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Review of the Comparative Survival Study (CSS) Draft 2021 Annual Report

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I. Background

The Columbia River Basin Fish and Wildlife Program calls for a regular system of independent and timely science reviews of the Fish Passage Center's (FPC) analytical products. These reviews include evaluations of the Comparative Survival Study's draft annual reports. The ISAB has reviewed these reports annually beginning eleven years ago with the evaluation of the CSS's draft 2010 Annual Report and most recently the draft 2020 Annual Report.[1] This ISAB review of the *draft 2021 CSS Annual Report: Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye* is the ISAB's twelfth review of CSS annual reports.

II. Summary

This ISAB review begins with an overview of the latest report's findings (this section). It moves on to suggested topics for further CSS review (Section III) and then general comments and specific editorial comments on each chapter of the draft 2021 CSS Annual Report (Section IV).

The annual CSS report is a mature product, typically including mostly updates with the latest year of data and expansion of analyses as more data are acquired. Many of the methods have been reviewed in previous ISAB reports and so now receive only a confirmatory examination. As more data are acquired, new patterns and questions arise on the interpretation of the results—this is now the primary focus of our reviews. The ISAB appreciates the CSS's detailed responses to suggestions provided in previous reviews (e.g., CSS 2020 Annual Report, Appendix H), and we do not expect the CSS to necessarily respond immediately to new requests for further analyses.

The Fish Passage Center has produced these reports since 1998, and the ISAB has reviewed them since 2010. As a result, the bulk of the CSS report focuses on the continuation of the analysis of long-term trends. Much of the text is taken verbatim from the text of previous

[1] ISAB 2010-5, ISAB 2011-5, ISAB 2012-7, ISAB 2013-4, ISAB 2014-5, ISAB 2015-2, ISAB 2016-2, ISAB 2017-2, ISAB 2018-4, ISAB 2019-2; review of Chapter 2 of the 2019 Annual Report (ISAB 2020-1); and ISAB 2020-2).

reports, with changes to update the time periods and results with additional data. Averaged values calculated over time series change very little because the additional year of data represents a small fraction of the total record. For most chapters, the final conclusions are identical to conclusions in previous reports.

The take-home messages in the Conclusions sections are useful for the Council, BPA, and fisheries managers. However, the Conclusions in most chapters are identical to the past conclusions, and they do not highlight any new issues or concerns. Several major issues and concerns are reported in this year's report, such as very low survival for several species and age classes with some outcomes much worse than predicted or the addition of fall Chinook and steelhead to the upstream migration analysis. The Discussions in several chapters made major recommendations, but many were not included in the Conclusions. It would strengthen the Conclusions to identify any positive or negative changes in this year's data and highlight any emerging issues and major recommendations.

The CSS Report does not emphasize the benefits of its program and the use of its data and analyses in other reports and peer-reviewed publications. These data are critical both for informing fisheries managers in the Columbia River and for providing valuable data for research in the Pacific Northwest, such as documents recently reviewed by the ISAB (Dam Bypass Selectivity Report, ISAB 2021-1; Comparison of Avian Research Findings, ISAB 2021-2); Coast-wide SARs Report, ISAB 2021-3). The annual report could describe major applications of the CSS data that have been published or reported over the last year and briefly highlight important findings based on CSS data. The importance of the critical information provided by the CSS can be lost under the volumes of graphs, tables, methods descriptions, and technical discussions. Given the rising costs of PIT tagging at the scale of the Columbia River system and funding limitations, the CSS should make the regional importance of its analyses abundantly clear to the Council, BPA, co-managers, and the public.

Many things have changed in the Columbia River Basin and hydrosystem over the 25 years of data collection, and the impacts of these changes on the long-term analyses are largely unknown. Many of the changes in the hydrosystem are summarized in Chapter 1, but the reader must infer possible impacts. The ISAB again suggests a table of the changes in the hydrosystem over the years, along with a brief indication of the possible impact of these changes on the estimates of the effects of the hydrosystem on salmon and steelhead survival.

Chapter 2 updates the analysis of the patterns of survival of wild steelhead in the Basin to include wild spring Chinook salmon. There was some confusion in the chapter about the environmental variables used, and this needs to be corrected. The regression methods may be affected by failure of the standard assumptions made; these need discussion. As with all initial analyses, the ISAB makes several suggestions on how to refine and improve the analysis.

Chapter 3 continues and expands previous years' work on the effects of the in-river environment on juvenile travel time, instantaneous mortality, and survival. The CSS now analyzes the Upper Columbia River based on PIT tag data from Rocky Reach to McNary dams rather than Rock Island to McNary dams. The CSS could explore analytical methods to use data from both reaches and capitalize on a longer period of record.

Chapter 4 also continues and extends past years' work on patterns in annual overall SARs. By now, the low level of SARs relative to the Council's 2%-6% objectives has been established. These essential but lengthy data sets and extensive summaries of results may overwhelm decision makers and the public, inadvertently giving the impression that persistently low values of SARs are inevitable. In the long-term, this can desensitize them to the potential consequences and relative effectiveness of alternative management actions that can better achieve the Council's SAR objectives. Clearly, the life cycle models of CSS and NOAA Fisheries rely on these estimates and provide some synthesis. However, the CSS could consider developing an Impact Report, perhaps developed collectively with other groups, to communicate the most critical take-home messages for the Council, BPA, and co-managers.

Chapter 5 presents work in progress on the analysis of upstream migration success, with the addition of fall Chinook and steelhead to the original analysis of spring Chinook only. All survival probability estimates are very high, with two segments having values of essentially 1.0. The ISAB is concerned that the lack of contrast in survival in many reaches over time will make it difficult to determine effects of other factors. What is the end-goal of this analysis? Are there management implications from the results of this analysis?

Finally, Chapter 6 reports on an updated analysis to estimate the number of outgoing smolt (both tagged and untagged) that pass Bonneville. This proposed methodology appears promising, and the ISAB looks forward to its application to other species and stocks.

The ISAB strongly emphasizes the importance of the CSS reports. There may be a tendency to think it is "more of the same" each year; however, with more than 25 years of data, the conclusions reached are now at the stage where the uncertainty in the results are small (and not just one-off artefacts of particular years). As well, the physical and human capital infrastructure added over the 25 years is extremely valuable going forwards. When funding is constrained, it is tempting to just apply reductions over the entire program (e.g., reduced tagging), which would lead to an overall erosion in the quality of results (i.e., larger standard errors). A sequence of such cuts can lead to a situation where the past data are high quality but current data are poorer quality, which makes it difficult to assess the effects of habitat restoration, climate change, or other management actions (e.g., changes in spill management). If funding is to be constrained, the entire CSS program should be reviewed in detail to see which parts are essential and which parts can be reduced without critically damaging the overall CSS program.

III. Suggested Topics for Further Review

Since 2011, the ISAB has suggested topics that warrant further CSS or regional review; see Section V below for the ISAB's evolving lists of topics. The latest CSS report incorporates many of our past suggestions (e.g., alternate estimation methods for estimating total smolt outmigration past Bonneville). As noted above, the ISAB appreciates the CSS's effort to respond to our past queries.

In ISAB 2020-2, we recommended the following topics (*italicized*) for future reports. After each recommendation, we summarize the current status of the work to address them:

1. *Given the large amount of information in the CSS reports and the similarity of each year's report with previous reports, It would be helpful for the Council, BPA, Tribes, NOAA Fisheries and other management agencies, and public to have an introductory section that highlights 1) an overall summary for the survival of Chinook salmon, steelhead, and sockeye salmon in the Columbia River basin and how the SARs for the year compare to the long-term means, 2) new analyses included in the report, 3) major changes that may signal emerging management concerns, and 4) major recommendations for management of the hydrosystem that substantially alter or reinforce previous decisions or concerns. This section could briefly identify these changes and recommendations and explain their relevance to the Fish and Wildlife Program, while directing readers to specific explanatory sections of the text.*

This recommendation was not implemented in the latest report and the Conclusions sections of most chapters were identical to previous years. In our opinion, this proposed change would greatly strengthen the utility and impact of the CSS reports and would avoid the impression of "more of the same" mentioned earlier.

2. *Consider ways to address the spatial and temporal aspects of the effects of total dissolved gas (TDG) on acute and long-term survival, as we also recommended in 2019. Are the current data sufficient to address this problem? Are there other sources of data that would be useful? The analysis in Chapter 3 continues previous years' work and should continue. The current analysis indicates no evidence of a TDG effect (Figure 3.15). The current analysis methods must use an "average" TDG that a cohort receives and cannot identify the TDG experienced by an individual fish. There may be an issue with a*

lack of contrast in the TDG (see Figure 3.16) where there are only a few years with higher TDG. Could an experiment be conducted, within an adaptive management framework, at one or two dams where the TDG is varied over the course of migration? Are there other ways in which contrast can be improved?

The current report updated the previous report with new data points but did not consider the proposed new analyses. Based on visual inspection, Figure 3.16 of the report appears to indicate that TDG has been increasing in the Snake and Columbia rivers since 2000. The Discussion section explains that "Combined, the analyses in this chapter and those of Haeseker (2019) show no evidence of detrimental effects of TDG levels that have occurred on freshwater, ocean, or smolt-to-adult survival." While it may not be detrimental, the CSS report could describe the trend quantitatively and discuss changes in the hydrosystem operations or regional climate and hydrology that might explain the trend.

The report did find that the new detector at the Lower Granite Dam removable spillway weir (RSW) was successful in detecting a large number of PIT tagged smolts in 2020. Consequently, this technology may allow a finer resolution of the data on TDG experienced by a smolt.

In our review of the 2019 report (the last report that included the estimation of outgoing smolts past Bonneville), the ISAB recommended:

3. *Continue work on methods to estimate numbers of outgoing smolts at Bonneville. Could additional data be helpful (e.g., targeted releases of known number of smolts directly above Bonneville to estimate detection probabilities directly)? What are other options if the current data provide estimates with poor precision?*

In the current report, additional estimators were investigated (pooled- and stratified-Petersen [BTSPAS]). The current analysis appears to be well done, and the ISAB looks forward to the application of the methodology to additional species/stocks.

In 2021, we recommend the following topics for future reports:

1. **The first part of this recommendation is the same as last year**. We reiterate the need for a more robust introduction section that includes a summary of major findings, highlights new analyses, and describes recommendations for potential management applications of findings, as noted in item 1 above.

   These changes are also useful in building a case of why the results from the CSS are important.

Similarly, the structure of the CSS report is not completely static from year to year. For example, Chapter 5 from the 2020 report appears to be amalgamated elsewhere. The lifecycle model chapters were split out in 2020 and not included in this draft. The chapter on estimating outgoing smolt abundance was introduced in 2019, not included in 2020, and then returns in this report. Please provide a short explanation when the structure of the report changes and identify past reports that are related to the specific chapters. Are the lifecycle models still being used and expanded?

2. Several analyses were recently conducted by others that include the salmonids in the Columbia Basin that use data and defined variables (e.g., SARs) collected by the FPC and reported in the annual CSS reports. These data are critical both for informing fisheries managers in the Columbia River and for providing valuable data for research in the Pacific Northwest, such as documents recently reviewed by the ISAB (Dam Bypass Selectivity Report, ISAB 2021-1; Comparison of Avian Research Findings, ISAB 2021-2); Coast-wide SARs Report, ISAB 2021-3).The CSS Report does not sufficiently emphasize the benefits of the program in terms of the use of this information in these other reports and peer-reviewed publications. Similarly, the same data as used in this report is used in analyses that have major implications for management. These include Faulkner et al. (2019, 2020), Payton et al. (2020), Haeseker et al. (2020), and Welch et al. (2020).

   The CSS report is due for an update in its literature referenced (many citations are now more than 10 years old) and the CSS report has not incorporated findings from these newer analyses. The CSS report could describe major applications of the CSS data that have been published or reported over the last few years and briefly highlight the important findings that are based on CSS data.

3. The CSS should also consider recent analyses conducted outside of the CSS to identify possible new analyses (or extensions to existing analyses) that would inform issues raised by these external analyses. For example, Faulkner et al. (2019, 2020) and Storch et al. (2021) analyzed factors affecting bypass success; Haeseker et al. (2020) and Payton et al. (2020) examined bird predation; Welch et al. (2020) analyzed broad geographic patterns in SARs; body size and migration timing have large impacts on in-river survival and SARs.

   The analyses should be tailored to advance our understanding of Columbia Basin salmonids and further leverage the usefulness of the contribution of the FPC database. The rebuttals prepared by the FPC and the recent ISAB reviews of these studies (ISAB 2021-1, ISAB 2021-2, ISAB 2021-3) would provide a good basis for further investigating the issued raised. For example, the role of body length in how fish use the bypass systems and affect return rates could be clarified with an analysis that examines both the marginal and population-level responses as a multilevel model. Such an analysis can also include ways to codify the experience of fish with dam-related structures (presently captured by the PITPH).

Whether bird predation on smolts is compensatory or additive could be clarified with an analysis that utilized both statistical methods used to date and applied to the same datasets (population, years). Such analysis could also assess the effects of tagging and release locations on results.

The Welch et al. (2020) broad geographic analysis, FPC rebuttal, and the ISAB review raised important issues about freshwater versus marine survival and the potential to achieve target SAR values through freshwater management actions; such questions could be investigated in much more detail and with methods better tailored for the data-extensive Columbia Basin populations.

Body size and migration/release timing could be integrated in the CSS analyses. These characteristics can vary within populations across time, including important difference with up-river populations that need to travel farther. However, the CSS analyses are primarily comparisons across time, and the effects of body size and release timing are not always central to the analysis. However, changes in body size or migration timing can be confounded with changes across time. Do across time comparisons need to adjust for these covariates? Comparisons across stocks would also need to factor in release time and location.

Ultimately, the choice of analysis depends on the "story" the CSS are trying to tell. The CSS is pulled in many directions (and sometimes sent along a new path by the ISAB). Given the cost constraints identified earlier, it will be useful to step back, decide on the core results that need to be presented, identify the major uncertainties in the results and how these could be addressed. Which results are now of lesser relevance? Which results will be crucial for the future in the face of climate change, habitat restoration effect, and hydrosystem management changes? The Council could ask the ISAB to review and recommend priorities for potential analyses.

4. The FPC has documented concerns about biases for smolts captured and tagged at Rock Island (RIS). The ISAB examined the evidence regarding the issue (ISAB 2021-2, Appendix B) and concluded that *"there does not appear to be strong evidence that tagging location bias affected estimation of the additivity coefficient or other parameters in Payton et al. (2020) in a way that would invalidate conclusions and interpretation, especially at the smolt to adult return (SAR) life stage. Nonetheless, the ISAB*

recommends that possibilities for survival bias associated with tagging and release localities, especially across cohorts within year be thoroughly evaluated." Fish passage data are available for a longer period from RIS-MCN (1998-2020) than RRE-MCN (2010-2020). In the process of changing study reaches, the FPC should explore analytical methods to adjust for the bias they have documented, which would maintain a longer period of information that might be important in future analyses. For example, a simple RCB model could use the paired observations of RRE-RIS and RIS-MCN to develop a correction factor for the previous 13 years.

5. The ISAB review of the 2020 CSS Report suggested that the Discussion should address the unusually high mortality rates of subyearling Chinook in the MCN-BON reach. The 2021 CSS Report includes a paragraph on this issue. The rates of subyearling Chinook mortality from MCN to BON have been increasing steadily since 2015, and the rates of mortality in 2020 are the highest observed (Figure 3.6). The ISAB concurs with the CSS's recommendation that "Further investigations into turbine operations or other potential factors that may be influencing these patterns in the MCN-BON reach are warranted." Lessons learned here may be applicable to other reaches. The ISAB strongly the authors to include this major recommendation in their Conclusions.

6. The CSS report is a large effort with many species and stocks analyzed. It is not clear to the ISAB how much individual manipulation is needed for each species/stock and how much is automated. For example, a simple manual update of the CSS report with new data points would require a massive effort. Over the last 20 years, computer technology has evolved considerably, and new tools may be useful for the CSS report (e.g., a RMarkdown document). The ISAB recommends that the CSS form a working group to explore how newer computer technology could reduce the human cost of reporting.

IV. Comments on New or Updated Analyses in the draft CSS 2021 Annual Report by Chapter

IV.1. Comments on Chapter 1. Introduction

Overall, the Introduction provides a comprehensive and reasonably readable overview of a complex program, but see our recommendation repeated from last year to include a more robust description of major findings, new analyses, and management applications.

Minor Comments

p. 11, paragraph 3. Three hydrosystem categories for SARs (T, C_1, C_0) are defined here, but no context is given. It would help to add a couple sentences explaining why these groupings are important and how they will be used later in the report. For example, "T" stands for "transported," but what does "C" mean (control?)? It seems that the two "C" groups are subgroups of the return "R" group defined on the next page – if so, why a different letter? Later (p. 12) the "T" group is subdivided into "T_0" and "T_x"; why is that not defined in the same place as the "C" subcategories? This is confusing for the reader. A summary of this terminology in a single table or paragraph would be useful.

Editorial Comments

Some language needs updating (e.g., "In 2018 … will be added"). A quick file search can find all occurrences of statements about future steps that should be updated.

p. 1, paragraph 2. Please spell out PIT at first usage here. (It is spelled out in the next paragraph, but not here.)

p. 16: Suggest adding "Tag" or "Mark" before the heading "Coordination and pre-assignments during 2021" so the uninitiated reader knows what is being coordinated.

p. 13. Use of weighted bootstrap. This has been included for many years and is always "still in development." Perhaps this needs to be updated – will it be useful? If not, then this part of the document can be dropped.

p. 19, paragraph 1. Please spell out "WTT" and "PITPH" at first usage here (or just drop these acronyms from the paragraph; they add very little beyond "low flows" and "high spill proportion" and are discussed immediately below).

p. 19. As the ISAB suggested in last year's review (ISAB 2020-2), definitions of PITPH vary and appear to be inconsistent (e.g., p. 19 paragraph 2, p. 19 paragraph 4, p. 21 "Note on the use of PITPH") with the term being used both for the probability of powerhouse encounter at a single dam and for the average number of encounters across several dams. This is confusing for the reader.

While the wording was improved following our earlier comment, we suggest the following further clarifications to the main definition on p. 19, paragraph 4 (added text is [bracketed]): "CSS developed a new index variable called PITPH that estimates the proportion of fish passing via the powerhouse at each dam [and sums those proportions across a number of dams within a river reach], based on ..." ... "PITPH is an index of the [average] number of powerhouses a cohort of fish would encounter in a reach given the flow and spill at each dam during their passage. [A reach may include one or more dams, and the value of PITPH for a particular reach thus varies between 0 and *N*, where *N* is the number of dams in the reach.]" ... "[For example, the] PITPH variable can vary between 0 and 8 conceptually for populations of fish originating above Lower Granite Dam that have to pass eight dams in their outmigration." With these changes, the single dam vs. multiple dams uses of the term can be unified.

IV.2. Comments on Chapter 2 Patterns of survival of [wild spring Chinook salmon and] wild steelhead in the Columbia River Basin

This chapter has been expanded from previous years by including an analysis of wild spring Chinook salmon. Methods are similar to those used in previous annual reports.

There appears to be some confusion about which environmental variables are used in the analysis. For example, the equations for ocean survival and SARs (page 38) include ichthyoplankton and upwelling indices, but the description of marine indicators (p. 34) and the relative variable importance (p. 44) both use SST and upwelling. There appears to have been a change in the environmental variables considered in analyses between 2020 and 2021 reports. This needs to be clarified.

This chapter refers to juveniles as “spring Chinook salmon,” but this term refers to the adult migration timing and is not a juvenile trait, and so may be confusing to some readers. It appears that “spring Chinook Salmon” is being used to refer to particular stocks or populations in general and not to specific parts of the life cycle. The authors then use “yearling migrant” or similar terms in Chapter 3. The ISAB suggests that the terminology be standardized throughout the document, or an explanatory note be inserted on first usage, or restrict using the terms “spring” and “fall” to adult timing patterns, not the duration of juvenile residence in fresh water.

Moreover, the top of p. 33 states that these Chinook salmon “typically out-migrate after 2 years of freshwater rearing.” Surely the authors mean 1 year here and might cite Harstad et al. (2014). The steelhead are said to “typically out-migrate [just “migrate” would do] after 1-2 years of freshwater rearing. A single year may be correct, but 2 or 3 years is the mode for wild steelhead, and sometimes even longer. See the NOAA Status Review by Busby et al. (1996) and Peven et al. (1994) on this topic.

The regression method for estimating powerhouse passage events for the upper Columbia dams (page 34) makes two key assumptions. First is the assumption that the relationships are stationary across dams and years. Second, the estimation error in the regressions themselves is small. Neither is discussed in the chapter, and so the reader may question the reliability of

PITPH estimates for this portion of the basin. Have these issues been documented elsewhere? If so, please provide a citation; if not, some discussion of them should be included.

The models using environmental indicators in predicting survivals (page 38) may be problematic due to statistical issues (von Storch 1999) and systematic non-stationarities in complex climate-ecosystem interactions (Walters 1987). Climate regime shifts are well-known to affect salmon dynamics as well as ecosystem structure (Overland et al. 2008; Beaugrand et al. 2015), and complexities in ecosystems can lead to strongly non-linear dynamics with multiple stable states (phases) and chaotic behavior (Turchin and Taylor, 1992; Polis and Strong, 1996). Traditional regression approaches commonly fail under these circumstances (Wainwright 2021). We recommend that, in the future, the CSS should explore using less error-prone techniques for incorporating environmental indices (e.g., dynamic models; Ye et al. 2015) and better indicator selection (van de Pol et al. 2016), though these are not panaceas and any analyses including environmental indicators need to be done with caution. These new analytical approaches may be beyond the scope of the CSS group but may become more important with longer time series.

It would be interesting to summarize the survival rates of the different population complexes (p. 41) not only on an overall basis (which is important for their conservation) but also on a per-km or per-project basis, which would facilitate comparison of the performance of populations with different distances to travel. For example, the higher survival of John Day steelhead compared to those from the Snake River might be due to smaller migration distances. If not, that is another important finding worthy of investigation.

Farther down in that paragraph, it is stated the “The higher estimates of average ocean survival for wild steelhead from the Yakima River compared to the John Day River are partially influenced by high ocean survival estimates in 2002 and 2003 for the Yakima River population, prior to the first estimates from the John Day River population, which began in 2004.” Can a similar RCB analysis be applied to the ocean survival probabilities as done for in-river survival probabilities?

Minor Comments

p. 33, last paragraph. "We used the CSS bootstrapping methods to quantify the uncertainty in the numbers of smolts that survived to the first dam and the associated SARs." This does not seem to be reported in the results. Was this estimation error incorporated into further analysis (e.g., the errors reported for average survivals)? If so, how?

p. 34. Given that each powerhouse and reservoir experience differs (because of environmental conditions such as temperature, migration time, or gas %), does simply counting the cumulative dam/PH/reservoir (described on p. 34) obscure important relationships? Also, the models appear to account only for mainstem dam/reservoir experiences. The tributaries have dams with varying spillways and passage apparatus. The approach appears to assume these are not important. This may be true, but it seems worth acknowledging and discussing.

p. 34. At the beginning of the last paragraph, which presents environmental correlates, it would be helpful to make clear that these are not assumed to have causal controls over survival.

p. 37. The ISAB thanks the CSS for the revised analysis to incorporate a randomized-block design for summarizing life-stage-specific survival estimates. This appears to have changed the estimates more than would be expected from adding one new year of data, which should be discussed more thoroughly.

p. 37-38. All of the survival models assume that there is no error in estimating WTT and PITPH, and that combined errors from estimating survivals and fitting the models are normal with equal variances. Please assess these assumptions and discuss how failure of these assumptions may affect the reliability of results. If the effects are likely to be small, then please provide evidence of that.

p. 37-38. Were tests done for independence/correlations among the independent variables in the survival models? (e.g., a Variance-Inflation Factor (VIF) analysis). Please discuss how such correlations might affect the results.

p. 46, Conclusions: This is just a summary of results without incorporating any interpretation of their importance and whether they agree with or contradict expectations. It would help the reader to have some interpretation. For example, regarding freshwater survival, it could be stated that the results are consistent with both distance traveled and number of reservoirs passed.

Editorial Comments

p.30. This Chapter now has both Chinook and steelhead results so needs a different title.

p. 33. First paragraph is very long. It should be broken into shorter chunks. For example, the shift of topics suggests a paragraph break before "The non-anadromous life-history ..." and again before "In addition to calculating ..."

p. 33. “Although steelhead parr can permanently residualize, … tactic is rare for these populations. Similarly, residualization of spring Chinook is rare.” What constitutes “rare,” and is it stable thru time? If data are available, report as % of juveniles produced. Or is rare (and therefore, unimportant) an assumption based on some other kind of observation?

p. 33. State explicitly that any fishing mortality is not distinguished from natural mortality.

p. 35. In Figure 2.1, given that Methow and Entiat Rivers are pooled, a single ellipse (with an appropriate label) is probably more appropriate than two ellipses.

p. 37, paragraph 1. " ... models were of the form ~~from~~ ..."

p. 37, paragraph 1. In the equation, are the logit-transformed survival estimates those ($S_{i,y}$, $S_{O,i,y}$, and $SAR_{i,y}$) computed using the formulas on pp. 33 & 34? Please clarify this.

p. 37, paragraph 1. How were average survivals summarized from the RCB model? Presumably, these are the (back-transformed) β_i terms from the estimation model? Please clarify.

p. 39. In Figure 2.2, WTT are presented as point estimates. Should they not have an uncertainty of some kind to account for variation across the outmigration period? Is this small? Either some shading or text in the legend would be helpful to discuss.

p. 40, paragraph 1. Are the life-stage survivals in the figures and tables the back-transformed β_i terms from the simple equation at the bottom of p. 37, or from some other estimate? Please clarify.

p. 40-41, Figures 2.4-2.6. Including error bars for the annual survival estimates would help give a visual assessment of the significance of differences among the populations, although at some cost to the readability of the figures. Perhaps some shading could be used? Some experimentation in how to include the variability may be needed.

p. 42, Table 2.2: Table numbering is off; this is the second Table 2.2.

p. 42. When comparing the results between Table 2.2 (previous report) versus Table 2.3 (this report), there are some differences that are arithmetically small but as percent of a small number are large. Given that these are means of many years, are these just due to adding a new year of data?

p. 46, bullet 3. Should read "Freshwater survival ... highest for steelhead and spring Chinook ..."

p. 36. Tables 2.1 and 2.2 report number of PIT-tagged thru 2019. Readers may wonder why not through 2020? Is there routinely a lag? Or is this because the tags are used for survival which the 2020 fish have yet to return? Please add a footnote to the table to help readers who are not a familiar with salmon biology.

IV.3. Comments on Chapter 3. Effects of the in-river environment on juvenile travel time, instantaneous mortality rates and survival

The chapter largely is an update of the previous data for 11 of the 13 species-reach combinations and most of the text is identical to the 2019 and 2020 CSS Reports. The 2021 report includes new data and analyses for the subyearling and yearling Chinook salmon and steelhead from Rocky Reach Dam (RRE) to (MCN) and from McNary Dam to Bonneville Dam (BON) and sockeye salmon from MCN to BON. The report defines the Upper Columbia reach from RRE to MCN.

The FPC has documented concerns about biases for smolts captured and tagged at Rock Island (RIS). The ISAB examined the evidence regarding the issue (ISAB 2021-2, Appendix B) and concluded that *"there does not appear to be strong evidence that tagging location bias affected estimation of the additivity coefficient or other parameters in Payton et al. (2020) in a way that would invalidate conclusions and interpretation, especially at the smolt to adult return (SAR) life stage. Nonetheless, the ISAB recommends that possibilities for survival bias associated with tagging and release localities, especially across cohorts within year be thoroughly evaluated."* Fish passage data are available for a longer period from RIS-MCN (1998-2020) than RRE-MCN (2010-2020). In the process of changing study reaches, the FPC should explore analytical methods to adjust for the bias they have documented, which would maintain a longer period of information that might be important in future analyses. For example, a simple RCB model could use the paired observations of RRE-RIS and RIS-MCN to develop a correction factor for the previous 13 years.

The text indicated that the CSS "calculated and summarized seasonal estimates of fish travel time, instantaneous mortality rate, and survival probabilities for sockeye salmon in the LGR–MCN, RRE–MCN, and MCN-BON reaches," but sockeye are not listed for the RRE-MCN reach in Table 3-1, and data for sockeye in the RRE-MCN reach are not presented. We could not find an explanation of why these estimates are not provided for sockeye in the RRE-MCN reach. Fish passage estimates date back to 1997 for both RRE and RIS, but it is unclear when PIT tagging was initiated at both sites.

The instantaneous mortality rates for wild yearling Chinook in 2019 and 2020 were higher than all previous years. Instantaneous mortality rates for hatchery-wild steelhead in the RRE_MCN reach in 2020 were more than double the mean of previous years and much greater than predicted. These patterns were not addressed in the Discussion or the Conclusions.

The ISAB review of the 2020 CSS Report suggested that the Discussion should address the unusually high mortality rates of subyearling Chinook in the MCN-BON reach. The 2021 CSS Report includes a paragraph on this issue. The rates of subyearling Chinook mortality from MCN to BON have been increasing steadily since 2015 and the rates of mortality in 2020 are the highest observed over the period of record (Figure 3.6). This trend should also be highlighted in this year's Discussion section. The issue and the CSS's recommendation that "Further investigations into turbine operations or other potential factors that may be influencing these patterns in the MCN-BON reach are warranted" definitely should be included in the Conclusions.

Based on visual inspection, Figure 3.16 appears to indicate that TDG has been increasing in the Snake and Columbia rivers since 2000. The Discussion section explains that "Combined, the analyses in this chapter and those of Haeseker (2019) show no evidence of detrimental effects of TDG levels that have occurred on freshwater, ocean, or smolt-to-adult survival." While it may not be detrimental, the CSS report could describe the trend quantitatively and discuss changes in the hydrosystem operations or regional climate and hydrology that might explain the trend, if it is statistically significant. In the 2019 and 2020 ISAB reviews of the CSS Report, we suggested that the data for TDG and the estimated instantaneous mortality rates could be included as tables in the text or in an appendix. The 2021 CSS Report still does not provide this information or provide directions to a source for these data. Is there a reason why the data or a source for the data should not be provided?

The Discussion included a major finding and recommendation:

> *"The analyses that have been conducted for the Columbia River Systems Operations Environmental Impact Statement indicate that substantial improvements in juvenile travel time and survival are expected with management alternatives that increase spill levels and/or breach the lower Snake River dams (see Chapter 2 of the 2019 CSS Annual Report). Although there are several impediments to dam breaching, the Action Agencies could implement increases in spill or reductions in reservoir elevations at any time."* [page 79]

This major recommendation is not included in the Conclusions. The ISAB encourages the CSS to identify this recommendation in the Conclusions to ensure that it is recognized by decision makers.

Overall, the chapter is well written, and the analyses and results are explained clearly. The take-home messages in the Conclusions section are well crafted and useful for managers, but they are identical to the past Conclusions and do not highlight any new issues or concerns. Several species and age classes exhibited very low survival that decreased substantially from 2020, such as RRE-MCN steelhead, RRE-MCN yearling Chinook, and MCN-BON subyearling Chinook. Also, the observed survival was substantially lower than the predicted survival for several species and age classes, such as yearling Chinook and steelhead in the RRE-MCN reach and subyearling

Chinook in the MCN-BON reach. It would strengthen the Conclusions to identify any positive or negative changes in this year's data and highlight any new issues.

The CSS Report does not emphasize the benefits of its program and the use of its data and analyses in other reports and peer-reviewed publications. These data are critical both for informing fisheries managers in the Columbia River and for providing valuable data for research in the Pacific Northwest, such as documents recently reviewed by the ISAB (Dam Bypass Selectivity Report, ISAB 2021-1; Comparison of Avian Research Findings, ISAB 2021-2); Coast-wide SARs Report, ISAB 2021-3). This chapter and others could describe major applications of the CSS data that have been published or reported over the last year and briefly highlight the important finding that are based on CSS data.

Minor Comments

Including time series plots of all environmental variables used in the analyses would help the reader and aid in interpretation.

The fish travel time for yearling Chinook in one of the release cohorts in the RRE-MCN travel time was substantially higher than previous years and approximately 10 days higher than the predicted travel time. Is there any explanation for this?

Editorial Comments

p. 50. The use of "fall" to describe subyearling Chinook is redundant. It is only necessary to label them subyearling Chinook, unless there is something specific to the adult timing that is pertinent here.

p. 67. In the 2020 ISAB review, we suggested that the scale and size of symbols should be increased to allow readers to see within-year trends. The 2021 CSS Report increased the scale for the histograms in Figures 3.11-3.14., but the more detailed graphs in Figures 3.2-3.10 are smaller than the same graphs in the 2020 CSS Report. The page is landscape orientation, so it should be easy to increase the size of the graphs. This would make visual inspection much easier without needing to zoom in on the image in a digital file of the report.

p. 69. Figures 3.11 and 3.12. each have 11 histograms. The ordering of the histograms is not obvious. For example, many readers are interested in examining by species, but these are not grouped together. Reorganizing the graphs by species would allow easier comparisons.

p. 70. The last paragraph is rather long with multiple ideas. Can this be broken into a few shorter ones?

p. 75. In Figure 3.15, the CI are very wide for the effect of the average TDG for last two cohorts, but very small for the effect of the maximum TDG. The maximum must have larger contrast (i.e., large difference in maximum TDG across years compared to the differences in the yearly average TDG across years), but this does not appear to be the case in Figure 3.16? Some explanation is needed.

p. 79. In the Conclusions, the ordinal day is listed as an important explanatory variable for migration. Given this, why was it not incorporated into the analyses described in Chapter 2? Or if in fact it was, perhaps that can be made more prominent in Chapter 2. Also, was fish size examined? Fish size often co-varies with migration date, speed, behavior, survival, and so forth. It would thus seem important to include. Again, if it was included, perhaps that fact could be made clearer and the effect or lack thereof stated explicitly.

p. 79. "We see these models … refinement of alternative hypotheses … rates." These may be detailed somewhere else in the report, but what are these alternative hypotheses, and are they formally tested within the report such that we can evaluate whether there is support or fail-to-support? They are described generally as "smolt transportation program, flow augmentation, and spill for the recovery of listed salmon and steelhead stocks." – p.47

p. 80 "References" should be plural, not singular, and they should be alphabetized. When the full listing of references is compiled, note that the list at the end of the chapter is only partial and is missing many that are cited in the text.

IV.4. Comments on Chapter 4. Patterns in annual overall SARs

This is an update from previous reports and the earlier versions have been extensively reviewed over time. Changes this year include subdividing SARS into subbasins for Grande Ronde/Imnaha MPG and results for Fall Chinook SARS are now incorporated (rather than being in a separate chapter). Most of the text is identical to the 2019 and 2020 CSS Reports.

The statements on page 110 that "The 2-week [survival] estimates are highly variable but consistently indicate that a large amount of mortality occurs from RIS to MCN for the run-at-large juvenile yearling Chinook and steelhead" is especially concerning because Chapter 3 documented that survival of subyearling Chinook in the MCN-BON reach is the lowest on record.

The addition of the scatterplots (Figures 4.4, 4.6, 4.10, 4.11, 4.13, 4.19, 4.21, 4.23, 4.29, 4.30, 4.33, 4.37) is informative and effectively illustrates complex information. The tick marks for SAR values across alternate boxes along the top and right margins are less useful than if the tick marks were provided along the left and bottom row of boxes that contain data points. The comparison represented by each box in the matrix could be explained more clearly for readers, either in the text or in the figure caption when the illustration is first used.

As indicated in our review of Chapter 3, the take-home messages in the Conclusions section are well crafted and useful for managers, but they are almost identical to the past Conclusions and do not highlight any new results, insights, issues, or concerns. It would strengthen the Conclusions to identify any positive or negative changes in this year's data and highlight any new issues.

When the first CSS reports were written, only a short time series was available and simple analyses were appropriate. Current reports still include estimated correlation coefficients and use fairly simple models, albeit with lots of intricate data manipulation. Now, with over 20 years of data is available, are more sophisticated tools useful? There appear to be underlying patterns that could be characterized, perhaps with a time series approaches. There is an apparent long-term decline, but also some evidence of a potential periodicity in these data. Once these trends are accounted for, would a pattern in the residuals become more apparent?

Minor Comments

The difference between SARS computed using PIT-tags and Run Reconstruction were examined but nothing further appears to have been done since 2014? Are new data unavailable to continue the analysis? Are new technologies available to help answer the question (e.g., change in PIT-tags).

Editorial Comments

p. 91. Y-axis label for Figure 4.1 has "to Columbia River." Does this mean Lower Granite Dam (see last line of second last paragraph on page 83; see First line of last paragraph on page 86).

p. 94. Graphs (such as Figure 4.4) often show one or two years with high SARSs. Which year(s) are this? What were the water and other environmental conditions for these cohorts?

p. 109. Table 4.2. Please report the uncertainty (SE from the model averaging) for each coefficient.

p. 133. Figure 4.35. Graph might be clearer if tick marks at the end of the confidence limits are removed.

p. 134. Tick marks along X-axis in Figure 4.36 (and similar) could be clearer to indicate which tick mark matches the axis label (e.g., by making it slightly longer, or remove tick marks between axis labels).

Appendix B: Supporting tables for Chapters 4 – Annual Overall SARs

These are updates from previous years, and the ISAB has no comments.

IV.5. Comments on Chapter 5. Upstream Migration Success

This chapter is updated from the previous CSS report on spring Chinook migration success with the addition of results for fall Chinook and steelhead. The contrast in inter-dam survival probabilities is small (low contrast), so the results are not too surprising.

The comments from Chapter 2 about problems with regressions and environmental indicators apply to this chapter as well, although this chapter describes the analysis as "exploratory" rather than predictive. Did the exploratory analysis provide any testable hypotheses? For example, the report notes that survival of steelhead is consistently lower in the reach from Bonneville to McNary. What is different about this reach of the river? Can hypotheses be developed that can be tested, either with the current data or propose new experiments. In 2015 Chinook survival in the reach BON-LGR was only 52%. How does this relate to the pejus temperature and critical thermal maximum? Is there research on physiological response to temperature that their data could be compared to.

Similarly, the report indicates a decrease in survival as fish migrate into upper reaches and encounter increased temperatures. Is there any evidence that these fish alter the timing of migration to earlier in the season? Is the rate of temperature change increasing recently over the migration time span?

The individual inter-dam (reach-specific) survivals are analyzed independently to see if different factors may be important in different reaches. This is a good start for exploration of the topic, but there is no attempt to integrate them to see which of these individual reach effects is most important for overall upstream survival. It would help to report an overall model (BON-LGR) with the same variables, then compare this with the reach-specific results to see where the largest effects occur, and how this differs by species/run.

The results on variable importance are useful from an exploratory perspective, but how good are the predictions from the resulting models? It would help the reader to better understand model quality if the model-averaged predictions (and/or residuals) were also shown, with error bars.

Minor Comments

p. 146. Methods for exploratory analysis of environmental covariates would benefit from equations defining the models used.

p. 147. Table 5.2. Numbers of detections vary from those reported last year (Table 6.2), substantially so for the early years "Above LGR." Please explain the differences (different data source?).

p. 176-177: This is a good discussion interpreting the different variables and their various species- and reach- specific responses. A final paragraph summarizing the importance of results for management and future directions for research (maybe testing some of the exploration-generated hypotheses) would be useful.

Editorial Comments

p. 145, last paragraph. Please define the term “conversion.” What is being converted? How does it differ from "survival"? The term "conversion" is specialized jargon that will not be understood by many readers. As noted below, “survival” and “conversion” seem to be interchangeable and both terms are used in chapter, which may confuse readers. Consistent usage throughout and a clear definition would be helpful.

p. 146. Show the linear mixed effect models in standard notation for reference.

p. 147, last paragraph. Should last sentence refer to Table 5.3, not 5.2?

p. 150, paragraph 1. "largest predictors of survival" – does this mean best predictor, largest effect size, or highest importance? Please clarify. (For other species, the phrase "most important predictors" is used in the corresponding paragraphs.)

p. 150-153: Table and figure numbers are mismatched in the text throughout this section.

p. 152, Table 5.4. There is a second Table 5.4 on page 155 that needs renumbering. What do NAs mean in the BON to MCN column? The caption says these are the variables contributing to the 95% total weight, so how can any not have estimates? Please explain in caption. (There were no NAs in last year's report.) Asterisks are used to indicate “significant” estimates – bolding is likely better? Estimate of “age5” year effect has huge SE which usually indicates a failure to converge or estimates on logit() scale that are essentially “1” and are not useful. When this table is compared to Table 6.4 from the previous CSS report, there are several instances of changes in magnitude and signs. These need some discussion.

p. 156. Figure 5.7 What happened in 2019 to give such a wide SE bar? Similarly, look at Figure 5.15 – what happened in 2016? Look at Figure 5.20 - what happened in 2019?

p. 176, paragraph 1. "quantifying and evaluating"?

IV.6. Chapter 6. Development and Assessment of an Approach to Estimate Daily Detection Probability and Total Passage of Spring-Migrant Yearling Chinook Salmon at Bonneville Dam

This chapter covers an important topic, which follows on the ISAB review of the 2016 CSS annual report. The work reported in this chapter was started in 2018 and expanded in 2019, but no new developments were reported in the 2020 report. In this year's report, the CSS added an assessment of two alternative estimators for prediction probabilities: (1) a pooled Petersen estimator and (2) a stratified Petersen estimator. The main text and figures here are substantially identical to Chapter 8 of the 2019 CSS annual report. In general, this analysis was carefully done, and progress has been made in developing methodology for estimating outmigration.

This analysis conditions on the number of fish detected at the downstream trawl (n_{DST}). These fish are known to be alive at Bonneville (BON). Consequently, the overall probability of detection at BON is estimated by the ratio of the fish also detected at BON ($n_{BON,DST}$) to this number (i.e. $\hat{p}_{BON,overall} = \frac{n_{BON,DST}}{n_{DST}}$). The chapter goes further to estimate daily detection probabilities at Bonneville by using a Shaeffer (1951) estimator which "hindcasts" the number of fish from n_{DST} that passed BON on each day, and a similar ratio gives the daily detection probabilities. Then, a regression model on the logit(daily detection probabilities at BON) was used to assess candidate variables' roles in explaining the variation in daily detection probabilities. AIC methods were used to assess relative variable importance. Finally, estimates of daily passage are found by expanding observed passage by the daily detection probabilities.

Alternate estimators are also considered, such as a pooled-Petersen and a stratified-Petersen estimator (BTSPAS), and estimates are compared among the alternative methods.

Unfortunately, the comparison of results on p. 197 gives little information if one method is better than the others. To compare results, probability or confidence intervals of the annual predictions for each method are essential. For example, a figure similar to Figure 6.7 that includes the two other predictors, would give a good visual assessment of the differences.

Equation [3] is a regression model on the logit(daily detection probabilities at BON) used to assess candidate variables' roles in explaining the variation in daily detection probabilities. The entire set of daily detection probabilities over all the years in the study are treated as independent observations. However, it may be likely that these are not independent. Can this be evaluated and methods adjusted if appropriate?

The chapter also includes a discussion of different error structures for the data but does not appear to consider a simpler model with a simple random year effect. For example, Figure 6.3 appears to show that, for example, detection probabilities in 2001 tend to be larger than those in other years.

The model uses several bootstraps to estimate uncertainty. Some imputation is needed when no fish were captured at the DST and/or the imputed number of fish available for detected at BON is zero. A completely Bayesian solution would automatically do the imputations and compute measures of uncertainty for all parameters directly.

As noted, this approach appears to be very promising. However, how much manual "intervention" is needed in doing the analysis? Also, it is unclear how readily it can be applied to other species and stocks. Can the process be streamlined and "automated" as much as possible so that the amount of manual intervention is reduced when applying the methodology to other species and stocks? This is where a Bayesian solution, while taking longer to implement, may be more amenable to expanding the analysis to other species/stocks.

Figure 6.9 appears to show that total outmigration of yearling Chinook salmon is increasing over time. Is this because hatchery production has increased over time, in-river survival had increased, more wild fish being produced, etc.? Some auxiliary plots showing, for example, hatchery production over time or in-river survival over time would be helpful to explore potential reasons for this trend.

Another way to validate the models could be to compare the total adult returns from the total smolt outmigration to the SARS based only on PIT-tagged fish. This would require estimates of the total number of adults (PIT-tagged and untagged) returning to Bonneville. It is not clear if this information is available – some discussion is in order.

Minor Comments

p. 180. Seven candidate predictor variables were identified. In later parts of the chapters, abbreviations are used (e.g., PH1:PH2) and the abbreviations used should be given here.

p. 185 Figure 6.2. Is lag measured in years or days?

p. 186, last paragraph. The description of the stratified Peterson estimator (the BTSPAS estimator) is inadequate. A description of the model structure, perhaps including equations, is needed. Without this, the phrase "non-diagonal entries" is meaningless. Variables "m2" and "u2" are mentioned once, but never defined nor referred to elsewhere. Strata are mentioned, but not defined.

p. 188, Figure 6.3. Because the detection probabilities are all close to 0, it is hard to discern the serial correlation effects. An alternate plot on the logit scale may be more informative, given that the modelling is done on the logit-scale.

p.190, Figure 6.4. Specify that these estimates are on the logit scale.

p. 191. Figure 6.5. The intercept is not of interest and does not need to be displayed.

p. 192, Figure 6.6. Does the blob of points in the right of the graph correspond to a single year? If so, which year and how did conditions differ in this year which was not well predicted?

p. 193. Table 6.1. Footnote 2 uses IOA, but this differs from table column title. Definition of PH1:PH2 is never provided in table or main text (appears to be ratio of powerhouse 1 flow to powerhouse 2 flow listed in the candidate predictor variable sections).

p. 195. Figure 6.8. This blob from Figure 6.6 appears in several models and in some models actually appears to be well predicted. Please provide an explanation.

p. 197, paragraph 1. "complements" rather than "compliments"?

p. 197. The loess-smoothed lines and intervals in Figure 6.9 are not informative for this purpose – the interest is not in the time-series trends here, but rather in comparing the estimates for individual years; they should be dropped so the underlying data can be seen more clearly.

p. 200, paragraph 1. "We found that output from all of the approaches tested was relatively comparable." What does "relatively comparable" mean? The estimates appear to be high or low together for most years but are strongly divergent in some years (e.g., 2006, 2011, 2016). Without a statistical comparison, or at least error bars in the comparison figure, this statement is meaningless.

IV.7. Comments on Appendix A: Updates the CSS time series of juvenile in-river survival from LGR to BON (termed SR), transported and in-river SARs, TIRs and D for Snake River hatchery and wild spring/summer Chinook, steelhead, and sockeye.

No substantial comments because this chapter is just an update.

Editorial Comments

p. A-70 onwards. Figures A.22, A.23, A.24, etc. Legend says that TIR or D is on natural log scale. This is incorrect. The Y axis shows the actual TIR or D and not log(TIR) or log(D). The Y-axis scaling is a logarithmic scaling, but the tick marks are actual TIR or D. Revise Y-axis legend to just read “TIR” or “D” as needed. Also revise text of figures to remove reference to natural log scale.

V. ISAB Appendix: Suggested Topics for Further Review 2011-2020

ISAB 2020-2, pages 3-7

1. Expand the annual report's introductory section to highlight 1) an overall summary for the survival of Chinook salmon, steelhead, and Sockeye salmon in the Columbia River basin and how the SARs for the year compare to the long-term means, 2) new analyses included in the report, 3) major changes that may signal emerging management concerns, and 4) major recommendations for management of the hydrosystem that substantially alter or reinforce previous decisions or concerns.

2. Consider ways to address the spatial and temporal aspects of the effects of total dissolved gas (TDG) on acute and long-term survival, as we also recommended in 2019.

ISAB 2020-1, Review of the 2019 Annual Report's Chapter 2, *Life Cycle Evaluations of Fish Passage Operations Alternatives from the Columbia River System Operations Environmental Impact Statement* (CRSO-EIS), pages 5-6:

1. Perform a sensitivity analysis to investigate the impact of climate change for potential future flow regimes.
2. Compare results between different types of flow years and include demographic and other stochasticity in the models so that year-to-year variation in the output measures is more reflective of the response from different operations.
3. Incorporate the relationship of individual fish characteristics—such as body size, body mass, and condition factor, and date of ocean entry—to survival. The current literature is confusing (e.g., Faulkner et al. 2019 vs the rejoinder in Appendix G of the 2019 CSS Annual Report). Collaborate on joint analyses and use a common data set to resolve this issue.

ISAB 2019-2, pages 3-4:

1. Include information about the effects of mini-jacks on estimates of SARs and other relevant parameters.
2. Investigate implications of very low smolt-to-adult survivals (SARs) to hydrosystem operation alternatives and explore whether there is enough information to estimate how much improvements in habitat and other "controllable" aspects of the hydrosystem are needed to improve SARs.
3. Continue the work on the integrated life-cycle model looking at smolt-to-adult survival.
4. Continue to model adult salmon and steelhead upstream migration and consider adding information on individual covariates.

5. Consider ways to address the spatial and temporal aspects of the effect of TDG on survival.
6. Continue work on methods to estimate numbers of outgoing smolts at Bonneville.

ISAB 2018-4, pages 3-6:

1. Develop models for multiple populations that include combined and interactive effects.
2. Use the life-cycle models to investigate potential benefits on survival of management actions such as spill modification.
3. Expansion of ocean survival estimates to additional populations.
4. Include an analysis of mini-jacking and impact on SARs.
5. Include a more in-depth analysis of the PIT/CWT tagging experiment.
6. Improve the model for estimating abundance of juveniles at Bonneville.

ISAB 2017-2, pages 2-5:

1. Modeling flow, spill, and dam breach scenarios is very useful for policy makers. Consequently, it is important that all assumptions be clearly stated and that the results are robust to these assumptions. Work on testing assumptions was suggested.
2. Include other important processes in the life-cycle models such as compensatory responses and predator control programs
3. Elucidate reasons for shifts in the age distribution of returning spring/summer Chinook Salmon.
4. The graphical analysis of the impact of TDG could be improved using direct modeling to deal with potential confounding effects of spill, flow, TDG, and temperature.
5. The (new) modeling of adult survival upstream of Bonneville should be continued and improved to identify the limiting factors to adult returns.
6. The CSS report is a mature product, and the authors are very familiar with the key assumptions made and the impact of violating the assumptions. These should be collected together in a table for each chapter to make it clearer to the readers of the report.

ISAB 2016-2, pages 5-6:

1. Use variable flow conditions to study the impact of flow/spill modifications under future climate change, and examine correlations between Pacific Decadal Oscillations (PDOs) and flows.
2. Examine impact of restricted sizes of fish tagged and describe limitations to studies related to types/sizes of fish tagged
3. Modify life-cycle model to evaluate compensatory response to predation.
4. Comparison of CSS and NOAA in-river survival estimates.

5. Examine factors leading to spring/summer Chinook Salmon declines of four and five-year olds and increases in three-year olds.

ISAB 2015-2, pages 4-5:

1. Use SAR data to examine both intra- and interspecific density dependence during the smolt out migration and early marine periods
2. Propose actions to improve SARs to pre-1970s levels
3. Explore additional potential relations between SARs and climate and ocean conditions
4. Consider ways to explore the variability of inter-cohort response

ISAB 2014-5, pages 2-3:

1. Hypotheses on mechanisms regulating smolt-to-adult return rates (SARs) [update from 2013 review]
2. Life-cycle modeling questions and Fish and Wildlife Program SAR objectives [update from 2014 review]
3. New PIT/CWT study

ISAB 2013-4, page 1:

1. Hypotheses on mechanisms regulating smolt-to-adult survivals (SARs)
2. Life-cycle modeling questions and Fish and Wildlife Program SAR objectives
3. Data gaps
4. Rationalization of CSS's Passive Integrated Transponder (PIT)-tagging
5. Publication of a synthesis and critical review of CSS results

ISAB 2012-7, pages 2-3:

1. Evaluate if the NPCC's 2-6% SAR goals and objectives are sufficient to meet salmonid species conservation, restoration, and harvest goals
2. Development of technology to improve PIT-tag recovery in the estuary
3. Review estimation methods for smolt survival below Bonneville Dam through the Columbia River estuary using PIT-tags, acoustic tags, and other methods
4. Examine measurement error in SAR estimates associated with PIT-tags

ISAB 2011-5, page 2:

1. Influence of mini-jacks on SARs

2. Effects that differential harvest could have on the interpretation of hydropower, hatchery, and habitat evaluations
3. Extent to which PIT-tag shedding and tag-induced mortality varies with species, size of fish at tagging, tagging personnel, and time after tagging

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