



**TO:** Pacific Salmon Commission

**FROM:** Chinook Technical Committee

**DATE:** February 16, 2017

**SUBJECT:** Review of PSC expert panel report on forecasting

On October 21, 2016 the CTC received a memo from PSC Commissioners requesting a response and review to an expert panel report “Review of Methods for Forecasting Chinook Salmon Abundance in the Pacific Salmon Treaty Areas”. Specifically commissioners requested that the CTC “provide a summary of its views on the feasibility of implementing the key recommendations specific to the three elements we charged the panel with reviewing”.

The CTC has chosen to respond to this request by providing comments for each of the issues identified by the expert panel. The expert panel organized issues into three categories: general issues and conclusions, regional agency forecasts and PSC Chinook model forecasts. These issues are organized accordingly in the tables below with corresponding CTC comments provided alongside those issues. For the latter two categories of issues, the expert panel also provided a priority code (near-term, intermediate and long-term) to each issue. Those priority codes are included herein. Additionally, the CTC included a feasibility ranking wherein the recommendations were rated on a scale of 1 to 5 where a 1 is highly feasible and 5 is not feasible without significant reprioritization of core CTC functions and the addition of resources. Many of the expert panel recommendations are directed at forecasts supplied by the agencies; the CTC did not provide a feasibility assessment for such recommendations.

The expert panel identified a number of different issues and improvements for forecasts. The CTC found that there were a number of different issues that could easily be remedied and others that were generally cost-time prohibitive. To this extent, the CTC would like to emphasize that while many of the expert panel’s suggestions were technically sound, they were also unrealistic given agency budgets and staff availability. The ForecastR package is capable of implementing many of the highly technical suggestions identified by the expert panel, and many agencies plan to use this tool upon its completion. However, this tool alone currently is not capable of implementing all of the panel’s suggestions.

The CTC would also like to emphasize that many of the CTC members do not conduct the forecasts that are supplied to the PSC Chinook model. In these cases, the CTC can only provide recommendations to the agency forecasters, but cannot necessarily force that they follow a recommendation. In order for the CTC to track agency forecasts, and whether or not these forecasts follow recommendations from the expert panel, we propose to develop a template that agencies could fill out when their forecasts are complete. This template will provide a platform to communicate CTC data needs and ask for information and clarification on the technical aspects of forecasts. This will promote an understanding of the methods and assumptions used in the generation of each agency forecast.

The expert panel also provided extensive comments on the PSC Chinook Model. In the CTC's response to these comments, identification of model improvement funds to carry out such tasks was a common theme in our response. Another consideration is the priority level identified by the expert panel and the time it would take the CTC to implement these recommendations. With treaty negotiations currently underway, and a new imminent agreement, it is unlikely that most of the issues and recommendations related to the PSC Chinook model could feasibly be implemented and tested prior to a new agreement.

Finally, the CTC would like to note that many of the methods identified by the expert panel will be constrained by the quality and availability of the data to inform the models. More sophisticated models are not always a remedy for inadequate data and have a tendency to shift the focus from the inadequacy of the data to the complexity of the model. The CTC generally agrees that the first priority is to improve the quality of the forecast data being collected, and then to apply progressively more complex models when the data can support that level of complexity.

**6. GENERAL ISSUES AND CONCLUSIONS from the Expert Panel report and CTC comments**

	Page	Issue	Expert Panel Conclusion	CTC Comments
<b>6.1 Documentation of Agency Forecasting Methods and Results</b>				
1.	43	Current documentation of agency forecasts of abundance that are sent annually to the CTC does not provide sufficient information for PSC modelers to identify the long-term accuracy and precision of those forecasts, let alone uncertainty about the current year's forecast.	More comprehensive documentation is needed by the CTC from regional agency forecasters regarding the agencies' methods, critical assumptions and uncertainties, and accuracy and precision of past stock-specific forecasts. Agencies should also state the uncertainty in each stocks' annual forecasted abundance. More frequent in-depth communication between PSC modelers and agency staff is also required.	The CTC recognizes that documentation is desirable, but also recognizes that this may represent an onerous task for the agencies especially given the time constraints for when forecasts are needed. The CTC proposes to develop a simple, clear template that includes a request for specific information that would be helpful to the CTC to inform annual calibration.
<b>6.2 Requirements for Stock Forecasts as Inputs to the PSC Chinook Model</b>				
2.	44	Efforts by agencies to provide forecasts as inputs to the PSC model are hampered by an incomplete understanding of (1) the PSC model's information requirements, (2) how those forecasts are used in that model, and (3) how those uses differ from those of fishery managers within regions.	More explicit direction from the Chinook Technical Committee is needed by agency-based stock forecasters regarding the annually requested forecasts.	See response to #1. The CTC AWG could include language from the proposed template describing the CTC's model requirements, explanation of how forecasts will be used, etc.
<b>6.3 Limitations of Existing Stock Assessment Data</b>				
3.	45	Accuracy and precision of stock forecasts are limited by the available stock assessment data; this is more of a problem for some Chinook stocks than others.	Substantial improvements in basic assessments of some Chinook stocks are needed to support current PSC model and management applications, otherwise expectations need to be rescaled/reduced to recognize existing data limitations. Further expansion of the PSC model's number of stocks and fishing areas may need to be postponed until the quality of relevant data is deemed suitable.	Agreed. Continue to include in LOA RFP and specify needed data as high priority for N and S Funds, and for directed resources to be sought under the next annex. Additionally, there are stocks and stock aggregates that do not have forecasts. It may be a worthwhile endeavor to identify such stocks and pursue development of forecasts.

<b>6.4 Definitions and Best Practices for Agency Stock Assessment and Forecasting</b>				
4.	46	There are substantial differences among regional agencies in how stock forecasts are produced and described.	Establishment of a set of "best forecasting practices" and standard definitions can improve the statistical foundation of methods for stock forecasting	Complete ForecastR and have workshops to facilitate usage of it.
<b>6.5 Statistical Rigor of Agency Forecasting Methods</b>				
5.	51	Forecasting methods for some stocks have not fully incorporated knowledge of changing parameters or recent advancements in statistical methods of analysis.	Accuracy, precision, and transparency of stock forecasting methods might be substantially improved by application of more formal model-selection criteria that match clearly defined management objectives. Forecasts might also improve by use of more advanced statistical methods that allow for time-varying parameters.	Roll out ForecastR to make it easier to investigate and evaluate multiple forecasting approaches. Processes that do not use ForecastR, but use rigorous methods and are well-documented are also supported.  The CTC notes that the application of more advanced statistical methods is dependent on the quality and availability of data.
<b>6.6 Limitations of Existing Agency Models for Forecasting</b>				
6.	52	Existing forecasting models used by agencies, especially sibling relationships, are reasonably effective in representing average conditions but are vulnerable to performing poorly for years of very low or very high returns.	Development of new models and advanced parameter estimation methods may improve the accuracy and precision of agencies' annual forecasts. Regardless of any such improvements, large uncertainties in forecasts should be expected, especially when they are based on data outside the range of past observations.	Agreed. This is a limitation of forecasting.
<b>6.7 Documentation of the PSC Model's Forecasting Methods</b>				
7.	54	Incomplete and out-of-date documentation of the current PSC Chinook model and its calibration and projection procedures (1) threatens loss of institutional knowledge as key staff move on, (2) increases challenges to new CTC members who want to understand the model and its procedures, and in the worst case, (3) increases the chance of	Comprehensive up-to-date documentation of the PSC Chinook model in a single, central location is necessary to support its effective and credible use and improvement. A succession plan for training new model users is also critical.	Agreed, better documentation of the PSC Chinook model is needed. However, this will require resource allocation. Systematic review and update of model documentation, including expansion of help menus, is needed.

		errors in the model's application and interpretation.		
<b>6.8 Statements of Uncertainty about the PSC Model's Output Forecasts</b>				
8.	55	The deterministic nature of the PSC model and paucity of routine sensitivity analyses do not provide information about uncertainties in the model's forecasts of abundance in the three AABMs and terminal areas, thereby hampering well-informed decision making by PSC Commissioners and fishery managers in AABM areas.	Point estimates of forecasts of abundance indices in the three AABM areas from the PSC model should be accompanied by descriptions of uncertainties in those forecasts. Uncertainties can be derived from extensive sensitivity analyses of effects of different assumptions and input parameters. Expression of uncertainty in these forecasts is essential for determining the confidence to be placed in them and allowing for appropriate consideration by fishery managers.	This process will be dependent on receiving additional forecasts from agencies or in development of procedures for evaluating effects of uncertainty reported for agency forecasts. Differences in AIs could be evaluated, especially in a retrospective analysis, but forecast or PSC Chinook model calibration selection method should be determined prior to calibration. Evaluating multiple outcomes is particularly difficult in the compressed time available for calibration. The CTC would need to develop procedures for deciding among calibrations based on different forecast inputs. Procedures for considering how to deal with the influence of particularly uncertain forecasts in the calibration results would also be needed.
<b>6.9 Limitations of the Existing PSC Chinook Model</b>				
9.	57	The PSC model's structure, parameterization, and calibration are complex and subject to substantial structural and parameter uncertainties.	Substantial revision, testing, or possibly even replacement of the existing PSC Chinook model is necessary to effectively serve continuing needs, including the need for statements of uncertainty in the model's forecasts. A subgroup of CTC members should be created to explore such revisions and new models.	Agreed. The CTC already has Model Improvement (MI) Group, but it needs continued MI funding to proceed. The availability of a functional DGM will facilitate the exploration of alternative models or management regimes.
<b>6.10 Consistency of Management Structures/Policies with the Limitations of Information and Assessments</b>				
10.	58	Limitations of data and uncertainties associated with stock assessments and	Alternative frameworks, as well as ways of using forecasts of abundance, should be	Investigation of alternative frameworks would require commitment of resources.

		forecasting models challenge effective implementation of abundance-based management of Chinook under the Pacific Salmon Treaty.	considered for Chinook if current information and resources are not sufficient to effectively conduct adequate analyses and implement provisions of the current Treaty. Those provisions may need to be changed during current negotiations.	Likely there will not be enough time to explore alternative frameworks prior to the new annex. Prior to implementation, an alternative model would need to be fully-functioning, tested, and reviewed. If the Commission requests this work, the CTC will need DGM and MI funding.
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## 7. REGIONAL AGENCY FORECASTS OF CHINOOK ABUNDANCE

The CTC recognizes that many of the Forecast Review Panel comments are applicable to work conducted by the agencies and there is no authority to commit the agencies to undertake these tasks.

### Priority Code as assigned by the expert panel

- N = Near-term. Relatively straightforward to implement with likely immediate benefit (within 1 year).
- I = Intermediate. Would require moderate investment of time and effort (1-2 years)
- L = Long-term. Would likely require substantial time and effort, but with high potential for long term improvements (3-5 years).

### Feasibility Code as assigned by the CTC

Rated 1 to 5 where a 1 is highly feasible and 5 is not feasible without significant reprioritization of core CTC functions and additional resources. The CTC did not provide a feasibility assessment for Forecast Review Panel comments directed at the agencies (denoted as 'agency').

	Priority	Page	Recommendation	CTC Comments	Feasibility
<b>7.1 General Comments about Agency Forecasts</b>					
1.	N	59	When regional agency forecasters send their stock-specific annual forecasts to the CTC, they should document their model-ranking procedures as well as the past performance of their methods (bias and precision).	The CTC is developing a template to collect desired information on forecasts and will provide this to agencies. Methodology/tools for assessing bias and precision could also be developed and provided. The CTC recommends this work be completed in time for the 2018 model calibration.	1
2.	I	60	Agency forecasters should not choose just one best model for forecasting abundance in each age class. Instead, they should conduct analyses across different models that make different assumptions and report the resulting set of forecasts to the CTC for use as inputs to the PSC model. The generally large prediction intervals (not confidence intervals) around point forecasts should also be reported.	Not a near term assignment/priority. Part of future analysis of model uncertainty. Most agencies already conduct analyses across different models, but only report the outcome from a single model for clarity and to avoid confusion. Can incorporate definition and methodology for desired prediction intervals in template in Recommendation 1. The reporting of prediction intervals can be informative but are only useful if decision-making procedures are developed to make use of this additional information. Currently, these do not exist within the Chapter 3 framework. A process to determine whether an agency forecast should be included or excluded in an annual calibration relative to the forecast that would be produced in its absence by the Chinook Model does not exist.	Agency
3.	I	61	Agency forecasters should also send to the CTC a set of forecasts, each one based on a different model-ranking criterion, as determined by	Intermediate term. Part of future analysis of uncertainty. This task would require agencies to provide multiple forecasts and documentation methods, or a forecast with measure of uncertainty.	4

			stated management objectives. As described in section 8.2, the CTC can then conduct sensitivity analyses with the PSC model to determine their effect on forecasts of abundance in the AABMs.	The CTC could define desirable attributes of forecasts (minimization of bias, maximization of precision, etc.) that could then be included in the template to agencies. This would reduce the volume of information received by the CTC from agencies. CTC could develop methods to evaluate impact of forecast uncertainty on AI estimation. A decision-making framework would also be required to determine the final annual calibration. This work would need to take place during the timeframe when the CTC-AWG is working on the model calibration and resources are already fully committed.	
4.	N	61	We encourage all agency forecasters to try applying ForecastR to their regions' stocks. As well, the CTC should run workshops to familiarize agency scientists with the ForecastR program.	The ForecastR tool is in development. CTC supports use of ForecastR pending completion and review. The CTC will need <u>funding</u> for workshops to make this tool available to the agencies and for further development.	1
5.	N	61	Agency forecasters should try applying a hybrid sibling model, especially to cases in which the fit of data to a standard sibling model is weak.	Need to specify methodology and develop tools. Not required for all stocks, but the CTC can make formal request to agencies to do this work. There are some capabilities that could be incorporated in ForecastR, which would facilitate the model selection process. Resources would be required to implement this function.	Agency
6.	N	62	We recommend that agency forecasters try using a Kalman filter estimation procedure for fitting their sibling relationships to account for time-varying parameters.	Intermediate. Need to specify methodology and develop tools. Not required for all stocks but can make request of agencies. Roll out ForecastR to make it easier to investigate and evaluate multiple forecasting approaches. Could incorporate time series filter capabilities in further development of ForecastR.	Agency
7.	L	63	Continue to improve upon the ability to estimate the contribution by stock to all AABM and ISBM fisheries with the objective of obtaining reliable stock contribution estimates by age. The Panel encourages the commitment of extra funding for the implementation of techniques to estimate stock contributions in a timely enough manner that the results can be used for forecasting in the subsequent year.	Dependent on high quality fishery sampling and age composition data by stock. Need continued funding for high quality assessment and indicator programs. Improving and maintaining current programs needs to be a long term commitment.	1
	<b>7.2</b>	<b>Columbia River</b>			



8.	N	64	The Columbia River Technical Advisory Committee (TAC) should explore whether using formal statistical model-selection criteria improves the accuracy and precision of their forecasts.	This request could be made to TAC and implementation of formal statistical model-selection criteria could be evaluated in the general template provided to agencies.	Agency
9.	N	64	Explore the use of natural-log transformations for sibling regressions. The examination should evaluate both the effect on meeting the regression assumptions and forecasting performance.	Incorporate exploration of transformations for sibling regressions as a desirable element for the template in recommendation 1.	Agency
10.	N	73	The Columbia River Technical Advisory Committee and the Pacific Salmon Commission's modeling group should communicate with each other to ensure that they are both working with the same definition of the Columbia River Summer stock and the same sets of data, and that any historical information reflects this change.	Need near term validation that TAC forecast is consistent with new base period calibration data. Need to explore treatment of subyearlings vs. yearlings in forecasts and validity of single mixed indicator stock in CTC model.	Agency
	<b>7.3</b>	<b><i>West Coast Vancouver Island</i></b>			
11.	N	78	The CTC modeling group and WCVI forecasters should decide (1) which type of forecast is required from WCVI (based on base-period data or recent years, for example), and (2) the forecast performance values (bias and precision) beyond which an extensive review of forecasting methods should be triggered.	Documentation that describes the Model's forecasting procedures and settings used in the calibration needs to clearly delineate how forecasts are used in stage 1 and stage 2 calibration process, i.e., in "base period units" or not, due to variable terminal harvest impacts.	1
12.	I	78	An evaluation of the WCVI sampling program should be undertaken to determine if (1) there has been a dramatic change in sample collection methods and sampling intensity over the years, and (2) whether the sample design and intensity is adequate to obtain meaningful age composition estimates. If the sample design appears to be adequate, then explore other ways to estimate the age-3 and age-6 components of the returns.	This objective and the expected result of pursuing this recommendation is not clear. Despite lack of understanding, the following comments are offered:  The WCVI Model stock aggregate includes many stocks and ideally requires numerical and age composition estimates for all the escapements and terminal fisheries. It is not clear how effort spent in investigating effects of sample data quality and quantity through time will result in near term improvements to the forecast. Rather, improvements in forecast accuracy and bias are anticipated from increased sampling intensity achieved through a currently funded NEF	Agency

				project, 'WCVI Chinook Terminal Abundance'. The objective is to collect additional samples in the WCVI terminal area (R12).	
13.	I	80	The use of recent harvest rates and maturation rates should be explored for the WCVI forecasting model. These analyses should estimate model sensitivity to uncertainties in these rates, and all results of these sensitivity analyses, including the associated forecasts, should be provided to CTC modelers along with estimates of uncertainty in the forecasts.	The use of recent harvest rates has already been incorporated into the WCVI forecast procedure starting with the forecast provided in 2014. In the near term, recommendations to use recent maturation rates and data transformations can be explored. Sensitivity analyses to estimate the forecast procedure's sensitivity to the recommended changes is a longer term activity.	Agency
14.	I	82	Explore a different and simpler method of forecasting terminal return to WCVI. The preferred method would reduce the complexity of the forecast by reducing the number of data manipulations and number of parameters and assumptions in the forecasting procedure. As with all new methods, it should be thoroughly evaluated to determine whether an increase in performance is actually obtained in terms of bias and precision, and sensitivity analyses should be performed to determine the influence of uncertainties in model parameters.	The current forecast method for the WCVI stock produces pre-fishing ocean abundances by age to which estimated pre-terminal exploitation rates must be applied to arrive at the expected terminal run size by age. This differs from forecasting methods employed in the Southern US which consist of sibling forecast or similar models which do not explicitly take into account ocean abundances or pre-terminal exploitation rates. Alternative forecast methods for WCVI, including simpler ones like those used in the Southern US, can be explored. ForecastR is a tool that can be used to accomplish this. The yearly stage 2 calibration of the Chinook model uses recent FP times RT averages to estimate the fishery exploitation rates for the projection years. The projected fishery exploitation rates when combined with the stock forecasts from the agencies refine the projected EV scalars from stage 1 which then determine the projected abundances by stock.	Agency
<b>7.4 North Oregon Coast</b>					
15.	N	83	We recommend that ODFW forecasters examine In e - In e sibling regressions, a hybrid sibling model, and a Kalman filter estimation procedure, the latter to account for possible temporal changes in parameters of the sibling relationship.	Many of the mentioned recommendations will be options within the analysis capable with updated versions of ForecastR. ODFW anticipates the utilization of these tools in the near future.	Agency
16.	N	83	A list of the alternative forecasting models examined and the criteria used to select among those models for producing a forecast for the Northern Oregon Coast should be clearly stated in the forecast document provided to the PSC	This will be accomplished using the reporting capabilities of ForecastR, given the utilization of this tool. If alternative models are employed, a rationale behind the selection of these models will be provided along with the results of this model.	Agency

			model group, as suggested in recommendations at the start of section 7.		
17.	N	85	All assumptions underlying the annual forecast, as well as data related to those assumptions, should be listed in the document provided to the PSC modelers so that everyone is aware of the forecast's strengths and weaknesses.	Agency response given within the proposed forecast template should easily address this recommendation.	Agency
18.	N	85	Continue the increased sampling in the Northern Oregon Coast for age, rapid reading of scales for age, and improvements in escapement estimation.	Given appropriate resources and agency prioritization, the maintenance of these critical data sources will be secured. Without additional resources, which are currently competed for annually, the quality, availability and timeliness of this sampling and the subsequent data will be degraded.	Agency
19.	I	85	As the population assessment models continue to evolve, NOC researchers should determine the sensitivity of the resulting forecasts to the uncertainty in estimated parameters in the models and quantify the uncertainty in the forecasts.	Evolving spawner assessments will necessitate evolving forecast assessments. The sensitivity of both estimations will be further informed for a greater understanding of the uncertainty inherent in these estimates.	Agency
20.	I	86	If more detailed data can be obtained from terminal fisheries for NOC, the forecast for this aggregate stock should change to a terminal run forecast instead of an escapement forecast.	Within the current time constraints of the need for forecasts, it is not likely ODFW will be able to comply with this suggestion. If future developments allow for expeditious estimation of terminal fisheries impact, this constraint would be removed.	Agency
21.	N	86	The Panelists encourage the continued use of ForecastR for Northern Oregon Coast Chinook Salmon.	OK.	Agency

**8 PACIFIC SALMON COMMISSION'S CHINOOK MODEL FORECASTS**

	Priority	Page	Recommendation	CTC Comments	Feasibility
	<b>8.2 Unclear management objectives and the PSC Chinook model</b>				
22.	N	92	The CTC should request each regional agency to provide to PSC modelers the forecasts of abundance for the model deemed best for each of the "relevant" ranking criteria (such as MRE, MAE, or RMSE), where "relevant" is defined as those that fit with stated management objectives for the AABMs.	See recommendation #1 in section 7.1 above. The CTC recognizes that agencies may choose other criteria, but the CTC would like documentation on which criteria were used to choose the forecast provided.	1
23.	I	93	A series of projection runs should be conducted with the PSC model to produce a range of AIs for each AABM area. These AIs would reflect the different agencies' stock-specific model-ranking criteria that are deemed relevant to AABM management objectives.	Dependent on receiving additional forecasts from agencies that met other ranking criteria. Differences in AIs could be evaluated, especially in a retrospective analysis, but forecast or AI selection method should be determined prior to calibration. Evaluating multiple outcomes is particularly difficult in the compressed time available for calibration. Clear procedures would need to be developed to determine the final AI among a range of possible AIs for each AABM fishery. This is a time intensive endeavor.	4
	<b>8.3 Structural uncertainty in the PSC Chinook model</b>				
24.	I	93	Functionality of the PSC Chinook model might be enhanced by including, where appropriate, nonlinear relationships such as those found in many other fisheries models, including the effect of fishing on reducing the fish abundance available to subsequent fisheries during a given year.	Long term consideration contingent upon model improvement funds required to commence work on alternative model structure or frameworks. Incorporating nonlinear relationships would require restructuring the model, and would likely require additional data on effort. This is also dependent on the DGM being completed.	5
25.	I	94	Effects of changes in marine spatial distribution of Chinook stocks on functionality of the PSC Chinook model need to be evaluated.	Long term consideration contingent upon model improvement funds required to commence work on alternative model structure or frameworks. The PSC could convene a workshop or special investigation to examine evidence for distributional changes related to environmental conditions.	4
26.	I	95	Sensitivity analyses with the PSC model should be used to explore different assumptions about (1) age structure for stocks without historical	Sensitivity analyses as suggested in (1) and (2) could be carried out but would require dedication of CTC time and resources. This work	5

			age composition data, (2) body-size structure used in the current method for estimating PN <sub>V</sub> , and (3) alternative structural formulations of the PSC model to calculate changes in age at maturity as a function of changes in body-size distributions. Some of those analyses could also assume various correlations with age-at-maturity schedules of other stocks.	could be conducted outside of the CTC but would require funding for a contractor. Alternative model structures or frameworks are a longer term consideration. This could be part of analysis with DGM and sensitivity analyses. Implementation in the Chinook Model would require time and effort.	
27.	L	95	The differences between pre-season and post-season abundance indices in each of the three AABMs might be reduced by including in the PSC model tendencies for multiple stocks to have positively correlated time series in productivities.	The CTC could be tasked to discuss how the current Model structure could be modified to incorporate common survival patterns among stocks. Long term consideration contingent upon model improvement funds required to commence work on alternative model structure or frameworks. Evaluate the properties with simulated data using DGM.	4
28.	L	96	The PSC model might be improved if factors such as EV and RT were calculated as functions of other variables.	The CTC could be tasked to discuss whether alternative approaches may be used to calculate or modify the EVs and RTs. This would involve structural changes to the current Model framework. Long term consideration contingent upon model improvement funds required to commence work on alternative model structure or frameworks. Possibility to evaluate the properties with simulated data using a modified DGM.	5
29.	L	96	Uncertainty in estimates from the PSC Chinook model should be explicitly represented either by making the model stochastic or running it across numerous sets of assumptions using sensitivity analyses.	This would require long term consideration contingent upon model improvement funds required to commence work on alternative model structure or frameworks. Making the Chinook model stochastic would require significant revisions, whereas running it across numerous sets of assumptions is more feasible with the current model. Numerous sets of assumptions would require numerous model calibrations, and the expenditure of additional resources to follow-through with this recommendation. Management frameworks, as currently configured, would need to be adjusted to handle uncertainty.	5
30.	L	97	Ideally, the existing PSC Chinook model and/or its procedures should either be tested and refined or an entirely new model (or models) should be developed.	Long term consideration contingent upon model improvement funds required to commence work on alternative model structure or frameworks. Evaluate the properties with simulated data using DGM.	5
			<b>8.4 Uncertainty in parameters of the PSC Chinook model</b>		

31.	I	100	Testing of the PSC model (and all other contemplated models) should be a high priority when the Data Generating Model is released.	Agreed. This would require prioritization that the CTC focus on this recommendation as substantial time and effort would be needed, similar to what was required in the 'harvest rate index investigation' of 2007-09. Additional MI funding would assist this task.	3
32.	N	101	Evaluations of the PSC model should include: (1) a check whether there is confounding of parameter estimates in the stage 1 calibration; (2) a series of sensitivity analyses/calibrations exploring alternative values for assumed age-specific natural mortality rates that might affect all other subsequent calculations and forecasts of abundance, and (3) consideration of whether the PSC model is being over-fit.	Requires substantial MI funding, time and effort; thus this is unlikely in the near term. Maturation rates and survivals are known to be confounded. To some extent this has already been investigated (i.e., Crandall et al (2003) and TCCHINOOK (16)-01). Sensitivity analysis requires a systematic approach.	4
33.	I	101	Documentation should be provided on the basis of estimates of Ricker stock-recruitment parameters, as well as uncertainty in those estimates. Also, some improvement in performance of the PSC model might be obtained if the AWG used a Kalman filter that allows for a time-varying maximum productivity parameter in a given stock's Ricker stock-recruitment model. That Kalman filter procedure will explicitly take into account observation error as well as natural variation.	At this point in time, this will have little effect on the overall calibration. This task would take a considerable amount and time to recode the model. The cost/benefit is not high under the current configuration of the model.	5
34.	I	102	Given the large number of input parameters, all possible combinations of low, medium, and high values for each parameter may be impossibly time consuming. However, only a subset of those combinations would be needed to produce a range of forecast abundances.	The AWG could review the sensitivity analysis completed in 2001 as a starting point to identify which parameters the model is most sensitive to. This could shed light on where to prioritize investments. A range of forecast abundances will only lead to further contention unless there is an objective and predetermined selection procedure for what will be agreed to.	4
35.	I	102	Additional evaluation and documentation are needed of the PSC model's methods for dealing with stocks for which age-composition data and/or forecasts of terminal abundance or escapement are not available, given the large relative abundance of those stocks in some AABM areas.	The CTC is currently engaged in the documentation of the new base period calibration.	2

36.		103	The Panel generally recommends use of stock-specific forecasts provided by agencies rather than forecasts derived solely from the PSC model in the absence of clear evidence of improvements in accuracy and precision across multiple years.	The CTC typically uses agency forecasts when provided.	1
	<b>8.5</b>	<b><i>Outcome uncertainty in the PSC Chinook model</i></b>			
37.	L	105	Considerations of outcome uncertainty (deviations between desired and realized outcomes such as catches), as well as uncertainties in forecasts, will influence expectations of managers of these AABM fisheries when they choose annual fishing regulations.	We are cognizant of this. No specific action required.	Agency
38.	L	105	The PSC Chinook model should take into account outcome uncertainty when making forecasts and presenting uncertainties in them.	This would require adjustments to the model structure. A range of forecast abundances will only lead to further contention unless there is an objective and predetermined selection procedure for what will be agreed to.	5
	<b>8.6</b>	<b><i>Other issues related to the PSC Chinook model's forecasts</i></b>			
39.	I	105	The calibration procedure for the PSC model should be standardized and thoroughly documented to such an extent that a new member of the Analytical Working Group could repeat previous example analyses and come to the same stopping point about which calibration is deemed "final".	Additional resources are needed to facilitate further documentation. The CTC recognizes the need for better documentation of the inputs and decisions made during the calibration process. Some work on improved documentation has already been completed or is in progress. The prioritization of this task should reflect the imminent retirement of some key AWG members.	1
40.	L	106	The abundance forecasts for AABMs areas produced by the PSC Chinook model should convey to managers the net effect of all of the major uncertainties described previously -- structural uncertainty, parametric uncertainty, uncertainty about management objectives, and outcome uncertainty.	On-going discussion within the CTC as to how to respond to and incorporate the recommendations of the Forecast Review Panel. The CTC agrees that this task is something to work towards, but also recognizes that within the current management framework of Chapter 3, how to incorporate uncertainty in AIs would be a policy decision.	Not Applicable

