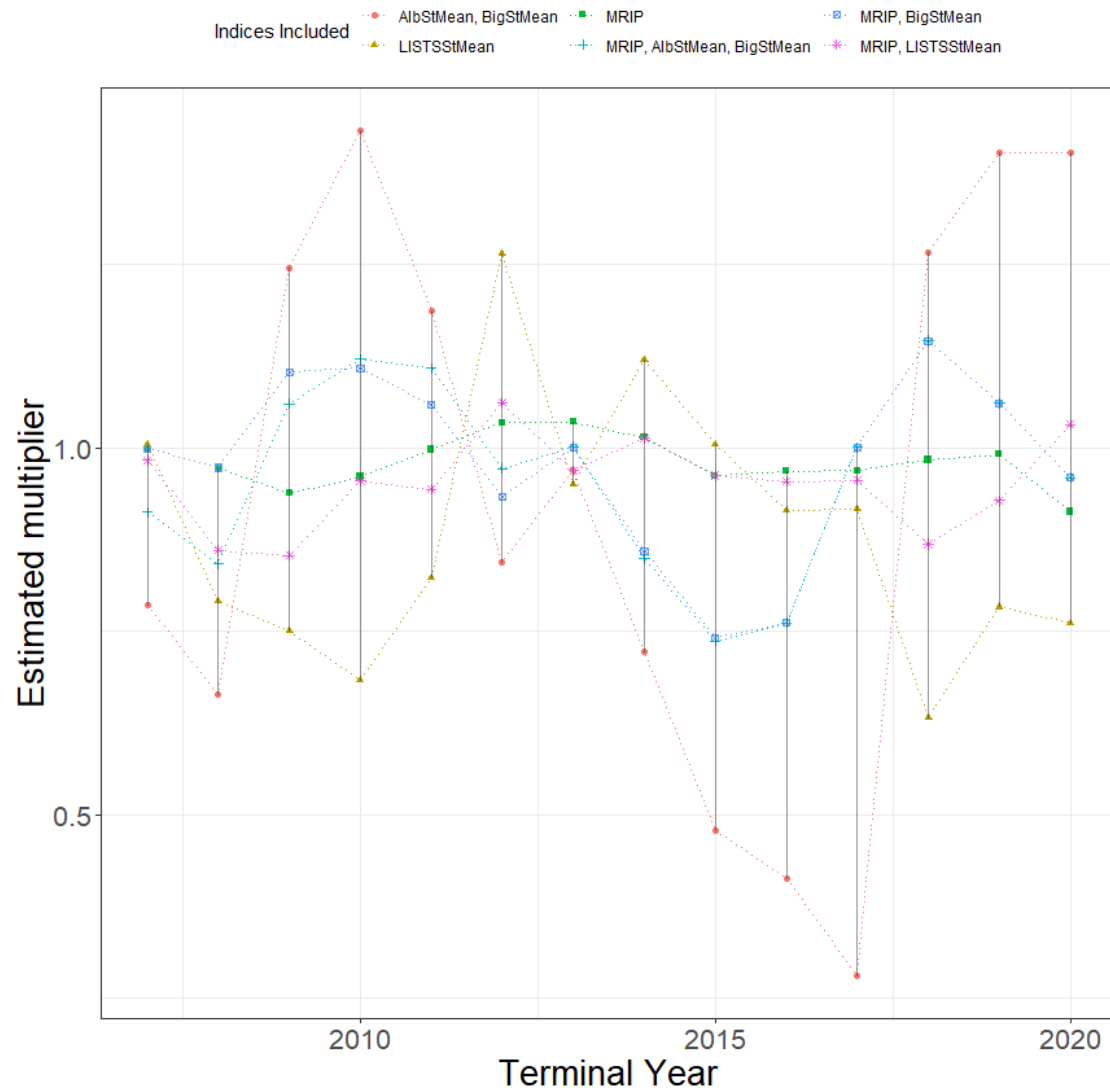


Terminal Year	Model Year	Mgt Year	Indices Included	Est multiplier
2012	2013	2014	MRIP, LISTSSStMean	1.062
2013	2014	2015	MRIP, LISTSSStMean	0.969
2014	2015	2016	MRIP, LISTSSStMean	1.014
2015	2016	2017	MRIP, LISTSSStMean	0.963
2016	2017	2018	MRIP, LISTSSStMean	0.954
2017	2018	2019	MRIP, LISTSSStMean	0.956
2018	2019	2020	MRIP, LISTSSStMean	0.869
2019	2020	2021	MRIP, LISTSSStMean	0.929
2020	2021	2022	MRIP, LISTSSStMean	1.032

## 5 Figures



*Figure 1: Indices considered in this analysis (before standardization to their time series mean). Note that the MRIP index is the continuity version from the previous benchmark.*



*Figure 2: Variability in annual multipliers estimated by the ISmooth approach according to the different indices that were employed.*

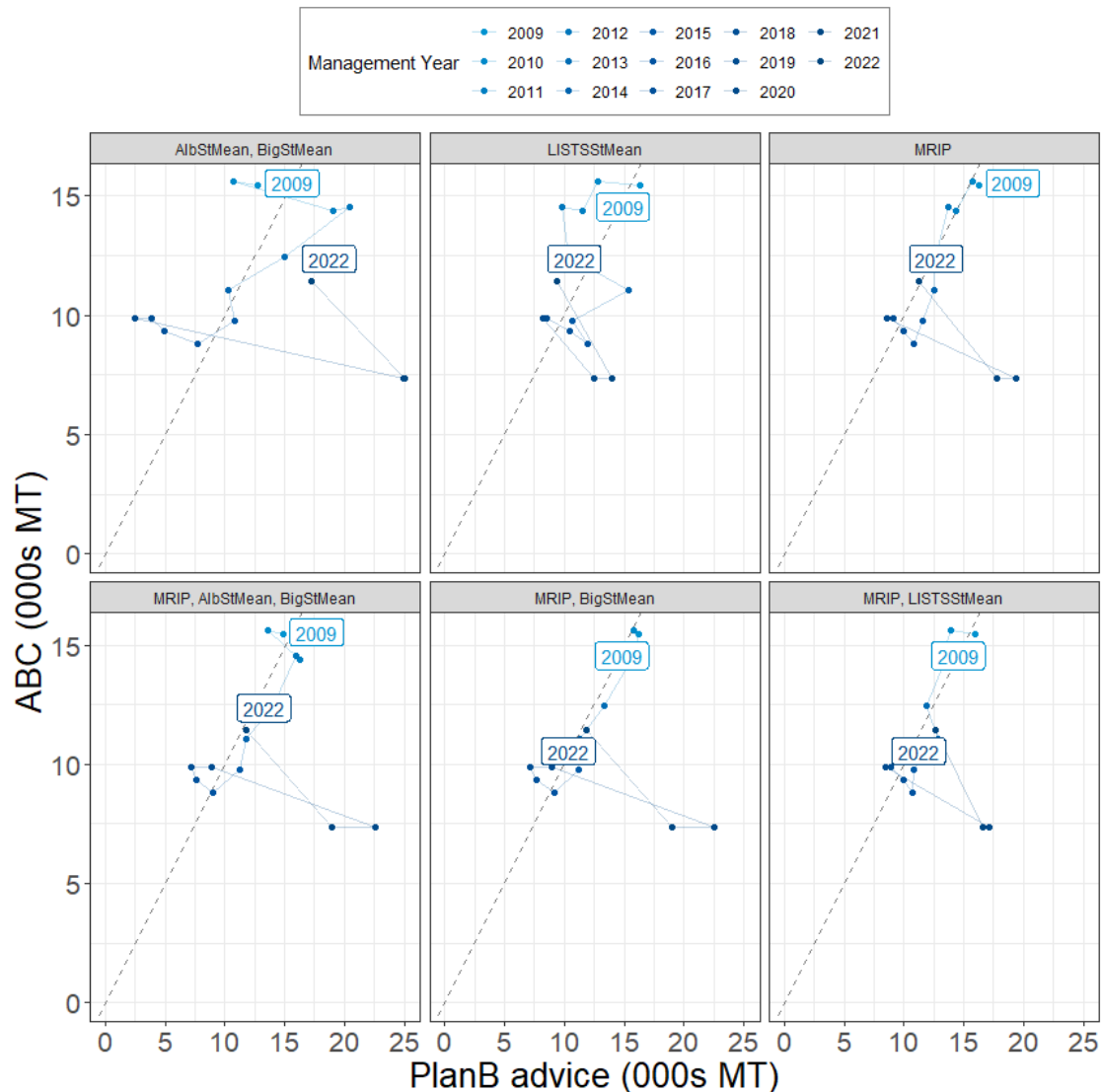


Figure 3: Results of applying a hypothetical ISmooth analysis relative to the actual ABC recommended for use in management. The dashed line is the 1-1 line.

## 6 References

NEFSC (Northeast Fisheries Science Center). 2020. Draft Report of the Index Based Methods Working Group. NEFSC Ref. Doc. (in prep).  
<https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/60391d7c0a8d8429d50f72b2/1614355837553/Draft+Index+Based+Methods+Peer+Review+Report.pdf>.