SSC Groundfish and Coastal Pelagic Species Subcommittees' Report on the Steepness Prior and Sigma Review Meeting Held on 01 November 2018

The SSC Groundfish and Coastal Pelagic Species (CPS) Subcommittees (the subcommittees) met at the San Diego Marriott Del Mar on 1st November 2018 to review a revised Bayesian prior distribution for steepness for rockfish species and two analyses pertaining to the scientific uncertainty (sigma, σ) associated with the buffer between the OFL and ABC for groundfish and CPS species. The draft agenda is attached as Appendix A; a list of background documents provided for the review is attached as Appendix B; and a list of participants is attached as Appendix C.

Estimating a Bayesian Prior for Steepness in Pacific Rockfishes (*Sebastes* spp.) off the U.S. West Coast for the 2019 Assessment Cycle

Dr. Chantel Wetzel (NWFSC) presented the update to the application of the method used to construct a prior for the steepness of the stock-recruitment relationship that is used in groundfish assessments, as well as results based on several alternative methods for constructing a steepness prior. The current method was first implemented in 2007, and involves using an MCMC procedure to construct a posterior distribution for steepness given likelihood profiles for steepness based on the most recent (category 1) stock assessments and a hyper-prior for steepness. The resulting posterior has a mean 0.846 and a standard deviation (SD) of 0.120, which is more optimistic than the prior for steepness used for the 2017 assessment cycle (mean 0.718, SD 0.158).

Dr. Wetzel showed that the increase to the posterior mean is driven by removal of the assessment of Pacific Ocean Perch (now a category 2 stock), inclusion of the 2017 assessment for yelloweye rockfish, and replacement of the 2005 assessment of yellowtail rockfish with that for 2017.

The subcommittees noted that some of the likelihood profiles exhibited discontinuities, perhaps due to an inability to find the true minimum of the objective function, but that there are fewer such cases in the current application of the method than in past applications. It was also noted that how the data are weighted in the assessment will impact the profiles and hence the posterior for steepness.

Discussion focused on the choice of stocks to include in the meta-analysis as well as the hyper-prior for steepness. Dr. Wetzel noted that category 2 stocks had been included in calculations made to inform management cycles through 2011 but not thereafter. None of the meeting participants could recall the reasoning behind the change, nor was an explanation found during a brief search of past reports. The subcommittees agreed that the approach of penalizing the profiles has merit, but that the approach outlined in the documents provided was not justified. In addition, it was agreed that while there was benefit to accounting for auto-correlation among stocks and among years for each stock, accounting for this was not a high priority at present.

The subcommittees identified the following short- (before March 2019) and longer-term tasks:

Short-term tasks:

- identify the rationale for the exclusion of the category 2 stocks from the meta-analysis;
- confirm that the northern of the paired vermillion rockfish assessments was used when computing the meta-analysis using category 1 and 2 stocks;
- determine the posterior for steepness based only on the hyper-prior; and
- review the basis for the selection of the prior for cases in which steepness is fixed in an assessment (should be it be based on the standard meta-analysis or a "type C" analysis).

Longer-term tasks:

- Identify and apply criteria for deciding when to include a stock in the meta-analysis. Such criteria could include examination of the likelihood profiles by component for the stock, whether there is evidence in the data that steepness is clearly high or low, etc. These criteria should be included in the SSC Accepted Practices document and be applied by the STAR Panel whenever a new stock assessment is conducted.
- Better understand how stocks with different shapes for the likelihood profile for steepness (e.g. centered away from 1, but broad vs centered close to 1 and informative) impact the resulting posterior.
- Explore the possibility that the profiles for steepness may be biased. This could be achieved using the simulations already conducted by He and Field ("Effects of recruitment variability and fishing history on estimation of stock-recruitment relationships: two case studies from U.S. West Coast fisheries"; *Fisheries Research*, in press).
- Examine alternative approaches for specifying a hyper-prior (such as the Mangel biologically-based approach). Such approaches might be able to more objectively address the intent of the penalization method included in the material provided to the subcommittees.

Analysis of Sigma that Accounts for Increased Uncertainty with Assessment Age

Dr. Chantel Wetzel (NWFSC) presented an analysis of how uncertainty in projected stock biomass scales with the length of the projection period. The analysis compares deterministic projections of stock biomass from the base model of an assessment with projections made using a model representing a low state of nature, and tracks the divergence in these trajectories through time. Specifically, the starting biomass for the low state of nature model (which may not correspond to the low state of nature described in a particular assessment's decision table) is specified as the lower limit of the 75% confidence interval corresponding to the point estimate of biomass from the base model and the current category 1 default sigma (σ) of 0.36. The low state of nature model is tuned to yield the desired starting biomass by varying R_0 while allowing other estimated parameters from the base model to be re-estimated, which the subcommittees agreed was an appropriate method for standardization.

Scaling factors to apply to year-specific sigma values were calculated by tracking how the ratio between biomass projections from the two models scaled against the starting ratio over the

course of ten-year projections (i.e., the scaling factor was 1.0 in the first year of the projection, and increased as the projections diverged). For both sets of projections, removals were assumed to equal the year-specific ABCs from the base model. Projections were based on the most recent full assessment for each category 1 groundfish assessment from the west coast, except that the most recent update assessment was used for chilipepper rockfish (because the most recent full assessment used an earlier version of Stock Synthesis) and gopher rockfish was excluded because it was last assessed using Stock Synthesis 2 and thus not easily incorporated into this analysis using current software.

Correlations between rates of change in biomass ratios for the different stocks and various life history parameters were explored, and median yearly ratios were calculated for all stocks combined and for groupings consisting of all rockfish, all roundfish, and all flatfish (although only two flatfish stocks were analyzed and so the flatfish-specific results were not considered robust). The rate of divergence in projected stock size was most strongly correlated with natural mortality. The subcommittees noted that the rate of divergence also depends strongly on stock productivity and F_{MSY} (or its proxy). This is expected because applying ABCs from the base model to a stock represented by the low state of nature represents a management error of allowing excessive harvest. The magnitude of these excess removals is larger for larger F_{MSY}. These errors accumulate over time, increasing the divergence of projected stock biomass trajectories.

The subcommittees noted that this analysis may be highly sensitive to the assumption of full ABC attainment. For some stocks (e.g., Dover sole), historical removals have been well below the ABC, and this is likely to remain the case for at least some of these stocks into the future. This would reduce the expected degree of divergence for such stocks, and would somewhat reduce the average rate of divergence across all stocks combined. If this approach were applied to stocks where attainment is expected to be low, it would be advisable to conduct catch-only updates or perform projections over a range of assumed attainment and base future sigma values on the projections assuming attainments closest to those actually achieved.

There were some discussions of theory regarding whether similar patterns would be seen if the model tracked ratios in projected depletion rather than projected biomass. However, since the immediate use of sigma is in relation to overfishing (i.e., the amount of biomass removed) rather than overfished status (i.e., depletion), the subcommittees agreed that projected biomass was the appropriate metric to use here.

Overall, the subcommittees endorse using this approach to adjust sigma over the course of projections used in groundfish assessments and the harvest specifications process. The subcommittees recommend using scaling ratios based on all stocks combined rather than splitting to rockfish versus roundfish versus flatfish, primarily due to the lack of sufficient numbers of flatfish and roundfish stocks. However, the sensitivity of the all-stocks-combined results to stocks with large projected removals but low historical attainment (i.e., Dover sole and possibly also chilipepper rockfish) should be explored; it may be appropriate to exclude one or both of these stocks from the analysis.

The subcommittees further noted that because the rate of divergence likely depends somewhat on the starting sigma value of 0.36, the numbers derived in Dr. Wetzel's analysis may need to be revised if substantially different values of sigma are adopted in the future. Also, the starting sigma used for this purpose should be based on uncertainty in biomass rather than uncertainty in

OFL (see Item D). Based on analyses presented later during the review meeting by Ms. Privitera-Johnson, which showed only a small upward revision in the biomass-based sigma[1], it seems unlikely that a revised starting sigma value will substantially change the results that Dr. Wetzel presented.

Projection uncertainty is also important to consider for coastal pelagic species (CPS). However, deterministic analyses do not consider uncertainty in future recruitment, which makes up a much larger proportion of projected biomass for CPS stocks than it does for groundfish. Therefore the subcommittees find that this approach is not ideal for application to CPS. Stochastic recruitment could also be a concern over the course of a full ten-year projection for some groundfish stocks, but the proposed approach is nevertheless a substantial improvement over the status quo approach of maintaining a constant sigma over the course of projections.

The subcommittees identified the following short- (before March 2019) and longer-term tasks:

Short-term tasks:

- repeat the analyses with Dover sole and/or chilipepper rockfish excluded; and
- (***optional***) recalculate the combined rockfish results including California scorpionfish. The subcommittees agreed it would be appropriate to consider scorpionfish as part of the rockfish group, but did not recommend using group-specific results.

Longer-term tasks:

- Ensure that the model description and code are sufficiently clear and completely documented that another analyst could perform an update many years in the future.

Analysis of Default Sigma Based on Past Assessment and Overfishing Limit Projections

Ms. Kristin Privitera-Johnson presented slides on "*Estimating among-assessment variation in overfishing limits*". Her work builds on the analysis of Ralston et al. (2011) [A meta-analytic approach to quantifying scientific uncertainty in stock assessments. *Fishery Bulletin* 109: 217–23], which estimated among-assessment variation in historical spawning biomass as a proxy for uncertainty in the overfishing limit. The Ralston et al. analysis provides the scientific basis for the Council's current value for sigma. The new analysis both updates the Ralston et al. (2011) analysis by including recent stock assessments and extends the analysis to consider variation in overfishing limits and to incorporate the effects of recruitment uncertainty in projections within a given stock assessment.

The steps taken for this analysis were:

1. Repeat the approach of Ralston et al. (2011) adding new assessments for the species used for that analysis (but excluding new assessments of Pacific hake, which are now managed under a treaty rather than a Council FMP). This results in a new sigma of 0.389 vs. 0.357 in the original analysis.
2. Limit the assessments to those which were conducted using SS3.24 and higher. This allows for the analysis described in step (3) to be applied to the following species: (rockfish)

[1] For example, the sigma value based on spawning biomass, stochastic recruitment, and pooled across species was 0.372.

bocaccio, canary rockfish, darkblotched rockfish, Pacific Ocean perch and widow rockfish; (roundfish) lingcod; and (flatfish) petrale sole. Each of these species has had two or three assessments conducted using SS3.24 and higher.

Note: When the analysis was conducted as in step (1) this resulted in a slightly lower value of 0.342 for sigma, but not so much lower to cause great concern. The steps below result in values of sigma larger than 0.389.

3. Conduct projections for each assessment starting the projection in 1998, 2003, and 2008, setting fishing mortality to the F_{MSY} proxy for those years, with deterministic or stochastic recruitment going forward 25 years. The stochastic projections also allow for uncertainty in recruitment for years prior to the first year of the projection, with the extent of uncertainty based on the asymptotic variance for each recruitment deviation from the assessment. Next calculate the following for overlapping years of these projections:

    a. Spawning biomass-based sigmas:

        i. Deterministic and ii. Stochastic

    b. OFL-based sigmas:

        i. Deterministic and ii. Stochastic.

The analysis takes account of four factors contributing to uncertainty.

1. Projection year – same as in Ralston et al.
2. Species – same as in Ralston et al. to start, but limited to those stocks with at least two assessments conducted using SS3.24 and higher.
3. Projection start year: 1988, 2003, and 2008.
4. Stochastic recruitment (only for the stochastic cases).

Overall, the subcommittees viewed this approach to looking at OFL values using retrospective assessments as an improvement over the Ralston et al. (2011) approach. However, the long term projection approach does not match the aim of understanding uncertainty when management is first put into place, and must rely on assumptions about future removals. The subcommittees suggested an alternative approach, described below.

Short-term tasks:

The subcommittees identified the following tasks, to be completed if possible before March 2019:

1. New analysis: conduct 1 year projections across 15 retrospective years (e.g. 1994-2008) for each of the two or three assessments for each species. First make sure that the recruitment variance (i.e., information) is consistent back that far. The number of years can be modified (increased or decreased) from 15 based on information in the assessments. Note that these are not retrospective assessments, but taking the estimate from the assessment in the retrospective year and projecting forward one year.

    a. Assume that uncertainty of the recruitment years prior to the start of the projection matches that for the recruitment years before the end of actual assessment. This should

lead to more realistic uncertainty in estimates of OFL (and biomass) if the assessment had been conducted in the year corresponding to the projection start year.

b. Calculate sigma based upon the between-assessment variation in the one-year projected OFLs across the last 15 retrospective years. *Rationale*: The default sigma should reflect the uncertainty in OFL values for the years immediately following an assessment. By comparing year-specific projected OFLs (and spawning biomasses) across a set retrospective years of the different assessment models, the uncertainty associated with assessment model choice can be captured.

2. Do the analysis of biomass-based sigma for the following category 2 assessments, which have all been assessed at least twice:

   blackgill rockfish (assessed in 2005 and 2011);

   blue / deacon rockfish (assessed in 2007 and 2017);

   cowcod (assessed in 2007 and 2013);

   China rockfish (assessed in 2013 and 2015).

   longspine thornyhead (assessed in 2005 and 2013); and

   shortspine thornyhead (assessed in 2005 and 2013);

   Rationale: Currently, the sigma for category 2 stocks is based on the category 1 sigma. By performing the same analysis for category 1 and category 2 stocks, the current basis for the category 2 sigma (that the category 2 sigma is twice the category 1 sigma) can be formally evaluated. The analysis results will inform the basis for the category 2 sigma going forward.

Appendix A.

SSC Groundfish and CPS Subcommittees Agenda
November 2018

PROPOSED AGENDA
Scientific and Statistical Committee's
Groundfish and Coastal Pelagic Species Subcommittees

Pacific Fishery Management Council
San Diego Marriott Del Mar
Grand F/G Room
11966 El Camino Real
San Diego, CA 92130
Telephone: 858-523-1700

November 1, 2018

Scientific and Statistical Committee (SSC) meetings are open to the public, and public comments will be accepted during the scheduled public comment period. Public comment at times other than the established public comment period will be taken at the discretion of the SSC Chair.

Committee member work assignments are noted in parentheses at the end of each agenda item. The first name listed is the discussion leader and the second, the rapporteur. A suggestion for the amount of time each agenda item should take is provided. All times are approximate and subject to change. At the time the agenda is approved, priorities can be set and these times revised. Discussion leaders should determine whether more or less time is required, and request the agenda be amended.

THURSDAY, NOVEMBER 1, 2018 – 10 AM

A. Call to Order

1. Call to Order and Introductions — Dave Sampson and André Punt
2. Approve Agenda
   (10 a.m., 0.25 hours)

B. Estimating a Bayesian Prior for Steepness in Pacific Rockfishes (Sebastes spp.) off the U.S. West Coast for the 2019 Assessment Cycle

1. Review Proposed Methodology — Chantel Wetzel
2. Recommend a Methodology
   (10:15 a.m., 1.5 hours; **Sampson, Punt**)

LUNCH (11:45 a.m.-1 p.m.)

C. Analysis of Sigma that Accounts for Increased Uncertainty with Assessment Age

1. Review Proposed Methodology — Chantel Wetzel
2. Recommend a Methodology
   (1 p.m., 1.5 hours; **Punt, Berger**)

D. Analysis of Default Sigma Based on Past Assessment and Overfishing Limit Projections

1. Review Proposed Methodology — Kristin Privitera-Johnson
2. Recommend a Methodology
   (2:30 p.m., 1.5 hours; **Sampson, Hamel**)

E. Public Comments

PFMC
10/05/18

Appendix B. Background Documents Provided for the Review

For Agenda Item B.

Wetzel, C. and Thorson, J. (2018). Estimating a Bayesian prior for steepness in Pacific rockfishes (Sebastes spp.) 1 off the U.S. West Coast for the 2019 assessment cycle.

Wetzel, C. (2018). Alternative meta-analysis applications and model ensemble approach for estimating a steepness prior for U.S. west coast groundfish.

For Agenda Item C.

Wetzel, C. and Hamel, O. (2018). Accounting for increased uncertainty in setting precautionary harvest limits from past assessments.

For Agenda Item D.

Privitera-Johnson, K. and Punt, A.E. (2018). Estimating among-assessment variation in overfishing limits.

Appendix C. Participant list

The *s indicate CPS and Groundfish Subcommittee members.

Last Name	First Name
Berger *	Aaron
Brown *	Evelyn
Budrick *	John
Byrne *	Alan
DeVore	John
Field *	John
Hamel *	Owen
Key *	Meisha
Punt *	André
Sampson *	David
Satterthwaite *	Will
Sharma *	Rishi
Tsou *	Theresa
Privitera-Johnson	Kristin
Wetzel	Chantel