Mid-Atlantic Fishery Management Council
Scientific and Statistical Committee
OFL CV Guidance Document

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Revised XX

Introduction

The Mid-Atlantic Fishery Management Council's (MAFMC) Scientific and Statistical Committee (SSC) currently uses a control rule to specify the acceptable biological catch (ABC; catch level that sets an upper bound for the Annual Catch Limit) for stocks that have accepted estimates of the overfishing limit (OFL; the catch that is expected to achieve the fishing mortality threshold (FMT)). The control rule is based on the P* (probability of overfishing) approach, which is used to calculate a catch level that is expected to achieve a pre-specified probability (P*) of exceeding the maximum fishing mortality rate reference point. In addition to the P*, which is specified by the MAFMC (Figure 1), the control rule requires a probability distribution for the OFL to describe uncertainty. Because of the difficulty in accurately quantifying the total uncertainty in the OFL, the SSC currently specifies a distribution for the OFL. The point estimate of the OFL from the stock assessment is used as the median of a lognormal distribution with a coefficient of variation (CV) specified by the SSC.

The true uncertainty in the OFL is needed to achieve the MAFMC's goal of a catch limit that meets a specific probability of overfishing. If the CV of the OFL is underestimated, the probability of overfishing will be higher than desired, and, conversely, if the CV of the OFL is too high, then the probability of overfishing will be lower than specified by the Council. The OFL CV is uncertain and difficult to estimate accurately. Three primary sources of uncertainty affect uncertainty in the OFL: uncertainty in the current stock biomass, uncertainty in the FMT and the OFL that is derived from it, and uncertainty from projecting into the future. Uncertainties in biomass and OFL derive from similar sources. Uncertainty is introduced by sampling variability when data are collected. Additional uncertainty is introduced as a result of assumptions and parameter estimates used in the assessment models. Because~~Since~~ assessment models are simplifications of the real-world, important uncertainties may be entirely uncharacterized. Therefore, the OFL is subject to substantial uncertainty, and the true uncertainty (instead of assessment model precision) is very difficult to estimate.

The SSC believes that no single model or even ensemble of models can fully capture un~~the full~~ assessment uncertainty. Rigorous consideration of key assessment parameters and assumptions and comparison among model simulations can improve one's understanding of the true but essentially unknowable uncertainty. This document describes the criteria used for determination of bins of uncertainty levels. The ABC is derived from the OFL by assigning the assessment to an appropriate uncertainty bin. Ultimately, the final determination is dependent on expert judgement and qualitative evaluation of a suite of factors that affect uncertainty of the OFL.

The MAFMC SSC has used a range of values, 60-150%, for the CV of the OFL distribution in determining the ABC. However, the ~~SSC,~~ MAFMC,~~ and~~ stakeholders, and even the SSC itself have questioned the rationale for various values of the OFL CV that have been applied by the SSC as well as the consistency underlying the decisions about OFL CVs among assessed stocks. When the ABC control rule was initially adopted, a default amount of uncertainty was estimated from a meta-analysis of accuracy of estimates from simulation studies of statistical catch-at-age model performance, including the uncertainty in biomass in the last year, uncertainty in the fishing mortality reference point, and their covariance[1]. This analysis indicated that a CV = 100% was a reasonable value for the average CV of the OFL distribution. Since that time, the SSC has chosen CVs for the OFL distribution that differ among stocks (Figure 2~~1~~, Table 1).

New research[2] looking across many jurisdictions and stock assessments has quantified the level of uncertainty in the OFL estimate among multiple assessments of the same stock. This "inter-assessment consistency" sets a lower bound on the true uncertainty in the OFL, i.e., it is only equal to the true uncertainty if the estimates are centered on the true (but unknown) OFL. Results from this study suggest that the range of OFL CV bins used by the MAFMC SSC is reasonable, and perhaps a bit optimistic on the 60% end. Therefore, unless a stock meets the criteria defined below for a 60% CV, which are largely dependent on data quality rather than assessment decisions, 100% CV will be the minimum uncertainty by default.

The SSC's intent for this document is to elevate confidence in ABC recommendations by continuing to develop and implement~~establishing~~ a replicable process that meets Council risk policy objectives and identifies relevant components of assessment uncertainty to be provided to the SSC. The approach outlined here will not resolve all scientific uncertainties and problems, and exceptions will arise that are not specifically addressed in this document; however, this approach should help alleviate many issues and provide a clear, consistent, and transparent process that documents the SSC deliberations and conclusions.

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[1] For more information, please see the SSC white paper titled "Description and Foundation of the Mid-Atlantic Fishery Management Council's Acceptable Biological Catch Control Rule" found at: http://www.mafmc.org/s/MAFMC-ABC-Control-Rule-White-Paper.pdf.

[2] Bi, R., Collier, C., Mann, R., Mills, K.E., Saba, V., Wiedenmann, J. and Jensen, O.P., 2023. How consistent is the advice from stock assessments? Empirical estimates of inter-assessment bias and uncertainty for marine fish and invertebrate stocks. Fish and Fisheries, 24(1), pp.126-141.

The SSC's approach to setting OFL CVs is intended to:

- ~~Result in~~Lead to prudent decisions for catch advice that are consistent in meeting the objectives of the Council's Risk Policy;
- Be based on clear decision criteria that are consistently applied across stocks; and
- Be supportable with scientific evidence.

Decision Criteria

The SSC originally included~~agreed to consider~~ nine decision criteria to help define an appropriate OFL CV when setting new or revised ABC recommendations. Several years after initial implementation, the SSC reviewed the application and relevance of all nine criteria and reduced the number of criteria to six. All six decision criteria will be considered by the SSC; however, the relative importance and "weighting" of each criteria may~~will~~ be different for each stock~~species~~ and consistent with the approaches and analyses evaluated within each assessment framework. In addition, while these criteria were specifically developed to help in SSC deliberations, they may also be helpful to stock assessment workgroups as they consider and evaluate data and model appropriateness and uncertainty.

The ~~nine~~six decision criteria are provided below with supporting language that generally describes the considerations and ideal information the SSC may utilize when considering each criterion.

Of the six criteria considered for setting an overall CV for the OFL, three stand out as the most critical: 1. Data quality; 2. Model appropriateness and identification during the assessment process; and 3. Informed by retrospective pattern. For example, the overall OFL CV should not be lower than the ranking for data quality, as data quality determines uncertainty throughout the assessment process -- an excellent model cannot overcome substantial data deficiencies. Even with data of good quality, poor model choice, or large retrospective patterns in the data due to factors other than data collection, can also seriously and negatively affect the overall CV uncertainty. Therefore, when evaluating all six criteria, the choice of an overall CV value for the OFL should be no lower than the value of the lowest CV value for any of the first three criteria, collectively called Tier 1 criteria.

1. **Data quality**
    a. Types and quality of available data are primary determinants of the accuracy of any assessment model;
        i. Therefore, this criteria is weighted higher than all others;
    b. Important fishery-independent data considerations include survey design, coverage (of the unit stock area), and efficiency of survey gear;
        i. 0% CV in simulation studies was achieved when survey indices were accurate. In the real world, important considerations for achieving this criterion is that the survey coverage matches the stock's range in time and space;

ii. Missing temporal and spatial survey coverage in areas important to a species increases uncertainty;

c. Fishery-dependent considerations include accuracy and precision of landings and discards;

i. 60% CV in simulation involved fishery catch being known with low uncertainty, e.g., <10%

ii. For some species, data quality (e.g., predominance of recreational catch) often leads to inherently higher uncertainty that cannot be overcome by low uncertainty in other criteria below;

iii. Need informative data to do a stock assessment (would replace criterion 8): the fishery needs to have a measurable effect on the population for typical stock assessments to perform well;

d. Availability of age and/or length data for fishery-independent and dependent sources; validity of underlying assumptions and any potential data borrowing (i.e., gap filling);

~~iv.~~i. 60% CV in simulation involved age data being accurate and highly precise (i.e., no aging error and a random sample from the catch or survey);

e. Data in support of key model parameters;~~.~~

~~v.~~i. 60% CV in simulation has M specified at the correct value and appropriate models for catchability and selectivity.

2. Model appropriateness and identification during the assessment process

a. Model selection process and tests are important for choosing assessment models that are likely to be more accurate (e.g., model sensitivities within a given model structure);

b. Comparison among the assessment baseline model and models with different structures is important to determine the effects of assumptions;

i. In general, multiple models providing similar information and trends are assigned the lowest uncertainty bin, however:

ii. Diverging models do not necessarily indicate increased uncertainty. In many cases, models with different assumptions should provide different estimates. If the causes of differences among models are understood, it may still be assigned a lower uncertainty;

iii. In addition, not all models are equal and some assessment models are known to provide more accurate estimates than other approaches;

~~i.~~iv. Consistency among models may be because of data processing decisions (e.g., assumptions about age-length keys) rather than model structure;

~~b.~~c. Model appropriateness in capturing species and fishery specific traits, such as biological characteristics, life history patterns, spatial/stock structure, and fleets;

d. Amount of model testing with consistent or divergent estimates (particularly for management relevant quantities like the OFL or stock status);~~.~~

e. Appropriateness of model assumptions during the projection period resulting in the catch advice;

~~e.~~f. Current criterion #9 (informed by MSE) could be accounted for here if available in the future.

3. **Informed by retrospective analysis**
   a. Retrospective pattern is evidence of model misspecification and suggests directionality of change with respect to "true" or at least improved model rather than an unspecified set of alternative models;
   b. Recent research[3] suggests that adjustments for retrospective bias perform better than data-limited methods but this adjustment introduces an additional source of uncertainty
   ~~b.~~c. Comparison of the adjusted OFL to the uncertainty of the OFL estimated from the baseline model to determine if retrospective pattern is a larger portion of uncertainty.

4. **Model estimates ~~i~~Informed by comparison with empirical or experimental~~simpler~~ analyses**
   a. Swept area biomass or gear comparisons that suggest appropriate minimum scale of population (maximum gear efficiency, fishing or natural mortality or migration from tagging studies, discard mortality studies etc.);
   b. Comparison with other empirical or simpler measures of trend; e.g., survey Z, Beverton-Holt length-based Z.

5. **Informed by ecosystem factors or comparisons with other species**
   a. Ecosystem factors considered may reduce or increase uncertainty; simply considering an ecosystem factor does not automatically decrease uncertainty;
   ~~a.~~b. Stock-relevant ecosystem factors directly included in the assessment model, e.g.,:
      - Environmentally dependent growth or other population processes;
      - Environmentally dependent availability or other observation processes;
      - Factors limiting/enhancing stock productivity (habitat quality, etc.);
      - Predation, disease, or episodic environmental mortality (e.g., red tide);
      - Time varying inputs such as empirical weight at age or stanzas of growth not explicitly tied to ecosystem factors are considered under criterion #2, not here. Stanzas of recruitment not explicitly tied to ecosystem factors are considered under criterion #6;
   ~~b.~~c. Ecosystem factors outside the stock assessment affecting short term prediction can inform uncertainty, e.g.,:
      - General measures of ecosystem productivity and habitat stability (e.g., primary production amount and timing, temperature trends, and other

[3] Legault, C.M., Wiedenmann, J., Deroba, J.J., Fay, G., Miller, T.J., Brooks, E.N., Bell, R.J., Langan, J.A., Cournane, J.M., Jones, A.W. and Muffley, B., 2022. Data-rich but model-resistant: an evaluation of data-limited methods to manage fisheries with failed age-based stock assessments. Canadian Journal of Fisheries and Aquatic Sciences, 80(1), pp.27-42.

MAFMC EAFM risk assessment indicators at the stock or ecosystem level~~etc.~~);

- ~~Comparisons among related species; e.g., recruitment, growth, condition patterns across Mid Atlantic fish species stable, varying synchronously, or varying unpredictably;~~
- Climate vulnerability or other risk assessment evaluation of potential for changing productivity under changing conditions;~~.~~
- Acute ecosystem events potentially affecting stock dynamics across the stock range in over the short term (e.g., marine heat waves, acidification or hypoxia events, harmful algal blooms);

~~c.~~d. Comparisons among related species; e.g., recruitment, growth, condition patterns across Mid Atlantic fish species that are: stable (low uncertainty), varying synchronously (supports common environmental driver, lower uncertainty), or varying unpredictably (higher uncertainty).

6. **Informed by ~~measures of trend~~ appropriate stanzas in recruitment (primarily affecting the accuracy of forecasts)**
   a. Uncertainty increases as recruitment patterns become less consistent, or if there is no recruitment estimate to inform short term predictions;
   b. Potentially decreased uncertainty if linked to environmental driver (see above);
   ~~a.~~ Uncertainty can be mitigated by using s~~S~~tanzas of abundance for recruits;
   ~~b.~~c. Decreasing R/SSB as SSB decreases (evidence of depensation). Depending on degree of depensation observed, an ABC set to zero may be warranted.

~~7. **Informed by prediction error**~~
   ~~a. Comparisons of model performance given prior assessments;~~
   ~~b. Consistency among repeated assessments should be considered in light of changes in the best available information or understanding of stock and fishery dynamics.~~

~~8. **Assessment accuracy under different fishing pressures**~~
   ~~a. Age-structured assessment approaches are generally more accurate under higher fishing mortality rates relative to natural mortality;~~
   ~~b. Non-age-structured assessment approaches may require specific patterns in the data to be highly accurate (e.g., high contrast in abundance and fishing pressure for a production model);~~
   ~~c. Prediction error and dynamic trends (e.g., decadal periods) in fishing selectivity patterns.~~

~~9. **Informed by simulation analysis or full MSE**~~
   ~~a. Simulation analyses can be used to test how robust assessment approaches or management strategies are to specific misspecifications in the models or issues in the data.~~

General Framework Discussion Table

The framework table is intended to provide qualitative assessment of the nine criteria and is not to be used to tabulate a specific score. Instead, the table will help the SSC document deliberations, ensure a consistent process is followed for all species and assessments, and help the Council and public understand the rationale for the decision reached by the SSC.

The table currently has OFL CV default values (bins) of 60%, 100%, and 150%,~~ and~~which were derived from a variety of simulation analyses, MSE evaluations, and expert judg~~e~~ment by the SSC. As new information, analyses, and assessment methods become available, the SSC may modify the default OFL CV bins or recommend a different OFL CV for a specific species assessment. If any changes to the current default OFL CV values are warranted, the SSC will provide justification and supporting documentation as to why a different value was recommended.

The framework table below provides general evaluation metrics associated with the ~~nine~~six decision criteria for each OFL CV bin. The focus of this table is to characterize uncertainty for the catch specification period for the stock (next 2-6 years).

Decision Criteria	Default OFL CV=60%	Default OFL CV=100%	Default OFL CV=150%
Data quality	One or more synoptic surveys of~~ver~~ the whole stock area for multiple years. High quality monitoring of landings and size and age composition. Long term, precise monitoring of discards. Landings estimates highly accurate.	Low precision synoptic surveys or one or more regional surveys which lack coherency in trend. Age and/or length data available with uncertain quality. Lacking or imprecise discard estimates. Moderate accuracy of landings estimates.	No reliable abundance indices. Catch estimates are unreliable. No age and/or length data available or highly uncertain. Natural mortality rates are unknown or suspected to be highly variable. Incomplete or highly uncertain landings estimates.
Model appropriateness and identification process	Multiple differently structured models agree on outputs; many sensitivities explored. Model appropriately captures/considers species life history and spatial/stock structure.	Single model structure with many parameter sensitivities explored. Moderate agreement among different model runs indicating low sensitivities of model results to specific parameterization.	Highly divergent outputs from multiple models without indication of which scenario is most likely or no exploration of alternative model structures or sensitivities.
Retrospective analysis (consideration of quantifying differences)	Minor retrospective patterns (e.g., < 65% outside confidence region).	Moderate retrospective patterns (66%-95% outside the confidence region).	No retrospective analysis or severe retrospective patterns (e.g., terminal year values adjusted and outside confidence region).
Comparison with empirical measures or ~~simpler~~experimental analyses	Assessment biomass and/or fishing mortality estimates compare favorably with empirical estimates.	Moderate agreement between assessment estimates and empirical estimates or simpler analyses.	Estimates of scale are difficult to reconcile and/or no empirical estimates.

Ecosystem factors accounted	Assessment considers~~ed~~ habitat and ecosystem effects on stock productivity, distribution, mortality and quantitatively includes~~d~~ appropriate factors reducing uncertainty in short term predictions. And/or e~~E~~vidence outside the assessment suggests that ecosystem productivity and habitat quality are stable. And/or ecosystem events affecting stock in the short term are absent. And/or c~~C~~omparable species in the region have synchronous production characteristics and stable short-term predictions. And/or c~~C~~limate vulnerability analysis suggests low risk of change in productivity due to changing climate.	Assessment considers~~ed~~ habitat/ecosystem factors but does~~id~~ not demonstrate either reduced or inflated short-term prediction uncertainty based on these factors. And/or e~~E~~vidence outside the assessment suggests that ecosystem productivity and habitat quality are variable~~, with mixed productivity and uncertainty signals among comparable species in the region~~. And/or acute ecosystem events are likely to have a low to moderate risk of affecting the stock in the short term. And/or mixed productivity and uncertainty signals among comparable species in the region. And/or c~~C~~limate vulnerability analysis suggests moderate risk of change in productivity from changing climate.	Assessment either demonstrates~~d~~ that including appropriate ecosystem/habitat factors increases short-term prediction uncertainty, or does~~id~~ not consider habitat and ecosystem factors. And/or e~~E~~vidence outside the assessment suggests that ecosystem productivity and habitat quality are variable and degrading. And/or acute ecosystem events are likely to have a high risk of affecting the stock in the short term. And/or c~~C~~omparable species in the region have high uncertainty in short term predictions. And/or c~~C~~limate vulnerability analysis suggests high risk of changing productivity from changing climate.
Appropriate stanzas~~Trend~~ in recruitment	Consistent recruitment pattern with no trend.	Moderate levels of recruitment variability or modest consistency in pattern or trends. OFL estimates adjusted for recent trends in recruitment. OFL estimate appropriately accounted for recent trends in recruitment.	Recruitment pattern highly inconsistent and variable. Recruitment trend not considered or no recruitment estimate.
~~Prediction error~~	~~Low estimate of recent prediction error.~~	~~Moderate estimate of recent prediction error.~~	~~High or no estimate of recent prediction error.~~
~~Assessment accuracy under different fishing pressures~~	~~High degree of contrast in landings and surveys with apparent response in indices to changes in removals. Fishing mortality at levels expected to influence population dynamics in recent years.~~	~~Moderate agreement in the surveys to changes in catches. Observed moderate fishing mortality in fishery (i.e., lack of high fishing mortality in recent years).~~	~~Relatively little change in surveys or catches over time. Low precision of estimates. Low fishing mortality in recent years. "One-way" trips for production models.~~
~~Simulation analysis/MSE~~	~~Can be used to evaluate different combinations of uncertainties and indicate the most appropriate OFL CV for a particular stock assessment.~~		

A worked example evaluation of the ~~nine~~six criteria provided in the table above is provided for Summer Flounder (see page 8).

Process for OFL Determination

The SSC's consideration, evaluation, and discussion of the ~~nine~~six decision criteria in determining the appropriate OFL CV level could potentially become cumbersome and time-consuming to be handled effectively during an SSC meeting, particularly if multiple species-specific ABC recommendations are required. In an effort to add efficiency to the ABC-setting process while still allowing for extensive SSC input and discussion, the SSC species lead will develop a pre-decisional, non-binding document evaluating the ~~nine~~six decision criteria ahead of the SSC meeting. This document will then be posted as part of the SSC meeting materials and available to SSC members for review ahead of the meeting in which an ABC recommendation is required. The process~~-~~ for developing the pre-decisional document and the SSC's OFL CV determination will follow the steps outlined below:

- Upon completion of a stock assessment, the appropriate SSC species lead, seeking input on critical factors and information to highlight from the stock assessment lead and Council staff as necessary, will evaluate the ~~nine~~six decision criteria and develop a draft summary document that provides an overview of relevant assessment information, key findings, and any additional pertinent information for each decision criteria. The summary document would also include a draft narrative (see example narrative on page 10 below) that identifies the most important decision criteria specific to the species and stock assessment under consideration and highlights any other relevant information. The narrative would not include an OFL CV recommendation.
- ~~The draft summary document would then be provided to a sub-group comprising the SSC chair, vice-chair, and Council staff for review and feedback. This sub-group will review the information and draft narrative to help ensure consistency in the interpretation and evaluation of the decision criteria.~~
- The draft summary document and narrative will be provided to the full SSC and posted as part of the meeting materials in advance of the meeting in which the ABC recommendations will be made.
- During the SSC deliberations to address the ABC Terms of Reference, the SSC species lead will provide an overview of the pertinent information associated with the ~~nine~~six decision criteria and draft narrative.
- SSC members present at the meeting will then discuss and deliberate any/all information available in order to make an OFL CV recommendation. The SSC meeting summary report will contain both the completed framework table with an evaluation and rationale of the ~~nine~~six decision criteria and a summary narrative. Providing both the framework table and narrative in the meeting summary will help provide a comprehensive record of the SSC's deliberations and justification for their recommendation for future reference.

Given the additional work and preparation necessary prior to a scheduled SSC meeting as outlined above, increased coordination among the SSC, NEFSC, and Council staff will be critical to ensure stock assessment documents and information are available in a timely manner. Ideally, stock assessment documents and any other pertinent information would be available at least three weeks prior to the scheduled SSC meeting. The SSC species lead would provide the draft summary document to the SSC chair, vice chair, assessment lead, and Council staff at least two weeks prior to the scheduled SSC meeting for review and feedback. The draft summary document would then be available to the SSC and posted to the meeting materials at least one week prior to the scheduled SSC meeting. In addition, continued SSC involvement in the NRCC stock assessment process[4] that includes research track and management track assessments ~~SAW/SARC process~~ (i.e., chairing ~~SAW/SARC~~ research track and management track assessment reviews, embedding with the assessment work group) will play a critical and informative role in the process to help ensure the timing and deadlines are achieved.

Worked Example [to be updated – pending SSC review of scup example]

Below is a worked example for Summer Flounder based on the results of the 2018 benchmark assessment. The worked example includes the SSC OFL recommendation, an evaluation of the ~~nine~~six decision criteria as outlined in the framework table and a short narrative documenting key conclusions.

Based on an evaluation of the ~~nine~~six decision criteria, the SSC recommends a CV of 60% be applied to the OFL estimate as an appropriate ABC for Summer Flounder in fishing years 2019-2021.

Decision Criteria	Default OFL CV=60%	Default OFL CV=100%	Default OFL CV=150%
Data quality	Two synoptic surveys (fall and spring) are available for all years in assessment. Additionally, 13 regional surveys are used in model tuning. Time series for R/V Albatross IV and R/V Bigelow treated separately for spring and fall trawl surveys. Bigelow estimates adjusted for results of cooperative research studies on gear efficiency. Age data available for all years in surveys, and age-length keys from surveys were applied to commercial landings, recreational landings, and commercial discards. Recreational and commercial discards are low and measured with good precision. Sex-specific information available for growth. Newly revised historical MRIP catch estimates were used in assessment.		
Model appropriateness and identification process	Models incorporating age and sex-specific growth and mortality rates were developed, tested, and reviewed. Multiple models by different assessment teams were considered. ASAP was preferred assessment model but SS and other statistical catch-at-age models were considered. These include models with age and sex-dependent rates of natural mortality, growth, and fishery selectivity. However, additional work on the more complicated models is needed to		

[4] For more information, please see: New England and Mid-Atlantic Region Stock Assessment Process (updated Feb 2022)

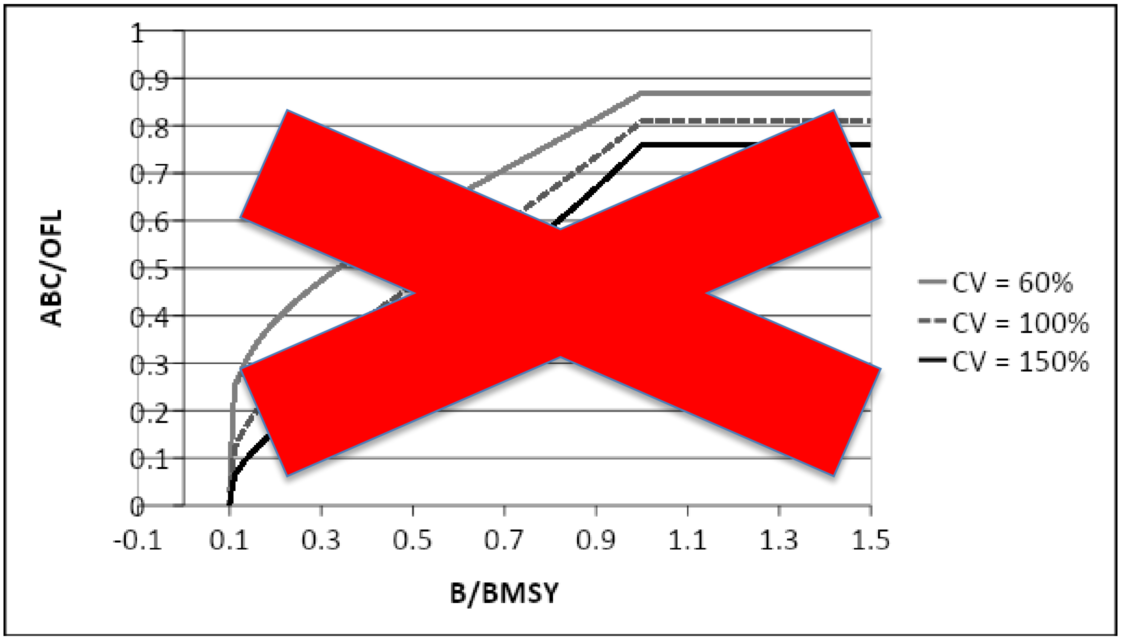
	appropriately evaluate to the single sex models.		
Retrospective analysis	Retrospective pattern in current assessment is minor with retrospective errors over the last 7 terminal years averaging -4% for F, +2% for SSB, and +2% for recruitment. These retrospective errors are about one-tenth as large as their magnitude in the previous benchmark assessment. Historical retrospective comparisons show general trends of fishing mortality, stock biomass, and recruitment have been consistent since the 1990s assessments.		
Comparison with empirical measures or simpler analyses	Assessment biomass and/or fishing mortality estimates compare favorably with empirical estimates. Results of cooperative research gear experiments were used to adjust scale of biomass indices used in model tuning.		
Ecosystem factors accounted		Aspects of the ecosystem seem to be changing in recent years. Fall ocean bottom and surface temperatures are increasing, and salinity is at or near the historical high. These physical data series may have shifted around 2012, the warmest year on record for this ecosystem. Spring chlorophyll concentrations, a measure of bottom-up ecosystem production in the Summer Flounder stock area, are variable, but the fall time series has been decreasing, especially during 2013-2017. Spring abundances for key zooplankton prey are variable and may be worth examining alongside recruitment patterns for future research. Both probability of occurrence and modeled habitat area show similar patterns of increases from the 1990s to the present, which suggests, despite reduced abundance in the past five years, the distribution footprint of Summer Flounder has not contracted.	
Trend in recruitment		Average recruitment from 1982 to 2017 is 53 million fish at age 0. Recruitment has been below average since 2011, averaging 36 million fish. Overall recruitment variability is modest and it is not possible to determine if recent decline is statistically significant. Projections do not account for recruitment trend.	

Prediction error	Prior to the 2018 benchmark, comparisons of annual forecasts of stock biomass with realized estimates of stock biomass in subsequent assessments reveal a one-year ahead forecasting error with a CV=14%. For two-year forecasts the CV is 26% and for 3-year forecasts the CV= 26%. The average percentage difference between the projection and the subsequent estimate for 1-, 2-, and 3-yr projections was +12%, +23%, and +24%, respectively. Inclusion of the revised MRIP data increased the population scale, rendering prediction comparisons less useful as a metric of model performance.		
Assessment accuracy under different fishing pressures		Fishing mortality has varied over a 6-fold range over the assessment period with major decline since imposition of effective management measures around 2000. This range of fishing mortalities, subsequent fluctuations in total abundance, and success of management changes suggest a moderate level of confidence in assessment results.	
Simulation analysis/MSE	No formal MSE-type analyses have been conducted for this stock.		

Example OFL CV Recommendation Narrative [to be updated – pending SSC review of scup example]

This is a data rich stock assessment and one of the most comprehensive in the Northeast US. Two synoptic surveys (fall and spring) are available for all years and multiple regional surveys are used in model tuning. Age data are available for all years in surveys, commercial landings, recreational landings, and commercial discards. Recreational and commercial discards are low and measured with good precision. The newly revised MRIP catch estimates were incorporated into the assessment for the first time. Extensive work on alternative model formulations (including size- and sex-based models) have been conducted by independent assessment teams. Spatial variations in catch rates by sex and fisheries have been examined. Multiple model formulations have been systematically evaluated. More complicated models have not been judged superior to single-sex models. The retrospective pattern for the current assessment is exceptionally low and comparisons of biomass estimates across historical assessments show good agreements with trend. Estimates of prediction error for 1- to 3-year forecasts are less than 25%. The stock has experienced a wide range of fishing mortality rates and appears to have responded as predicted by theory to aggressive management measures in the early 2000s; this suggests a high level of confidence in the results.

Consideration of ecosystem factors apart from the model suggest some cause for concern as increases in temperature and salinity have occurred, especially since 2012. It is too early to tell if changes in chlorophyll indices and zooplankton abundance are related to recent reductions (about 31% decline) in average recruitment in this same period.



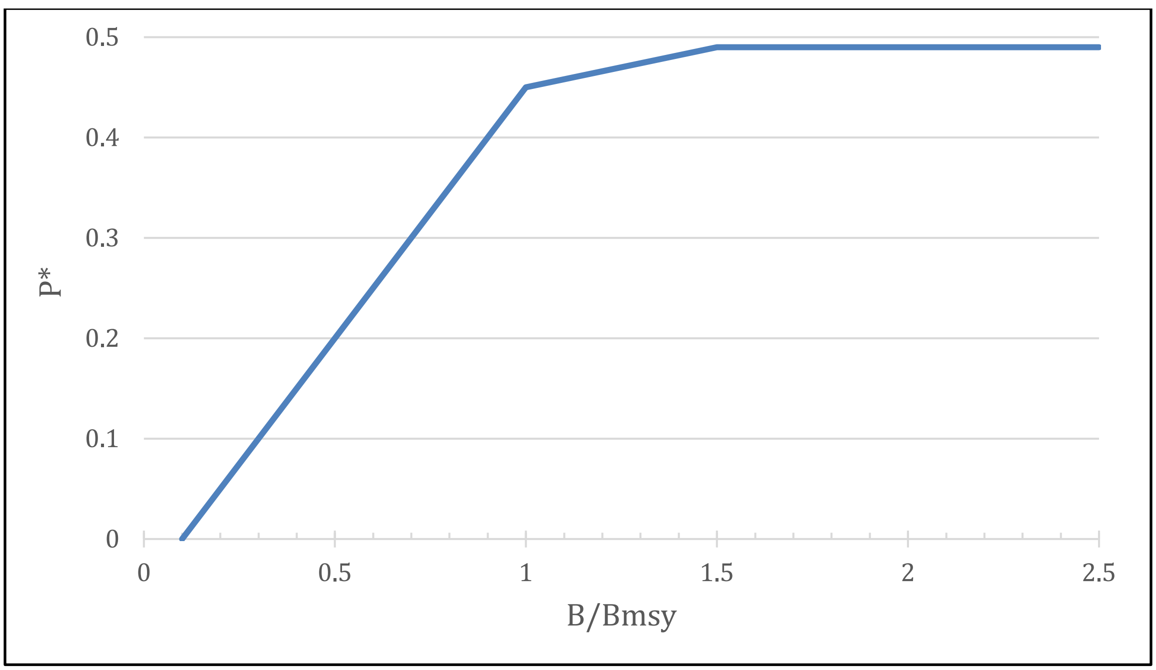


Figure 1. Acceptable probability of overfishing (P*) as a function of stock size adopted by the MAFMC (December 2020). The acceptable probability of overfishing is zero if relative biomass (projected biomass divided by the expected biomass if the stock was fished at the maximum fishing mortality rate threshold) is less than 0.1. The acceptable probability of overfishing increases to 0.45 as relative biomass approaches 1 and then increases to its threshold of 0.49 as the relative biomass approaches 1.5.

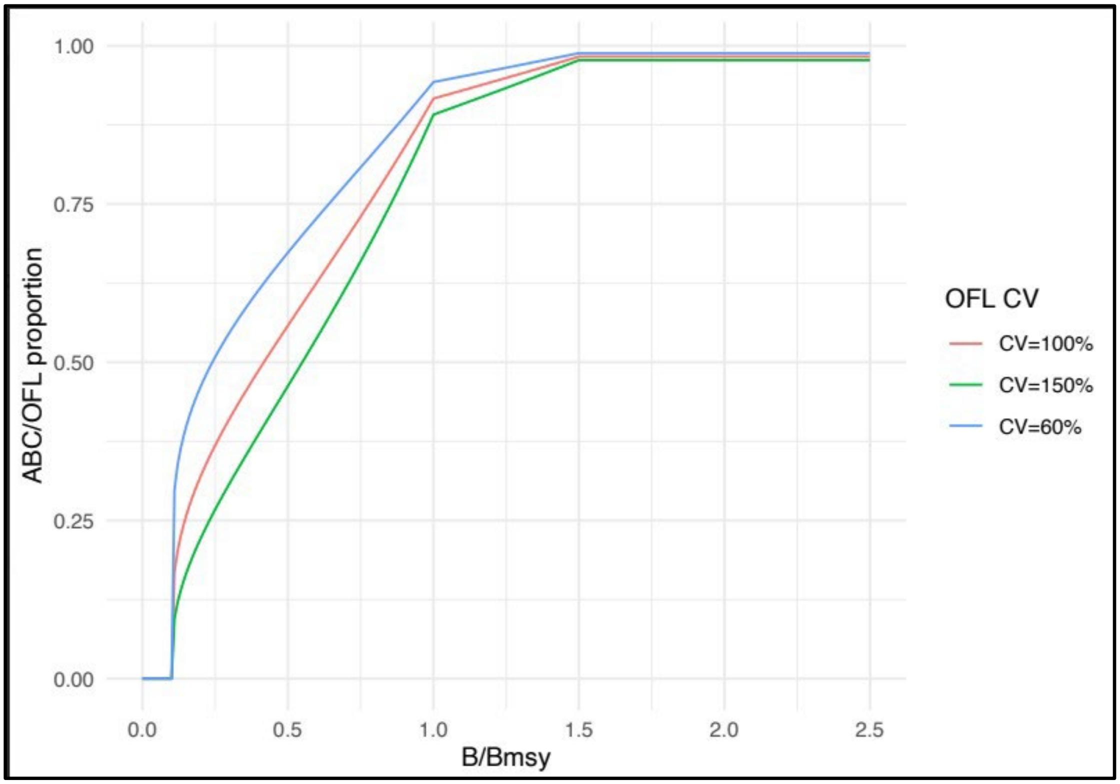


Figure 2~~1~~. Effect of different CV values currently selected by the MAFMC SSC on the ratio of ABC to OFL for varying levels of biomass relative to the B_{MSY} as determined by the Council's risk policy (revised in 2021). Note that the decision on OFL CV makes the most difference for stocks with low biomass status.

Table 1. Example Acceptable Biological Catch (ABC) values derived from the application of the Mid-Atlantic Council's under the currently used OFL CV values. ABC values are in MT and assume an OFL of 1,000 MT. Note: stocks with a B/Bmsy ratio of ≤ 0.5 would be subject to a rebuilding plan and ABCs would be established as part of the rebuilding plan approved by the Council which may/may not be determined using the standard application of the risk policy and ABC control rule.

B/Bmsy ratio	ABC with a 60% OFL CV	ABC with a 100% OFL CV	ABC with a 150% OFL CV
≥ 1.50	986.2	979.3	973.2
1.25	959.1	939.3	921.5
1.00	932.7	900.7	872.5
0.75	777.5	685.4	611.0
0.50	627.1	496.2	401.0
0.25	450.1	301.6	209.5
0.10	0.0	0.0	0.0