Issue: SAFMC ABC Control Rule

Background

The SAMFC SSC first discussed acceptable biological catch (ABC) control rules in June 2008 in response to publication of a proposed rule addressing National Standards 1 (NS1) guidelines for the Magnuson-Stevens Reauthorization (MSRA). An issue paper outlining various alternative approaches to establishing ABC was provided to the Council in September 2008. The Council supported further developing a control rule approach which specified ABC as a function of yield at maximum sustainable yield (MSY) and assessment uncertainty. The council further specified that ABC should be set at a level providing a 25% chance of overfishing, with a range of values corresponding to 10 to 50% chance of overfishing. The Council intends to specify ABC control rules in its comprehensive annual catch limit (ACL) amendment.

While the approach suggested in September 2008 provides guidance for assessed stocks for which the probability of overfishing can be provided in terms of yield, it does not address those stocks which lack assessments. Therefore, the SSC requested a special meeting for March 2009 devoted solely to developing an ABC control rule that can be applied to all managed stocks. During that meeting the SSC developed the control rule reflected in this document after much deliberation and discussion.

First, the group decided on general characteristics and components of the rule and developed a framework of dimensions and tiers. Dimensions reflect the critical characteristics to evaluate, including data and assessment information availability and life history traits. Tiers are objective levels within dimensions that reflect the range of information available. Each tier is assigned a score, essentially a buffer adjustment value, and scores are summed across dimensions to determine the total buffer adjustment.

Once the general approach was established, a number of example stocks were put through the framework to ensure that an adequate range of dimensions and appropriate tiers were included. This exercise led to considerable further discussion that better defined the concepts and resulted in some tiers being combined to keep the rule as parsimonious as possible. In the final step, buffer adjustment values were summed across stocks to provide the overall adjustment from

the Council's acceptable probability of overfishing, which is then used to calculate the buffer between the ABC and the OFL/MSY level.

The approach described here is a first step and is applicable when the OFL can be stated in fish weight and some measure of statistical uncertainty about the OFL can be estimated. Future discussions will focus on ways to apply this methodology in a consistent manner to stocks for which the OFL or its statistical uncertainty cannot be estimated.

Control Rule Concept

The SSC agreed that the ABC control rule should provide an objective means of determining the buffer between the overfishing level (typically MSY) and the ABC. The rule should include multiple characteristics, accommodate varying levels of data and assessment information, and incorporate evaluations of productivity and susceptibility. Adjustments to the level of buffer are based on the probability of overfishing, which can be reflected in yield through frequency distribution or a "P*" analysis.

Control Rule Characteristics

The SSC began deliberations by developing a list of desirable characteristics and principles for ABC control rules. These included:

- Incorporate a tiered system based on data and assessment information availability
- Include objective criteria with numerical scoring that can be applied to all stocks
- Incorporate stock status
- Reflect the degree to which uncertainty is characterized
- Acknowledge the cumulative nature of uncertainty
- Provide a means to incorporate vulnerability and life history traits, ideally through inclusion of productivity-susceptibility analyses (PSA) scores
- Provide flexibility to accommodate a wide range of biological characteristics, assessment methods and information, data availability, and assessment age
- Provide an objective means of incorporating potential changes in data and assessment information availability over time

Control Rule Dimensions

The SSC incorporated these general characteristics and principles into a series of tiers and dimensions that form the foundation of the control rule. Four dimensions are included in the proposed control rule framework: assessment information, characterization of uncertainty, stock status, and productivity/susceptibility of the stock. Each dimension contains multiple levels or

tiers that can be evaluated for each stock to determine a numerical score for the dimension (TABLE)

1. Assessment Information

The assessment information dimension reflects available data and assessment outputs. The five tiers within this dimension range from a full quantitative assessment which provides biomass, exploitation, and MSY-based reference points to the bottom tier for those stocks which lack reliable catch records.

The age or degree of reliability of an assessment can be incorporated when determining the scoring for an individual stock. For example, a stock having a pre-SEDAR assessment may be ranked at a lower tier despite that assessment having the required outputs for a higher tier, because the reliability of an output value cannot be determined or the method by which an output was obtained is not clearly documented. Estimates from an assessment may be considered unreliable or inapplicable when considered at a later date (e.g. assumed equilibrium conditions may have changed). Similarly, an age-aggregated assessment approach may provide an estimate of MSY, but in some instances such estimates may be considered less reliable than estimates from an age-structured approach. The intent is that tier rankings are based on the data and outputs considered reliable at the time the ranking is made.

Tiers.

1. Full quantitative assessment available that provides estimates of exploitation, biomass, and MSY derived benchmarks.
2. Full quantitative assessment available that provides reliable estimates of either exploitation (F and Fmsy) or biomass (B and Bmsy)
3. Quantitative assessment that provides reliable estimates of exploitation and proxy reference points.
4. Reliable catch history available
5. Scarce or unreliable catch records

2. Characterization of Uncertainty

This dimension is considered critical because the MSRA states that ABC should be reduced from OFL to account for assessment uncertainty. Tiers for this dimension reflect how well uncertainty is characterized, not the actual magnitude of the uncertainty (the magnitude is already addressed through the assessment and is reflected in the yield estimates at any given

probability level). This dimension provides additional buffering in situations where uncertainty may be only partially addressed by the assessment. Because accounting for uncertainty tends to be a cumulative process, an incomplete or partial accounting of uncertainty will tend the underestimate the underlying uncertainty. Tiers are initially assigned qualitatively (complete, high, medium, low, none) with each receiving a numerical score for the buffer adjustment.

Tiers

1. Complete. This tier is for assessments providing a complete statistical (eg Bayesian resampling approach) treatment of major uncertainties, incorporating both observed data and environmental variability, which are carried forward into reference point calculations and stock projections. A key determinant of this level is that uncertainty in both assessment inputs and environmental conditions are included.

   Example: No currently assessed stocks meet this level.

2. High. This tier represents those assessments that include resampling (eg Bootstrap or Monte Carlo techniques) of important or critical inputs such as natural mortality, old landings, discard rates, age and growth parameters. Such resampling is also carried forward and combined with recruitment uncertainty for projections and reference point calculations. Outputs include distributions of MSY and F_{MSY}. The key determinant for this level is that these distributions reflect more than just uncertainty in future recruitment.

   Example: SEDAR 4, South Atlantic snowy grouper and tilefish.

3. Medium: This tier represents assessments in which key uncertainties are addressed via statistical techniques and sensitivities, but the full uncertainties are not carried forward into the projections and reference point calculations. Projections may, however, reflect uncertainty in recruitment and population abundance. Although outputs include distributions of F, F_{MSY} as in the 'High' category above, in this category fewer uncertainties are addressed in developing such distributions. One example for this level is a distribution of F_{MSY} which only reflects uncertainty in recruitment.

   Examples: SEDAR 15, South Atlantic red snapper and greater amberjack; SEDAR 17, South Atlantic Spanish mackerel and vermilion snapper

4. Low. This tier represents those assessments lacking any statistical treatment of uncertainty. Sensitivity runs or explorations of multiple assessment models may be available. The key determinant for this level is that distributions of F_{MSY} and MSY are lacking.

   Examples: SEDAR 1, South Atlantic red porgy; SEDAR 2, South Atlantic black sea bass

5. None. This tier represents assessments that only provide single point estimates, with no sensitivities or other evaluation of uncertainties.

Example: None.

3. Stock Status

Stock status is included among the dimensions so that an additional buffer can be added for stocks that are overfished or overfishing. Five tiers are included, ranging from a high biomass and low exploitation level where no additional buffer is applied to the situation where either is unknown and the highest buffering is applied. With the exception of distinguishing between the top two tiers which both reflect stocks that are neither overfished nor experiencing overfishing, application of these tiers is straightforward and based directly on the final status determinations, independent of the sensitivity or uncertainty in that final determination.

Tiers.

1. Neither overfished nor overfishing, and stock is at high biomass and low exploitation relative to benchmark values.
2. Neither overfished nor overfishing, but stock may be in close proximity to benchmark values
3. Stock is either overfished or overfishing
4. Stock is both overfished and overfishing
5. Either status criterion is unknown.

4. Productivity and Susceptibility Considerations

The final dimension addresses biological characteristics of the stock. This includes productivity, which reflects a populations reproductive potential, and susceptibility to overfishing, which reflects a stocks propensity to be harvested by various fishing gears. Efforts to quantify these characteristics, generally termed “PSA analyses”, typically incorporate a variety of life history characteristics in a framework that distills many metrics into a single risk score. The two primary approaches currently available, one from NMFS and the other from MRAG, follow similar procedures with slight differences in how characteristics are scored and how missing information is addressed.

The SSC developed two sets of tiers for this initial rule, one based on qualitative descriptions of productivity and susceptibility and the other based on the range of scores presented in the MRAG approach. This approach allows the rule to accommodate all stocks, regardless of whether a formal PSA is available. The various available approaches will be reviewed in June 2009 when the SSC finalizes the control rule.

Qualitative Tiers

1. Low Risk. Productivity High, Vulnerability Low, Susceptibility Low
2. Moderate Risk. Moderate Productivity, Moderate Vulnerability, Moderate Susceptibility
3. High Risk. Low Productivity, High Vulnerability, High Susceptibility

Quantified MRAG Tiers

1. 0 – 2.5 (Lowest Risk. Highest productivity, lowest vulnerability and susceptibility. Near annual crops?)
2. 2.5- 3 (Low Risk. Productivity High, Vulnerability Low, Susceptibility Low)
3. 3 – 3.5 (Moderate Risk. Moderate Productivity, Moderate Vulnerability, Moderate Susceptibility)
4. 3.5 – 4 (High Risk. Low Productivity, High Vulnerability, High Susceptibility)
5. 4+ (Maximum risk. Lowest productivity, highest vulnerability and susceptibility)

<u>Determining Total Buffer Levels</u>

Buffers are expressed in terms of "probability of overfishing", sometimes referred to as P*. Setting ABC equal to OFL that implies a P* equal to 50%, where 50% represents the chance of overfishing occurring. A reduction in P* would result in a reduction in ABC and a reduction in the chance of overfishing occurring. The relationship between the amount of reduction in P* and the resulting reduction in ABC is determined by the shape of the distribution of yield about the management parameters. For the same reduction in P*, broad distributions (suggesting higher uncertainty) will result in larger reductions in ABC compared to narrower distributions (suggesting lower uncertainty). Using the ABC control rule described here, the total possible range for P* is from 50% down to 10%. This range was derived intentionally to correspond with Council guidance directing the SSC to consider a range of ABCs based on probabilities of

overfishing between 10% and 50%. The top tier in each dimension does not reduce P*, so the ABC recommendation for a stock receiving the top score across all dimensions would be the same as the OFL recommendation and there would be no buffer applied between ABC and OFL. Given the above metrics, the only situation in which this would occur is for a stock with a complete assessment including full uncertainty evaluations that is at low exploitation and high biomass, and is considered highly productive with low vulnerability and susceptibility. No stocks falling in this category have been identified.

In this ABC control rule, additional buffer is added for each stock by reducing P* based on values derived for each of the tiers in each dimension. The overall range of possible P* adjustments is designed to result in a maximum buffer of 40%, which, when applied to the normal MSY specified at the 50% level, would result in an ABC corresponding to P* = 10%, equivalent to the minimum of the range of ABCs approved by the Council. Buffering scores for each tier are provided in (TABLE). For this ABC control rule, each dimension is assumed equally important and tiers are assumed to follow a linear reduction in P*, which in most cases will result in a non-linear reduction in ABC, due to the common shape of distributions.

Buffering scores are totaled across dimensions once tiers are assigned for each dimension. This total buffering score determines the final P* (by subtracting the buffering score from 50%) to be applied in computing the ABC value. The intent is that each stock will be categorized by tiers before the buffer score is tallied so that categorizations are made independent of the final outcome.

In addition, when categorizing multiple stocks, tier assignments should be made in a single dimension for all stocks before moving on to the next dimension so that tier assignments are appropriately consistent within a dimension. Working through the process in this order should help avoid situations where stocks with similar conditions receive different tier ratings.

Overfished Stocks and Rebuilding Plan Selection

The buffer adjustment score can also be used to derive a probability of rebuilding success for use in developing rebuilding schedules. The probability of rebuilding success is determined by subtracting the P* critical value from 100%, such that stocks with high P* values could be managed using a rebuilding schedule that approaches the 50% level used now, and those with the

lowest P* values will require rebuilding schedules with higher probability of success, with a maximum of 90%.

The buffer adjustment for stocks achieving the best or lowest scores across all dimension would be 0, resulting in a P* of 50% and rebuilding projections with a 50% (100-50) probability of success by the end of the rebuilding period. It should be noted that current rebuilding schedules are based on this 50% level. The buffer adjustment for stocks receiving the highest scores across all dimensions would be 40%, resulting in a P* of 10% (50 baseline – 40 for buffer adjustment) and requiring rebuilding projections based on 90% probability of success by the end of the period.

Values for the rebuilding success probability are provided for all stocks in Table 2 for illustration of the concept. In application, only stocks with status 'overfished' would require this parameter. Because the decisions required to develop the rebuilding plan are the same ones required to develop ABC, this framework allows estimation of both the rebuilding schedules and the final yield for a rebuilt stock from a single set of decisions. The only change required would be to calculate the new total buffer adjustment required once stock status changes from 'overfished' to 'not overfished and not overfishing'. Any such changes can be evaluated and the system is essentially self-adjusting to critical events such as a change in stock status because the criteria and scorings are all determined in advance.

Using red porgy as an example, the total buffer adjustment value of 15 results in a P* of 35 (50% baseline – buffer adjustment of 15) and a rebuilding probability of success of 65% (100% baseline – P* of 35). However, once the stock is rebuilt and the stock is neither overfished nor is overfishing occurring, the status score would change from a 3 (buffer adjustment of 5) to a 2 (buffer adjustment of 2.5) and the overall buffer adjustment value would therefore decrease by 2.5 to 12.5. The expected P* for the rebuilt stock becomes 37.5 and the expected ABC for the rebuilt stock can be determined from the probability distribution table of MSY at equilibrium or rebuilt conditions.

Depletion Threshold

The NS1 guidelines state that an 'ABC control rule…may establish a stock abundance level below which fishing would not be allowed.' Currently the Pacific Fishery Management

Council uses a 10% threshold. Specifically if biomass is estimated below 10% of the virgin condition, then fishing is not allowed (i.e. ABC=0). In this ABC control rule, we propose the same 10% of virgin rule. If the stock biomass is estimated to be below 10% of the virgin estimate, then fishing will not be allowed and ABC = 0.

Table 1. Dimensions and buffer add-ons for each tier

Assessment Info	Buffer Add-on	Uncertainty Characterization	Buffer Add-on	Stock Status	Buffer Add-on	Biology/Vulnerability/Susceptibility Results of a PSA analysis	Buffer Add-on
Estimates of F, Fmsy, B, and Bmsy available	0	Ultimate	0	Minimal F, Large B	0	Productivity High, Vulnerability Low, Susceptibility Low	0
Reliable estimate of at least one of F, Fmsy or B, Bmsy	-2.5	High	-2.5	Not overfish, not overfishing – less buffer??	-2.5	Moderate Productivity, Moderate Vulnerability, Moderate Susceptibility	-5
F & Reliable proxies for Fmsy or Bmsy	-5	Medium	-5	Overfished or Overfishing	-5	Low Productivity, High Vulnerability, High Susceptibility	-10
catch history	-7.5	Low	-7.5	Overfished and Overfishing	-7.5		
No catch records at all	-10	None	-10	UNKNOWN. -- More buffer	-10		

Table 2. Examples applied to currently assessed stocks

Stock	Assess info Score	Uncert. Score	Status Considerations Descriptive	Score	PSA (MRAG VALUES)	Score	Assess	UNC	Status	PSA	Total	P* Critical	Rebuild TGT
							BUFFER ADJUSTMENTS						
Red Porgy	1	3	Yes fished, Not fishing rebuilding	3	3.39	3	0	-5	-5	-5	-15	35	65
Vermilion Snapper	3	3	Fished=UNK, fishing=Y,	5	3.39	3	-5	-5	-10	-5	-25	25	75
Black Sea Bass	1	3	Fished, not Fishing, Rebuilding	3	3.39	3	0	-5	-5	-5	-15	35	65
Yellowtail snapper	1	3	Not fished, not fishing	2		2	0	-5	-2.5	-2.5	-10	40	60
Golden Tilefish	1	2	Not fished, fishing	3	3.77	4	0	-2.5	-5	-7.5	-15	35	65
Snowy Grouper	1	2	Threshold 4% Virgin. Fished, fishing. Rebuilding	4	3.77	4	0	-2.5	-7.5	-7.5	-17.5	32.5	67.5
Hogfish	4	5	Fished UNK; Fishing UNK	5	3.69	4	-7.5	-10	-10	-7.5	-35	15	85
Goliath Grouper	4	5	Fished UNK, Fishing UNK	5		5	-7.5	-10	-10	-10	-37.5	12.5	87.5
Spiny Lobster	3	3	Fished UNK, not Fishing	5		1	-5	-5	-10	0	-20	30	70
Gag	1	3	not fished, Yes fishing	3	3.69	4	0	-5	-5	-7.5	-17.5	32.5	67.5
Mutton Snapper	1	3	Not fished, not fishing	2	3.69	4	0	-5	-2.5	-7.5	-15	35	65
Red Snapper	3	3	fished, fishing, rebuilding, threshold	4	3.53	4	-5	-5	-7.5	-7.5	-25	25	75
Greater Amberjack	1	3	not fished, not fishing	2	2.60	2	0	-5	-2.5	-2.5	-10	40	60
King Mackerel	3	3	not fished, not fishing	2		2	-5	-5	-2.5	-2.5	-15	35	65
Spanish Mackerel	3	3	fished UNK, not fishing	5		2	-5	-5	-10	-2.5	-22.5	27.5	72.5