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ADF&G response to peer reviewer comments on the early-run and late-run Kenai River Chinook salmon run reconstruction and escapement goal recommendation reports

Two ADF&G Fishery Manuscript reports (McKinley and Fleischman 2013, Fleischman and McKinley 2013) were provided to three fisheries professionals in August of 2013. All three reviewers are external to ADF&G, possess a doctorate, have extensive backgrounds in quantitative analyses of Pacific salmon population dynamics, and knowledge of Chinook salmon ecology and management. All reviews were received by the end of September 2013. There was no financial compensation offered or provided to the peer reviewers for completing this work.

External peer review of these reports was solicited to provide critical review of the analyses and to make recommendations for future analyses and/or data collection. Specifically, we were interested in technical reviews of the methodologies used to reconstruct each run and conduct the stock-recruit analyses. We also asked each reviewer to comment on how the analyses and information provided in each report supported (or did not support) the recommended interim escapement goals.

All comments received from the reviewers were divided into three categories: general comments, specific questions or comments, and recommendations for future work. The entirety of their comments is reproduced here. ADF&G's response to peer reviewer comments follow each set of comments.

General Comments

Reviewer 1, General Comments: These two reports are very similar. They share the same authors, employed the very similar methodologies, and the analyses were conducted under the guidance of the same review team. Because of these similarities, I chose to review the two reports together rather than individually. They have also been previously reviewed and published, and are thus in a final form, so my focus was on the substance of the reports rather than the details.

The analyses are very thorough, and carefully explore and characterize the uncertainty in both the data and the resulting estimates of parameters and reference points. The use of a state-space model in a Bayesian framework allows for incorporation of nearly all available data as well as evaluation of the uncertainty in those data. In my view, this a far superior approach to conventional spawner-recruit analyses where all these data are condensed into time series of spawner and recruit abundance, and most of the uncertainty is ignored. Nevertheless, the estimates of reference points are contingent on the assumptions embodied in the structure of the model. A number of alternative models were analyzed and considered to evaluate the sensitivity to model assumptions. This uncertainty is reflected in the recommendations for escapement goal ranges.

In my opinion, the recommended interim escapement goals are well supported by the analyses.

Reviewer 2, General Comments: Modern statistical methods are used to integrate all sources of available data into an age-structured, state-space framework. Where estimates are available, the uncertainty associated with each data source is accounted for. The effects of other main sources of uncertainty (lacking CVs) on the parameter estimates are investigated with sensitivity analyses. The methodology has been published in a leading fisheries journal (Fleischman et al. 2013).

Reviewer 3, General Comments: This is a very complex model that mixes run reconstruction with spawner recruit analysis in an analysis that is at the cutting edge of "state of the art." I am quite impressed by the overall work and it seems to capture all of the uncertainty in an integrated package. I don't know enough about the individual data sources to critically review all of the assumptions, and with something as complex as this the best peer review is to repeat the calculations, which was far beyond my available time. So primarily I am able to review the overall approach and highlight some specific elements.

I admit I was overwhelmed at the complexity of the analysis in that I ran out of time to dive into details. I only looked at the early run paper in some depth – it looks to me like the issues I identify are relevant to both papers.

My overall comment is this is an excellent analysis. I particularly liked the explicit representation of uncertainty, and the search for harvest strategies that were robust to this uncertainty.

ADF&G Response: *We agree that the methodologies used to develop the recommended respective interim escapement goals are the best available in terms of incorporating uncertainty in run reconstruction into the escapement goal analysis. The methods used in these analyses are the preferred approach for developing an escapement goal. These methods utilize knowledge of the production capabilities of each stock, rather than utilizing ad hoc approaches that maintain an arbitrary level of observed escapements independent of the production capability of that stock. The interim escapement goal recommendations are based on production data from the reconstructed runs and represent our best attempt to develop an escapement goal based on high probabilities of achieving the fishery objective of MSY of each stock.*

<u>Specific Questions or Comments</u>

Reviewer 1, Specific Comment 1: Fisheries manuscript Series # 13-03 (early-run Kenai Chinook):

Page 16, 3rd paragraph under Stock Productivity, Capacity, and Yield – the CI for *SEQ* is reported as 9,204 to 7,950. That should be 9,204 to 17,950.

ADF&G Response: *Correct. This is a typo where the "1" was inadvertently left off from the value of 17,950.*

Reviewer 1, Specific Comment 2: Both reports:

Equation 19 – For early-run Chinook, the equation allows for the change in size selectivity in the inriver gillnet fishery that is used to obtain age samples. The equation used for late-run Chinook does not. The addition of 5 inch mesh in 2002 affected the sampling of both runs. Why is this accounted for in the analysis of the early run, but not in for the late run?

ADF&G Response: *The reviewer is correct that the late-run analysis did not incorporate the effect of adding the 5-inch mesh to the netting program. The late-run analysis and report was completed prior to the early-run analysis and report. The model that was ultimately used in the early-run analysis was not fully implemented until after the late-run report had been finalized. When this model is fit to the late-run data, the estimate of* S_{MSY} *increased by only 10% (22,600 versus 20,260) and* p_{MR} *by only 4% (0.81 versus 0.78). The effects of applying the model used in the early-run analysis to the late-run data set were within the range of those found in the sensitivity analysis conducted by Fleischman and McKinley (2013), being similar to those of the trending age-at-maturity (TAM) model (Table 5, configuration 6), but lesser in magnitude. We agree with the reviewer that age at maturity and age composition considerations deserve closer attention. We continue to develop ways to accommodate and consider age structure in escapement goal analyses (Fleischman et al. 2013). Thus far, for Kenai River Chinook stocks, escapement goal recommendations have been relatively robust to these considerations.*

Reviewer 2, Specific Comment 1: Other authors have used a random walk (RW) to describe the changes in productivity. In simulation studies, the RW had some advantages over the AR(1) model. A fundamental difference between the two approaches is that the AR model assumes a central tendency, whereas the RW implies that recent conditions will persist in the near future. More generally, it would be desirable to simulation test this methodology with known data with known distribution of errors, especially if the method is going to be applied to other stocks. These simulation trials would obviously take a long time in WinBUGS.

ADF&G Response: *As the reviewer states, RW models are very useful to describe changes in productivity over time. However, we are unsure how one would use the results of the RW model to inform an escapement goal recommendation, since the RW model recommends that the escapement goal range change, potentially annually, in response to changing productivity. Such a strategy can cause volatile swings in estimates of* S_{MSY}*, and potentially risk-prone reductions (or increases) in the escapement goal. A comparison of the AR and RW approaches is documented in the online supplement to Fleischman et al. 2013. Our approach is to use the best estimate of long-term productivity to determine the escapement goal, thereby developing a goal range that is robust to times of lower (or higher) productivity. We agree that more work is needed to devise policies that make the best use of timely estimates of stock productivity. However, until such policies are more thoroughly investigated, our approach provides a sensible balance between the competing considerations of maximizing yield and minimizing risk to the stock.*

Reviewer 2, Specific Comment 2: The map of the Kenai River (Figure 1) could use more detail about the locations of items mentioned in the text (e.g. RM9, sonar locations, Soldotna bridge).

ADF&G Response: *We agree. Future versions of these reports will provide additional details to better identify key geographic features used in assessing Kenai River Chinook salmon.*

Reviewer 2, Specific Comment 3: Age at maturity is described with the Dirichlet distribution. I thought there could be a little bit more explanation of the difference between the predicted age compositions, true year-to-year variations in age of maturity, and sampling error. It only became clear afterward that the predicted age distribution is needed to fill in data gaps.

ADF&G Response: *Perhaps we could have been clearer about the role of age at maturity in our escapement goal analyses. Variations in age at maturity that occur due to natural variation and measurement error, if not accounted for separately, incorrectly affect the amount of process variation (σ_w and ϕ) in a stock-recruitment relation. By using a sampling distribution (the Dirichlet) for age at maturity rather than assuming age at maturity is known and only due to natural variation, we are better able to separate the effect of measurement error and natural variation in the estimation of the parameters and variances of the stock-recruitment model. We used alternative formulations of the stock-recruitment model for the late-run stock (Table 5, Configurations 2a and 2b in Fleischman and McKinley 2013) to investigate this by varying the amount of measurement error (i.e., the effective sample size) of the age composition data and found that parameter estimation was only marginally affected.*

Reviewer 2, Specific Comment 4: Hilborn's Eq. (20) provides a good approximation of S_{MSY} over a range of α. However, it isn't really necessary since S_{MSY} can be solved from the transcendental equation with a root finder.

ADF&G Response: *While true that the solution to S_{MSY} can be found iteratively, Hilborn's (1985) approximation provides a computationally efficient-to-implement solution that is within a few percentage points of the value from the iterative solution for values of ln(α) between 1 and 3. For larger values of ln(α), Peterman et al. (2000) also gives an approximation that is computationally efficient.*

Reviewer 3, Specific Comment 1: Some specific comments on the early run paper:

Page 3 top paragraph: If prior to 2002 there is concern that some sockeye were counted as chinook, shouldn't the correction depend on the sockeye run, and not be constant?

Page 12: do we get posterior implied by prior?

Equations 20 and 22. Hilborn 1985 formulation of the Ricker has a different alpha and beta meaning than the alpha and beta in equation (1) of this paper. I couldn't tell if the appropriate transformation in alphas and betas had been made to use the formula in equations 20 and 22. This needs to be checked.

ADF&G Response: *Perhaps we were unclear about our concerns. There is concern that sockeye salmon were counted as Chinook salmon for the entire time series of inriver runs. The run reconstruction was needed to estimate inriver run in units comparable to the DIDSON sonar rather than a simple conversion of one counting system to another. The only difference is that during 2002 to 2012 we had additional means (e.g., adding a smaller mesh size to the netting program) to better estimate numbers of actual Chinook salmon entering the river.*

In terms of "posterior implied by prior," we take it to mean that we chose an informative prior for characterizing uncertainty of the late-run reconstruction as an input variable in the early-run reconstruction and therefore influenced the posterior distribution of early-run inriver runs. As stated on page 12 of McKinley and Fleischman (2013), we subjectively increased the variance of the late-run inriver run to reflect our belief that the time series of inriver runs during the early run may not be correlated with inriver run during the late run. We also ran the early-run model with a non-informative prior on variance of late-run inriver run size and found very little difference with the base model (Table 7, Configuration 4 of McKinley and Fleischman 2013).

Yes, equations 20 and 22 use the appropriately transformed parameters to match the form of the Ricker equation we used in our reports.

<u>Recommendations for Future Work</u>

Reviewer 1, Future Work Comment 1: Both reports:

Equations 4-6. Distributing the recruits from a brood over ages at return using a Dirichlet distribution effectively assumes that there is no marine mortality after age 3, and that the maturity schedule is stationary. This is pretty thoroughly described in the reports. However, under these assumptions one would expect that the age composition of brood returns should be stable over time. Consequently you should see the age composition of the mature runs getting younger during periods when the population is increasing, and older when it is declining. This should happen because changes in the strength of returns would be driven by changes in year-class strength. When the population is increasing, younger year classes would be more abundant that older year classes, and when the population is declining, younger year classes would be weaker than older year classes.

The age compositions in Table 3 of both reports do not reflect this.

The apparent trends in age composition of the inriver run seem to persist over the entire time series since 1988 regardless of whether the population has been increasing or declining. Part of the increase in younger ages can be attributed to changes in gillnets used to sample the in-river run for age composition in 2002, but that doesn't alter the overall trends. The trends in age composition include older ages, and extend over nearly the entire time series for both early and late runs. This is more consistent with either an increase in natural mortality in ocean fish between the ages of 3 and 7, or concurrent declines in productivity and age of maturation. The structure of the model does not allow for the former possibility because it assumes that there is no mortality after age 3, and the adopted model assumes that age of maturity is stationary. As a result of this, the posterior age compositions that come out of the state-space model do not reflect the observed trends in age structure (Figure 6 in both reports). The alternative model (TAM) allowed for trends in the age of maturity of broods, and may adequately capture this, but the base model doesn't really seem to. Trends in marine survival would result in trends in apparent maturity, and the TAM model would describe this aspect of trends in marine survival. However, I am not sure that the structure of TAM model would capture all relevant consequences of marine survival trends.

Results from the TAM alternative model differed substantially from those of the base model. While for the early run, some of the changes in parameter estimates were compensating, resulting in negligible change in the estimate of *SMSY*, this was not the case for the late run. The estimated *SMSY* was higher and the estimated recent spawning escapements, were lower, reflected by the higher *pMR* under the alternative model compared to the base model. As pointed out in the report, this suggests (and the report recommends) that further investigation into the apparent trends in maturation rates is warranted. I concur with that recommendation, and further suggest that the investigation should include explicitly incorporating marine survival to confirm that the TAM model adequately describes the effects of such trends.

ADF&G Response: *As we have stated above, varying the influence of age at maturity information had no appreciable effect on the outcome of the late-run stock-recruitment analysis. Moreover, many of the posterior median estimates of key statistics from the state-space model are not substantially different between the base and trending age at maturity (TAM) models for the early or late-runs. Posterior median estimates of* β, S_{EQ}, S_{MSY}, *and* p_{MR} *are very similar between the base and TAM models for early-run (Table 7, page 36 of McKinley and Fleischman 2013), as are* β *and* S_{EQ} *for late-run (Table 5, page 30 of Fleischman and McKinley 2013). Although the median estimates of* S_{MSY} *and* p_{MR} *for the late-run are notably different between the base and TAM models (Table 5, page 30, bolded values shown under TAM model of Fleischman and McKinley 2013), the posterior median estimates of the TAM model are well within the 90% credibility intervals of these two statistics of the base model (Table 7, page 32 of Fleischman and McKinley 2013).*

We do agree that a directional change in the maturity schedule can influence the forecast of, and is a factor to evaluate in, future runs. We have already incorporated the TAM model into the forecast of both the early- and late-runs in 2013, and will continue to do so. It appears that age at maturity may be changing subtly for a number of Chinook salmon stocks throughout Alaska. ADF&G plans to collect data to allow assessing and evaluating a potential change in maturity schedule and changes in marine survival among indicator stocks as part of the Statewide Chinook Salmon Research Initiative, including Kenai River Chinook salmon.

Reviewer 2, Future Work Comment 1: There is a whole series of papers, starting with Peterman et al. 2000, that have estimated time varying productivity of salmon stocks and its consequences for salmon management. When productivity declines, as in recent years, it becomes more difficult to attain the escapement goal. In other words, S_{MSY} declines. Interestingly, changing productivity affects S_{MSY} but not the spawning abundance for maximum recruitment (Eq. 23).

ADF&G Response: *Theoretically, the reviewer is correct. When productivity declines, the escapement that maximizes yield should also decline as is proffered by the random walk (RW) models that speak to time varying productivity. In Alaska, we believe that declines in productivity are usually short-lived and that protection of spawning abundance has priority over all other uses of salmon. In this way, we parameterize stock-recruitment models to provide best estimates of the average long-term productivity and attempt to maintain escapement goal ranges that maximize long-term yield despite downturns in productivity, within the limits of uncertainty in our data and trends in productivity. We are supportive of further investigations into time varying productivity such as the RW and trending age at maturity (TAM) models for forecasting runs as these models take into account current productivity and maturation rates.*

Reviewer 2, Future Work Comment 2: The study does a very thorough job estimating the stock recruitment parameters; the weak link is their translation to escapement goals. The recommended escapement goals are based on optimal yield profiles and optimal recruitment profiles, where 'optimal' is interpreted as maximal. The calculation of the optimal yield profiles seems to ignore outcome uncertainty, by assuming that a manager can meet a given escapement goal and harvest all the fish in excess of this goal. Actual managers can only approximate this policy because of the many challenges of in-season management. As a result, actual yields will be less, sometimes considerably less, than optimal. Actual harvest rates have been below U_{MSY}, and for the early run, considerably below. It appears that the objective is not to optimize the yield but to meet the escapement goal.

The stated management objective is simply to "achieve adequate escapement." The escapement goal lies somewhere between the value that would maximize yield and the value that would maximize recruitment. There are likely to be multiple objectives for the fishery, some of which conflict with each other. If the management objective were more operational, it would be possible to define escapement goals that quantified the risks and benefits to different sectors. As it is, the setting of escapement goals seems subjective. This is not the fault of the analysts. In the absence of operational objectives, they project their own.

ADF&G Response: *See response below.*

Reviewer 3, Future Work Comment 1: However, the analysis of the consequences of the harvest policy could be carried a bit further. The final recommendation of escapement goals does not really tell you what the consequences will be. To understand that one has to model the relationship between total return and the resulting escapement and catch. For instance it will make a difference if the managers end up hitting the midpoint of the range each year or if they hit the lower end in poor return years, and the high end in high return years (as commonly happens). It would also be useful to compare those outcomes to alternative harvest policies, such as constant exploitation rates. It has been shown that when the underlying spawner recruit relationship is uncertain (particularly the beta value) that constant harvest rates or closely related policies, may produce higher average yields than escapement goals. I would have liked to see simulations of the outcomes of harvest strategies and a broader range of harvest strategies explored.

ADF&G Response: *The purpose of the work contained in these two reports was to develop interim escapement goals as required by the Policy for the Management of Sustainable Salmon Fisheries (5 AAC 39.222) and Policy for Statewide Salmon Escapement Goals (5 AAC 39.223) that could be used to manage fisheries based on the sustained yield principle. We recognize there may be multiple objectives impacting fisheries management, which is a study of its own worth exploring in the future.*

We also agree that operational objectives for fisheries could potentially simplify the selection of escapement goals. A management strategy evaluation (MSE) approach (Jones and Volk 2011) is a sensible next step for both runs of Kenai River Chinook salmon. The MSE would provide the ability to evaluate harvest policy performance with respect to yield, frequency of fishery restrictions, and other objectives. The current analyses and reports are a necessary pre-cursor to this work, because it supplies information on stock productivity and capacity directly into the MSE simulations.

Reviewer 2, Future Work Comment 3: In summary, age-structured, state-space models hold great promise for assessing salmon populations. They can be framed with frequentist or Bayesian approaches as the authors have done here. Many of my comments from reading the Fishery Manuscript Series were addressed more fully in the journal article by Fleischman et al. (2013), so it is obvious that the authors have thought about these issues. The challenges for salmon management in Alaska are twofold. Managers and stakeholders may find this Bayesian methodology inaccessible. Those who do understand it might question some of the choices made along the way. Perhaps this gap could be bridged with public workshops and other forms of outreach.

ADF&G Response: *We agree that the complexity of the models and modeling approaches presents a gap to bridge between the scientists and the stakeholders in fisheries management. Although much more could be done, on at least two occasions ADF&G staff did give presentations to the public and Alaska Board of Fisheries members describing data, analyses and results for the late-run Kenai River Chinook salmon stock. Additional outreach efforts are ongoing.*

Our Bayesian state-space formulation of stock-recruit analyses is not "brand new." It was first developed in 2003 and has now been applied to more than a dozen Alaska salmon stocks. We recognize that the methodology is more complex and thus more difficult to explain and understand. However, for every application (including this one), it has been found to provide sensible results compared to more traditional methods. A partial list of other related analyses is referenced on pages 10 and 11 of the late-run report (Fleischman and McKinley 2013).

Reviewer 3, Future Work Comment 2: One of the big issues in spawner recruit data is that environmental variability makes the underlying relationship more difficult to detect, and sustained runs of good and bad years tend to cause low spawning stock to produce low recruitment and large spawning stock to produce larger recruitments even if there is little underlying relationship between stock and recruitment.

One can use the estimated recruitment deviates from other stocks subject to the same pattern of good and bad years as a prior on the recruitment deviates to help "clean up" the spawner recruit relationship.

ADF&G Response: *This is an excellent idea and one we have not yet taken into account in our stock-recruitment analyses. Perhaps this idea could best be implemented as a meta-analysis of Chinook salmon stocks throughout Cook Inlet.*

References

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