SSC WORKSHOP ON RISK TABLES: FRAMEWORKS FOR ADDRESSING UNCERTAINTY PART I

MARTIN DORN

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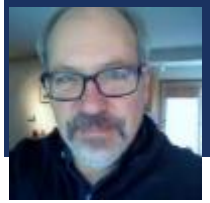


TOPICS COVERED

- Genesis of the tier system
- What do existing buffers in the NPFMC Tier system accomplish?
- What additional role do risk tables accomplish?
- 2006 Magnuson Act reauthorization and NS 1 guidelines.
- P* approach
- P* in the Pacific Council
- P* in the Mid-Atlantic Council
- A final thought

GENESIS OF THE TIER SYSTEM

- 1992-1996: Many iterations of early versions on of the tier system.
  - Controversies over appropriate limit and target fishing mortality reference points.
  - Controversies of appropriate proxies for FMSY and BMSY.
- Groundfish tier system in its present form dates from 1999.
- Given its performance over the last 20 years it would have to be considered highly successful (both nationally and internationally).
- References:
- Goodman et al. 2002. Scientific review of the harvest strategy currently used in the BSAI and GOA groundfish fishery management plans
- DiCosimo et al. 2010.Use of annual catch limits to avoid stock depletion in the Northeast Pacific

Table 1. Description of the groundfish tier system used by NPFMC since 1999 for defining fishing–mortality rate related to overfishing level (F_{OFL}) and to acceptable biological catch (F_{ABC}) based on the type of information available (Info).

Tier 1	Info: reliable point estimates of B and B_{MSY} and reliable pdf of F_{MSY}	
	(1a)	Stock status: $B/B_{MSY} > 1$
		$F_{OFL} = m_A$: $F_{ABC} \times m_H$
	(1b)	Stock status: $a < B/B_{MSY} \leq 1$
		$F_{OFL} = m_A \times (B/B_{MSY} - a)/(1 - a)$; $F_{ABC} \leq m_H \leq (B/B_{MSY} - a)/(1 - a)$
	(1c)	Stock status: $B/B_{MSY} \times a$
		$F_{OFL} = F_{ABC} = 0$
Tier 2	Info: reliable point estimates of B, B_{MSY}, F_{MSY}, $F_{35\%}$, and $F_{40\%}$	
	(2a)	Stock status: $B/B_{MSY} > 1$
		$F_{OFL} = F_{MSY}$; $F_{ABC} \leq F_{MSY} \times (F_{40\%}/F_{35\%})$
	(2b)	Stock status: $a < B/B_{MSY} \times 1$
		$F_{OFL} = F_{MSY} \times (B/B_{MSY} - a)/(1 - a)$; $F_{ABC} \leq F_{MSY} \times (F_{40\%}/F_{35\%}) \times (B/B_{MSY} - a)/(1 - a)$
	(2c)	Stock status: $B/B_{MSY} \leq a$
		$F_{OFL} = F_{ABC} = 0$
Tier 3	Info: reliable point estimates of B, $B_{40\%}$, $F_{35\%}$, and $F_{40\%}$	
	(3a)	Stock status: $B/B_{40\%} > 1$
		$F_{OFL} = F_{35\%}$; $F_{ABC} \leq F_{40\%}$
	(3b)	Stock status: $a < B/B_{40\%} \leq 1$
		$F_{OFL} = F_{35\%} \times (B/B_{40\%} - a)/(1 - a)$; $F_{ABC} \leq F_{40\%} \times (B/B_{40\%} - a)/(1 - a)$
	(3c)	Stock status: $B/B_{40\%} \leq a$
		$F_{OFL} = F_{ABC} = 0$
Tier 4	Info: reliable point estimates of B, $F_{35\%}$, and $F_{40\%}$	
		$F_{OFL} = F_{35\%}$; $F_{ABC} \leq F_{40\%}$
Tier 5	Info: reliable point estimates of B and natural mortality rate M	
		$F_{OFL} = M$; $F_{ABC} \leq 0.75 \times M$
Tier 6	Info: reliable catch history from 1978 to 1995	
		OFL = average catch (1978–1995), unless otherwise established by SSC; ABC $\leq 0.75 \times$ OFL

WHERE DOES SCIENTIFIC UNCERTAINTY COME IN?

- From the FMP:
- “The above control rule is intended to account for scientific uncertainty in two ways:
- First, the control rule is structured explicitly in terms of the type of information available, which is related qualitatively to the amount of scientific uncertainty.
- Second, the size of the buffer between maxFABC in Tier 1 of the ABC control rule and FOFL in Tier 1 of the OFL control rule varies directly with the amount of scientific uncertainty.
- For the information levels associated with the remaining tiers, relating the buffer between maxFABC and FOFL to the amount of scientific uncertainty is more difficult because the amount of scientific uncertainty is harder to quantify, so buffers of fixed size are used instead.”

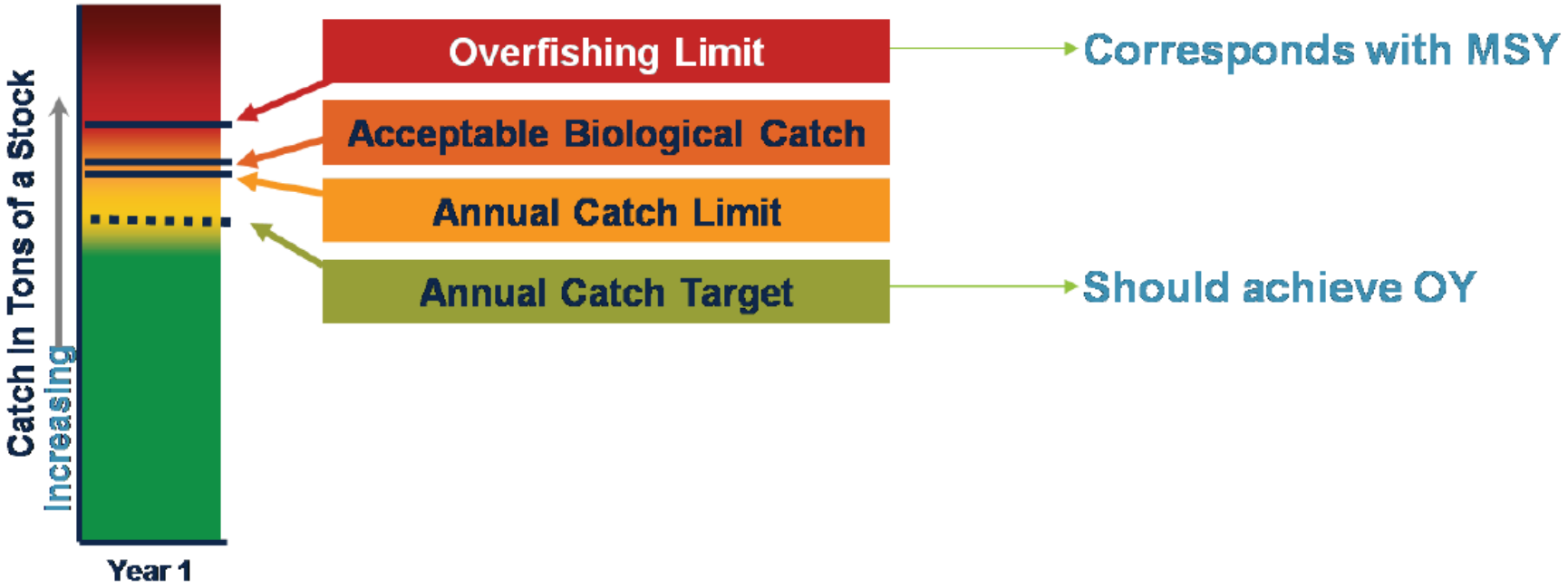
WHERE DOES SCIENTIFIC UNCERTAINTY COME IN? (MY POSSIBLY BIASED TAKE ON THIS)

- The primary type of uncertainty addressed in the tier system is the uncertainty in the stock production curve (i.e., the shape of the stock recruit relationship)
- This is true for Tier 1, Tier 3, and Tier 5, all of which have an OFL/ABC calculation based on FMSY or proxies thereof.
- ABCs are calculated using the point estimate of stock size (usually the MLE).
- For Tiers (1-5), if a reliable pdf of *B* is available, the preferred point estimate is the geometric mean of its pdf. But this provision is never used (except for EBS pollock?)
- Uncertainty in stock size is not dealt with in the tier system.

WHAT UNCERTAINTY DOES THE RISK TABLE CONSIDER?

- The NPFMC tier system uses the buffer between the OFL and ABC to implement precautionary management
- The SSC's intent is that the tier system should be regarded as the primary basis for establishing the ABC.
- Sloping harvest control rule for the ABC will substantially reduce the harvest rate when the stock is at a low abundance. This reduction in harvest rate addresses concerns related to low stock abundance.
- The risk table evaluates whether there is either additional uncertainty in the assessment and/or additional risks (probability of something bad happening) to the stock that are not adequately taken into account by the default precautionary settings.

2006 MAGNUSON ACT REAUTHORIZATION AND NATIONAL STANDARD 1 GUIDELINES



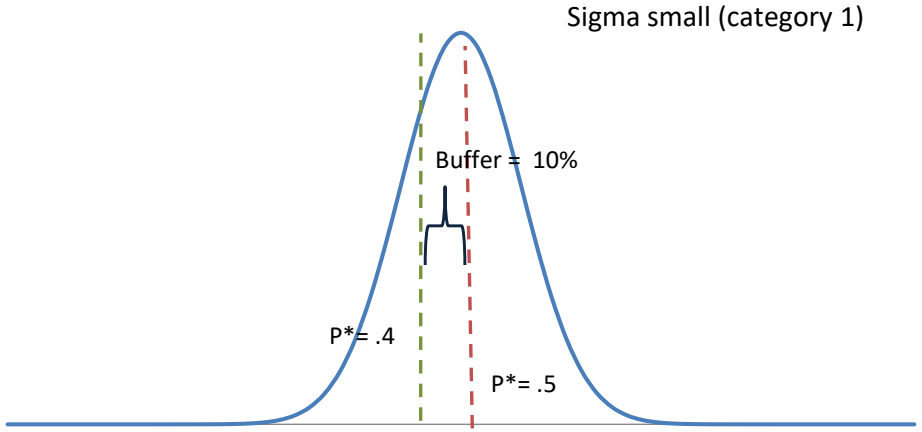
A BIG CHANGE

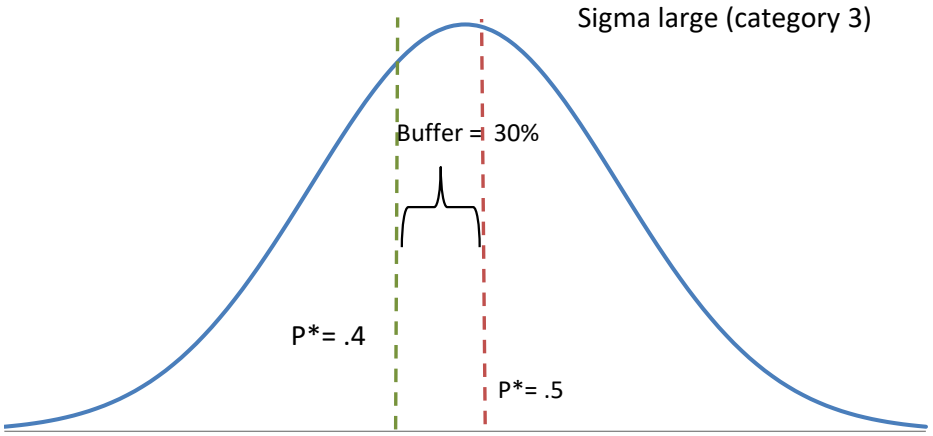
- *Acceptable biological catch (ABC) is a level of a stock or stock complex's annual catch that accounts for the scientific uncertainty in the estimate of OFL and any other scientific uncertainty (see paragraph (f)(3) of this section), and should be specified based on the ABC control rule. (National Standard 1, 2009)*
- *NMFS believes that determining the level of scientific uncertainty is not a matter of policy and is a technical matter best determined by stock assessment scientists as reviewed by peer review processes and SSCs. Determining the acceptable level of risk of overfishing that results from scientific uncertainty is the policy issue. The SSC must recommend an ABC to the Council after the Council advises the SSC what would be the acceptable probability that a catch equal to the ABC would result in overfishing. (National Standard 1, 2009)*

P-STAR APPROACH TO ACCOUNT FOR SCIENTIFIC UNCERTAINTY IN SETTING THE ABC (SHERTZER ET AL. 2008)

- Adopted by other Councils, including the Pacific Fishery Management Council (Ralston et al. 2010), Mid-Atlantic Fishery Management Council.
- Used by the NPFMC for crab harvest specification
- Approach:
- SSC adopts or specifies some level of uncertainty (sigma) (usually uncertainty in the OFL, but uncertainty ending biomass is also used)
- The Council specifies its p-star value, which is the acceptable probability of exceeding the OFL, which needs to be less than 0.5 to be in compliance with National Standard Guidelines.
- These two assumptions, along with an assumption about of the form of a probability density function, usually lognormal, produces a unique result for the buffer between OFL and ABC

ILLUSTRATION OF THE P-STAR APPROACH





QUANTIFYING UNCERTAINTY USING BETWEEN ASSESSMENT VARIATION (RALSTON ET AL. 2009)

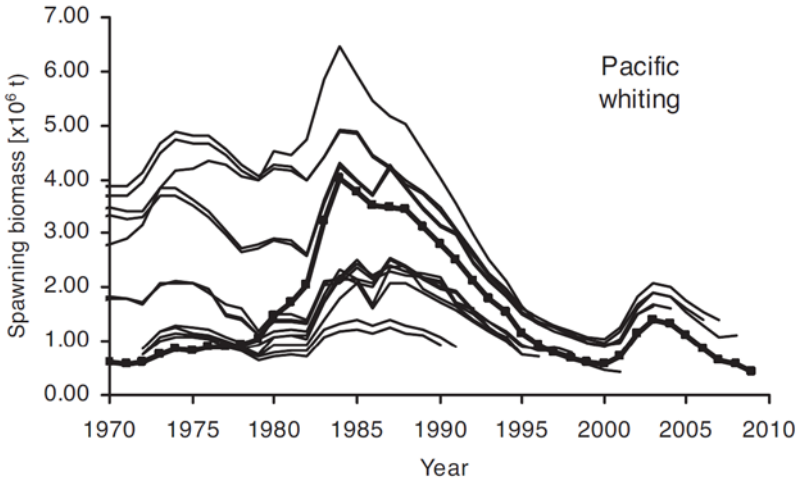


Figure 1

Biomass time series for Pacific whiting (*Merluccius productus*) based on 15 historical stock assessments conducted for the Pacific Fishery Management Council. The bold line with square symbols represents the most recent stock assessment used in the meta-analysis; the other lines represent time series of abundance developed from earlier assessments.

- Estimated coefficient of variation (C.V.) of the among-assessment variation in estimates of historical biomass
- Based on 81 assessments of 15 groundfish and 2 coastal pelagic stocks

PFMC IMPLEMENTATION

- Sigma = 0.36 (unless estimated ending year uncertainty is larger that 0.36)
- Three stock categories:
  - Category 1: Data rich, Age/size structured assessment with year-class estimation.
  - Category 2: Data moderate, Aggregate production model, M*survey biomass, year classes not resolved, or highly uncertain category 1 assessment
  - Category 3: Data poor. Average catch assessment.
- Sigma for category 2 is 2 X sigma for category1, sigma for category 3 is 4 X category 1 sigma.
- SSC informed the Council that any P* greater than 0.45 as would not be considered a meaningful response to MSA mandate to account for scientific uncertainty in setting the ABC.
- The Council adopted a P* = 0.45 for all category 1 assessments, and P* = 0.40 for category 2 and 3 assessments

PFMC RECENT DEVELOPMENTS

- Sigma based on uncertainty in the projected OFL instead of ending year biomass (Privitera-Johnson and Punt 2020) New sigma = 0.50.
- Implement stock assessment ageing (sigma increases as time since the last assessment increases (Wetzel and Hamel 2019).
- There is still additional uncertainty that could be quantified.
- Ratchet effect on buffers as methods to quantify scientific uncertainty improve.

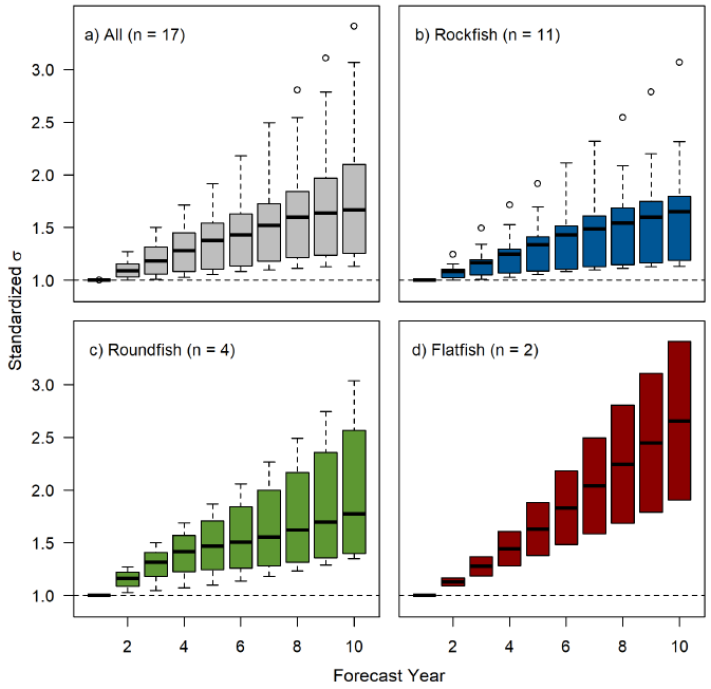


Figure 2: The change in σ during the projection period between the base and low state of nature grouped by life history. The number of species in each life history grouping is shown in each figure.

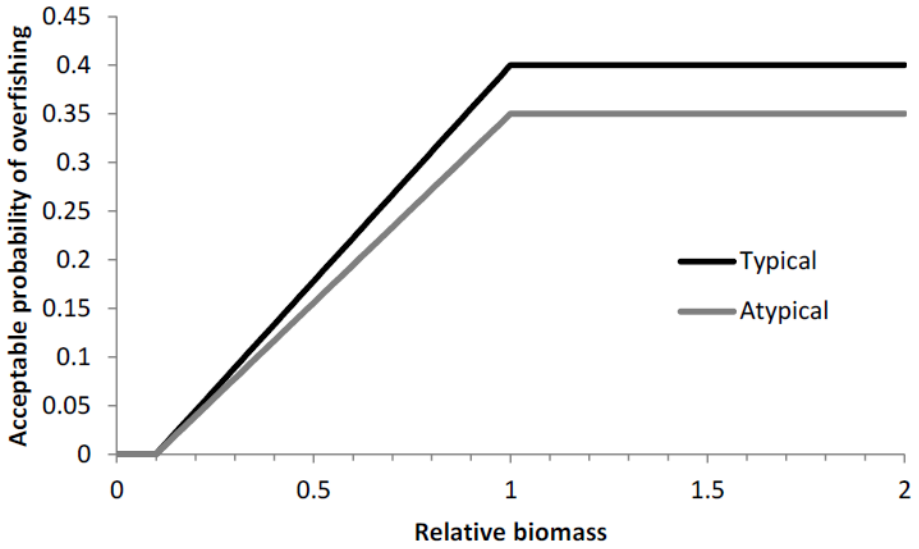
PFMC RECENT DEVELOPMENTS

Table 3. A comparison of the old and new scientific uncertainty reductions for P* = 0.45.

P*=0.45	Category 1		Category 2		Category 3	
Year	Old	New	Old	New	Old	New
1	4.4%	6.1%	8.7%	11.8%	16.6%	22.2%
2	4.4%	6.5%	8.7%	12.6%	16.6%	22.2%
3	4.4%	7.0%	8.7%	13.5%	16.6%	22.2%
4	4.4%	7.4%	8.7%	14.3%	16.6%	22.2%
5	4.4%	7.8%	8.7%	15.1%	16.6%	22.2%
6	4.4%	8.3%	8.7%	15.9%	16.6%	22.2%
7	4.4%	8.7%	8.7%	16.7%	16.6%	22.2%
8	4.4%	9.1%	8.7%	17.4%	16.6%	22.2%
9	4.4%	9.6%	8.7%	18.2%	16.6%	22.2%
10	4.4%	10.0%	8.7%	19.0%	16.6%	22.2%

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL ABC CONTROL RULE

Fig. 1. Acceptable probability of overfishing (P) as a function of stock size adopted by the MAFMC in an Omnibus Amendment (July 2011). The threshold acceptable probability of overfishing is 0.4 for species with a typical life history and 0.35 for those with an atypical life history. 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 its threshold as relative biomass approaches 1. Whether a species is deemed typical or atypical depends on the degree to which its life history has been incorporated in the development of fishing mortality reference points.*



MAFMC FRAMEWORK TABLE

- Qualitative assessment of nine criteria.
- Assessments are assigned to one of three categories generally on a spectrum of good to poor assessment performance. No scoring is allowed!
- OFL default CV values of 0.6. 1.0, and 1.5. for each category based on simulation values, MSE evaluations, and expert judgement.

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL ABC CONTROL RULE

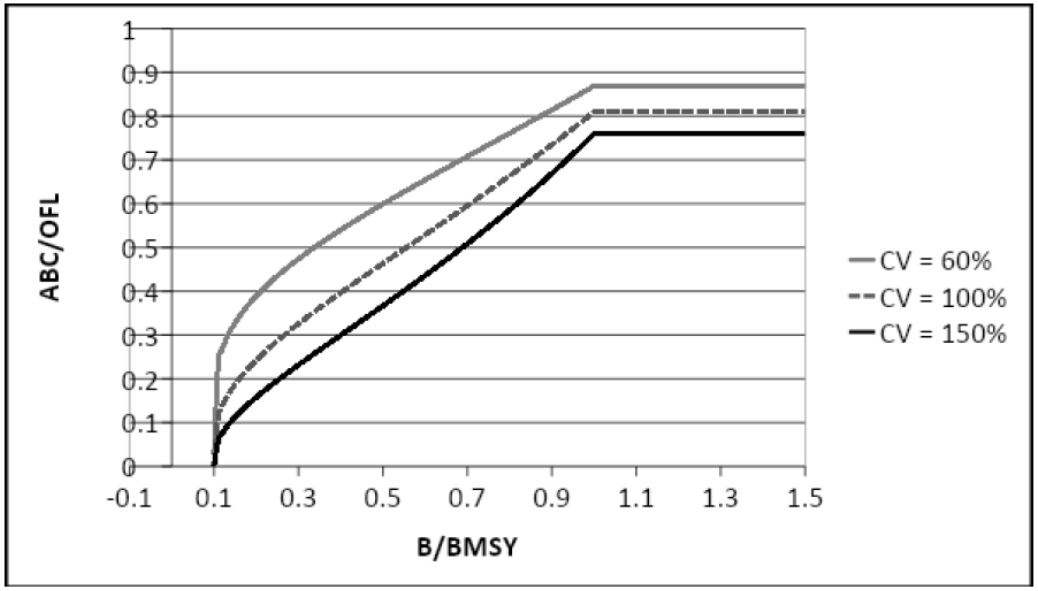


Figure 1. Effect of different CV values currently selected by the MAFMC SSC on the ratio of ABC to OFL for varying levels of biomass relative to the B_{MSY}.

Decision Criteria	Default OFL CV=60%	Default OFL CV=100%	Default OFL CV=150%
Data quality	One or more synoptic surveys over stock area for multiple years. High quality monitoring of landings 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 or no exploration of alternative model structures or sensitivities.
Retrospective analysis	Minor retrospective patterns.	Moderate retrospective patterns.	No retrospective analysis or severe retrospective patterns.
Comparison with empirical measures or simpler 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 considered habitat and ecosystem effects on stock productivity, distribution, mortality and quantitatively included appropriate factors reducing uncertainty in short term predictions. Evidence outside the assessment suggests that ecosystem productivity and habitat quality are stable. Comparable species in the region have synchronous production characteristics and stable short-term predictions. Climate vulnerability analysis suggests low risk of change in	Assessment considered habitat/ecosystem factors but did not demonstrate either reduced or inflated short-term prediction uncertainty based on these factors. Evidence outside the assessment suggests that ecosystem productivity and habitat quality are variable, with mixed productivity and uncertainty signals among comparable species in the region. Climate vulnerability analysis suggests moderate	Assessment either demonstrated that including appropriate ecosystem/habitat factors increases short-term prediction uncertainty, or did not consider habitat and ecosystem factors. Evidence outside the assessment suggests that ecosystem productivity and habitat quality are variable and degrading. Comparable species in the region have high uncertainty in short term predictions. Climate vulnerability analysis suggests

Decision Criteria	Default OFL CV=60%	Default OFL CV=100%	Default OFL CV=150%
	productivity due to changing climate.	risk of change in productivity from changing climate.	high risk of changing productivity from changing climate.
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.		

FINAL THOUGHT

- SSCs for PMFC and MAFMC (like the NPFMC SSC) are review bodies whose principal role is to review analyses used to support fisheries management decision-making by the Council.
- However in both examples presented here, the SSCs took in developing their approach to consider scientific uncertainty in the setting the ABC, which is a defined role of the SSC in MSA.
- The SSCs also engaged extensively with their Councils to guide them in adopting a risk policy.