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Review of the Comparative Survival Study (CSS) Draft 2019 Annual Report

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ISAB Review of the Comparative Survival Study (CSS) Draft 2019 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 (CSS) draft annual reports. The ISAB has reviewed these reports annually beginning nine years ago with the evaluation of the CSS's draft 2010 Annual Report and most recently the draft 2018 Annual Report (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). This ISAB review of the draft 2019 CSS Annual Report is the ISAB's tenth 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 2019 CSS Annual Report (Section IV). The annual CSS report is a mature product, typically including only 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 cursory 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 2018 Annual Report, Appendix L), and we do not expect the CSS to necessarily respond immediately to new requests for further analyses.

Chapter 1 (Introduction) lays the foundation for the entire report. Most of the chapter is identical to the previous year's report. The ISAB reiterates last year's review comments regarding the need for careful definitions of tagged and release groups (ISAB 2018-4). These definitions are critical and need to be included in the report's introduction so that readers new to the work have a clear understanding of the analyses and results that follow. It is crucial that this chapter be well written and clear on study design because it is the first chapter that a person who is new to the CSS will read.

Chapter 2, an analysis of alternatives for the Columbia River System Operations –Environmental Impact Statement (CRSO-EIS), is not yet released and not reviewed here.

Chapter 3 (Effect of the in-river environment on juvenile travel time and survival) is updated with new data and focuses on the impact of total dissolved gas (TDG). The results indicate that over the range of TDG measured during the 20-year study period, there was no evidence of strongly detrimental effects.

Chapters 4 (Patterns in SARs) is an update from previous years with additional populations included. The ISAB is concerned that the smolt-to-adult survivals (SARs) of Snake River wild spring/summer Chinook and steelhead continue to fall well short of the Council's 2%-6% SAR objectives. While the CSS is only the messenger of bad news, we reiterate our previously unanswered question that given the large amount of effort in the past to improve SARs through dam passage improvements, habitat improvements and other changes, to what extent might further improvements in hydrosystem management, predator control, and estuarine habitat lead to achieving SARs of 2%-6%?

Chapter 5 (SARs and productivity) is a continuation of previous reports with additional data and populations. Overall, the analysis of the 2018 data and two additional populations supported previous analyses that indicate that 2%-6% SARs are required to maintain or increase steelhead populations. The CSS investigators speculate that differences in population productivity among populations might be due to age-related differences in juvenile mortality in freshwater and adult prespawn mortality and sex ratio. The ISAB suggests that population-specific differences might also be due to age- or size-related differences in estuary and ocean mortality. Evaluation of these and other potential factors in future CSS analyses is warranted.

Chapter 6 is a new chapter that reviews the literature on delayed mortality effects. The ISAB is generally pleased with the review and suggests some additional literature to be included. However, the ISAB would like some context on why this chapter was included in this iteration of the report.

Chapter 7 (Adult salmon and steelhead upstream migration) is similar to the previous year's chapter. The integrated model developed to estimate the probability of adult survival over time (e.g., from one dam to the next) seems reasonable and carefully thought out. The conclusions of the model also seem to generally correspond to empirical observations. The proponents plan on refining the model in the future. However, there are several aspects of the results which need a more substantive discussion and some aspects of the modeling that need refinement to improve this chapter.

Chapter 8 (Preliminary development of an approach to estimate daily detection probability and total passage of spring-migrant yearling Chinook salmon at Bonneville Dam) is an update of last year's chapter 9 incorporating some of the ISAB's recommendations. In particular, non-linear models were developed to attempt to explain some of the over estimation—fortunately, results were similar to those from similar models. Additional model diagnostics were provided. This chapter will continue to evolve over time and will provide very useful information.

Chapter 9 (A Multistate Model to Estimate Upper Columbia River Spring Chinook Life Cycle Survival from Passive Integrated Transponder Tagging and Detection) is a new chapter presenting life-cycle analysis of multiple-populations to estimate survival from smolt back to returning adults. This is a sophisticated analysis that allows modeling capture histories of some 93,000 tagged and recaptured spring Chinook salmon from the upper Columbia River tributaries (Wenatchee, Entiat, Methow). The take-home message appears clear and is sobering. Smolt-to-adult returns (BON-to-BON) are below management goals of 4% for most estimates, and SAR estimates for smolts tagged in their natal streams to adults returning to those streams were <1%. It is possible that tagging effects also cause lower survival, but this bias seems unlikely to be the main reason for such low survival. This is an interesting chapter, but readability and basic documentation needs to be improved, for example, by including a glossary of symbols or model equations.

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. For example, Chapter 9 is a new integrated model looking at the entire life-cycle for three systems. As noted above, the ISAB appreciates the CSS's effort to respond to our past queries.

Some of the past recommendations from the ISAB appear to be beyond the current scope of the CSS (see several from 2017) but will become increasingly important in the future. Some of our earlier and current recommendations may seem repetitive and unachievable within a year to inform the next report, but they deserve some advance planning as these issues will become much more pressing in the future. In particular, if there are data gaps, these gaps should be identified for potential new data collection procedures. When life-cycle models are modified, the modification should be flexible enough to incorporate these issues. This is reflected in our recommendations for future work below.

In 2019, we recommend the following topics for future reports:

1. Include information about the effects of mini-jacks, male Chinook that remain in freshwater and mature two years after fertilization, on estimates of SARs and other relevant parameters. Standard hatchery rearing protocols have been shown to amplify the precocious maturation of Chinook and steelhead as residuals or minijacks that do not migrate to the ocean (ISRP 2018-8, see review of Growth Modulation in Chinook Salmon Supplementation project, 200203100). Are there hydrosystem effects on mini-jack rates?

2. Smolt-to-adult survivals (SARS) continue to be very low. Do we have enough information to suggest changes to hydrosystem operations that could improve SARs? Is there now enough information to estimate how much improvements in habitat and other "controllable" aspects of the hydrosystem are needed to improve SARS? [This may be part of Chapter 2 which is not yet ready for review.]

3. Continue the work on the integrated life-cycle model looking at survival from smolt back to adults (Chapter 9). A more detailed comparison with the CSS results is needed, and discrepancies need to be explained. Include individual covariates such as body mass when tagged or timing of migration to elucidate important factors that affect survival.

4. Continue the work on modeling adult salmon and steelhead upstream migration and consider adding information on individual covariates such as, for example, the dates tagged as juveniles, body mass as juvenile, the dates when juveniles were detected at Bonneville to elucidate important factors that affect upstream migration success.

5. Consider ways to address the spatial and temporal aspects of the effect of TDG on survival. Are the current data sufficient to address this problem? Are there other sources of data that would be useful? What modifications to the current data collection systems would be needed to address this issue?

6. 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 2018-4, we recommended the following topics (*italicized*) for future reports. After each recommendation, we summarize the current status of the work to address them:

1. *The ISAB previously recommended that combined and interactive effects of populations be studied (2016 #3; 2017 #2). This recommendation is still applicable to the life-cycle models for the Wenatchee and Entiat populations. Currently, the populations from the two rivers are analyzed separately. The CSS indicates in Chapter 2 that they are considering a single model for both populations. This would allow sharing of information between the two populations (e.g., on detection probabilities) but also then allows modelling interactions. Given that there are only two populations modelled, this seems to be a logical place to start with a combined population model.*

The ISAB is pleased to see the development of such a model (Chapter 9) and look forward to future improvements of the model.

2. *Chapter 2 should be extended to investigate potential benefits on survival of management actions on the hydrosystem, such as spill modifications, as has been done in previous CSS reports. The CSS indicates in their report that it is under active investigation. We look forward to the results.*

Chapter 2 (Life Cycle Modeling) in the 2018 report is currently being used for the CRSO EIS alternatives and is not yet ready for review.

3. *The ISAB recommends expansion of ocean survival estimates to additional salmon and steelhead populations with sufficient data, and collaboration between CSS and NOAA investigators (Project 199801400, Ocean Survival of Salmonids) to address relevant questions about salmon ocean survival in an adaptive management framework.*

This has not yet been included in the report, but the CSS indicates in their response to our 2018 review that this is under consideration for future years.

4. *Add information on mini-jacking. The ISAB/ISRP reviewed several studies that showed an increase in mini-jacking over time. Is the current CSS system able to track this? This shift in the age-distribution of returning fish has serious implications on estimates of SARs. Has this been incorporated in the current analyses?*

This has not yet been included in the report, but the CSS indicates in their response to our 2018 review, that this is under consideration for future years.

5. *Chapter 8 is an important chapter because PIT-tagging is used throughout the Basin. A more in-depth treatment is warranted for Chapter 8 including a discussion of how the results compare to those of Knudsen et al. (2009). Also, Knudsen et al. (2009) report reduced growth in adults that were PIT-tagged as juveniles. Why is such a comparison not included in this study? We assume that the hatchery has data that allow for a similar comparison. The major problem with these studies is that very large sample sizes are required to detect the sometimes subtle effects and, consequently, no one study is likely to give definitive results. It would be an opportune time to do a meta-analysis of the many different studies that have looked at this issue to help guide managers on this important topic.*

This was addressed in the revised 2018 CSS report and reviewed by the ISAB in February 2019 in an addendum to ISAB 2018-4.

6. *Chapter 9 is important because estimates of abundance are needed when investigating compensatory and interactive effects among stocks. The authors estimated the probability of detection at Bonneville Dam which forms the basis of the estimator for abundance. A similar approach may be applicable for each dam in the hydrosystem. The feasibility of extending the analysis to the other dams should be explored.*

This model has been extended this year in response to the ISAB comments, and further work is ongoing.

IV. Comments on New or Updated Analyses in the draft CSS 2019 Annual Report by Chapter

IV.1. Chapter 1. Introduction

Substantive comments

Most of the chapter is virtually identical to the previous year. The ISAB appreciates the adjustments made based on last year's comments, but several problems remain that will make it difficult for a new reader (such as the several new ISAB members next year) to understand the chapter. The ISAB stands by its recommendation that a reader who has some background in salmonid biology, but is learning about this program for the first time, should be able to understand the basic study design without referring to the Appendix. Comments along these lines in previous reviews were not adequately addressed.

A major problem is created by using the code "T" in three places for three release groups that may or may not be different): those collected at three Snake River dams and transported (labeled as *T*; middle p. 12), fish assigned randomly to be transported (vs. return to river; bottom of p. 12), and a Group T which reflects the untagged population (top of p. 13). Likewise, as noted last year, the term "Monitor-mode" is confusing. By the time the reader reaches the middle of p. 13, they are likely to be quite confused about the meaning of the various uses of the variable T, as well as that of R, C0, C1, and the like. Overall, readers new to the study will not be able to proceed further unless they read Appendix A first, which seems counterproductive.

It is crucial that this chapter be well written and clear on study design because it is the first chapter that a person who is new to the CSS will read. A careful review by an (external) reader who is new to the CSS process would help identify confusing areas.

Minor comments

The acronym for the variable PITPH needs to be defined, and the calculation of this variable described more clearly. In particular, the following phrase is not clear, "based on the relationship between spill proportion and proportion of the juvenile population that would pass via the turbines and bypass at the dam."

One option might be to move the section titled "Note on the use of PITPH" up so that the metric is explained earlier, and to improve this section as needed.

Editorial

The chapter needs editing to correct incomplete sentences and remove unnecessary jargon, some of which was noted last year. Again, this pertains to the goal of making it easy for a new reader to grasp the study, since ISAB members rotate and others may also be new to the CSS project.

p. 16. "Beginning in 2016, CSS tags will be provided for releases of sockeye…" If this was done, it should now be described in past tense.

p. 17. The abbreviation "MY" needs to be defined on first use.

p. 20. Last sentence on this page need punctuation or editing.

p. 22. Readers won't understand the meaning of "greater than 1:1 spill passage efficiency", so this needs to be defined.

p. 23. Some of the references need repair. For example, the Ricker (1954) reference is in the same paragraph as the Raymond (1988) and in the wrong location (i.e., not alphabetical).

IV.2. Chapter 2. Analyses of CRSO EIS Alternatives

During 2019, the CSS Oversight Committee and the Fish Passage Center completed data analyses using the CSS Cohort models and the Grande Ronde Life Cycle model and provided the analyses to the federal action agencies for the Columbia River System Operations – Environmental Impact Statement (CRSO-EIS). However, the analyses are currently not available for public or ISAB review. An ISAB review is anticipated in February 2020 when the draft CRSO EIS becomes publicly available. The ISAB looks forward to reviewing the analyses.

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

This chapter was well written, and the analyses and results were explained logically and clearly. The take-home messages are well crafted and clear, and useful for managers. The new analysis on TDG effects appears appropriate, and the results indicate that over the range of TDG measured during the 20-year study period, there was no evidence of strongly detrimental effects. With the important exception of the analysis of the effects of TDG, the chapter is an update of the previous data and most of the text is identical to the 2018 CSS Report.

Substantive comments

The Discussion does not address the spatial or temporal scale of the analysis of the effects of TDG on survival. These estimates are based on reach-level survival. While that is informative and important for interpreting the effects of TDG, it is possible that local studies of survival of marked fish at a dam and the tailrace immediately downstream could have higher instantaneous mortality rates. These localized rates could be obscured by reach level influences on mortality (and potential compensatory processes). The discussion of the TGD results should be expanded to discuss this issue. Are there any data available to investigate this issue or can additional data be collected (perhaps not part of the CSS) to investigate this issue?

Minor comments
The results of the TDG analysis should be added to the Conclusions.

The Results section indicates that "While there were some special cases, mean *FTT* generally decreased over the season, *S* both increased and decreased over the season, and *Z* increased over the season." But *S* is a function of *Z*; therefore, how could *S* increase and decrease while *Z* only increased? Is this related to the pattern of *FTT* within a season?

The graphs in Figures 3.2 to 3.7 are useful for illustrating the trends across years, but the scale and size of symbols are too small to allow readers to see within-year trends. Such information could be provided in tables in an appendix

Editorial
p.i. The conclusions section is not listed in the Table of Contents. The "Results of TDG Evaluations" is a different font style (italics) compared to other section titles.

p.36. The first paragraph of the Results section refers to Table 3.4, but it should be Table 3.3.

p.54. The data for TDG and the estimated instantaneous mortality rates should be added to the report in an Appendix as tables.

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

Chapter 4 is a summary of annual (smolt migration year) estimates of overall smolt-to-adult return rates (SARs) for wild and hatchery salmon and steelhead populations. Annual overall SARs are based on cohorts of PIT-tagged fish that experienced the same conditions as untagged smolts under a given year's fish passage management scenario. Populations analyzed are from the Snake River, Mid-Columbia, and Upper Columbia regions.

The analysis of annual overall SARs was mostly consistent with the 2018 CSS Report. Overall annual PIT-tag SAR estimates are updated with newly acquired data, primarily for 2016 (steelhead) and 2017 (Chinook and sockeye) smolt outmigration-year cohorts. The new SAR estimates are as yet incomplete, including data from adult returns only through June 28, 2019 (Snake River spring or spring/summer Chinook, Upper and Mid-Columbia spring Chinook, and all steelhead) and July 31, 2019 (Snake River summer Chinook, Upper Columbia summer Chinook, and all sockeye). Fall Chinook overall annual SAR estimates for PIT-tagged fish, previously reported in a separate chapter of the annual CSS Report, are now incorporated into Chapter 4. Reach-level overall SAR estimates for Upper Columbia PIT-tagged groups were reported for the first time. SARs were calculated as adult returns to the uppermost dam with adequate adult PIT-tag detection capabilities (Appendix B).

Reach survival estimates were re-estimated in 2019 using a new method (described in an Appendix to this chapter). In addition, PIT-tag recovery data from island bird colonies in the

Columbia River estuary and adult PIT-tag detections below Bonneville Dam were used to augment estimates of detection probability at Bonneville Dam. The investigators concluded: "Despite this new method, and some subsequent small changes to reach survivals, the overall relationship between reach survival and TIR ["Transport: In-River" ratio, which is the SAR of transported fish divided by the SAR of in-river fish] observed in past years analyses did not change noticeably." Continued analytical improvements are important even when the changes in estimates are small. Each improvement contributes to the overall credibility of the collective analyses.

The addition of estimates of SARs to Bonneville Dam was informative and provided a consistent reference for analysis of different stocks. The estimates of SARs were higher, as expected. The information provides a consistent basis for comparisons with other stocks to a common point in the Columbia River as adults re-enter the basin.

Substantive comments

The ISAB is concerned that the overall SARs of Snake River wild spring/summer Chinook and steelhead continue to fall well short of the Council's 2%-6% SAR objectives. In fact, new estimates for the 2017 juvenile migration year are a record low for the entire time series (1994-2017) (Appendix B, Table B.1; 2017 migration year LGR-to-GRA SAR: 0.13% without jacks, 0.15 with jacks; 2017 migration year LGR-to-BOA SAR: 0.20% without jacks, 0.23% with jacks).
The CSS concludes that SARs for wild spring/summer Chinook from the mid-Columbia region generally fall within the Council's SAR objectives. Nevertheless, the ISAB is concerned that the overall JDA-to-BFA SAR for the 2017 cohort of John Day River Basin wild spring Chinook is a record low (without jacks: 0.76% (CI 0.40% - 1.18%) for entire time series (2000-2017), which continues a dramatic decline in SARs since the 2013 juvenile migration year (4.18% overall SAR; Table B.73). As discussed in the introduction to Chapter 5, "patterns in the SARs of John Day spring Chinook populations were similar to those observed in the Snake River, but higher SARs are needed for population replacement in John Day Chinook (>3%) than in Snake River Chinook (1-2%), likely reflecting the higher relative spawner abundance and influence of density dependence in the John Day populations. In addition, historical levels of productivity were achieved with pre-harvest SARs in the range of 4% to 6% for John Day River wild spring Chinook."

The investigators conclude that "PIT-tag SARs for Upper Columbia wild spring Chinook and steelhead have fallen short of the NPCC 2%-6% objectives since CSS monitoring began in 2006." The ISAB is concerned that overall MCN-to-BFA SARs for Upper Columbia Wild Spring Chinook (Wenatchee River, 2007-2017) dropped to a record low in 2017 (0.33%, CI 0.20% - 0.48 %) without jacks (Appendix B, Table b.95). There were also no PIT-tag detections of adult Upper Columbia Wild Spring Chinook (Entiat and Methow Rivers) for the 2017 juvenile migration year (Appendix B, Table B.98).

The ISAB appreciates that the 2019 report was streamlined by merging SAR analyses of subyearling fall Chinook with Chapter 4; however, no conclusions were made regarding these groups. The ISAB is concerned that there were no adult PIT-tag detections from the 2016 migration year for Hanford Reach subyearling wild fall Chinook, even though the number of smolts arriving at MCN in 2016 was the highest since the 2008 juvenile migration year (Appendix B, Table B.86). The report should include an explanation of why this occurred.

The ISAB reiterates last year's request to develop time series estimates of first-year estuary and ocean survival rates (So1 for mid-Columbia and upper Columbia wild spring Chinook and steelhead and other populations with sufficient data). At present, So1 is estimated only for Snake River wild spring/summer Chinook and steelhead (Appendix B, Tables B.126 and B.127). The report should estimate these quantities or explain why they cannot be obtained.

The ISAB appreciates that the CSS's continuing analyses have responded to our past annual reviews of this chapter, and we agree with the CSS's conclusion that their analyses provide a sound basis for developing quantitative planning objectives. The ISAB recognizes that the CSS is merely the messenger for the poor SARs. Many recipients will read only the executive summary and not read the fine details of the report, so this issue needs to be highlighted more forcefully in the overall report conclusions and the executive summary. The ISAB notes that an executive summary was not included in the draft report under review.

Minor comments
The analysis of the relationship between transport and in-river survival is improved by estimating survival to Bonneville Dam. This was a new analysis included in response to the previous ISAB review. Unfortunately, it was not included in the Discussion or Conclusions sections. It should be included.

Editorial
The figures in Chapter 4 do not illustrate years in the graphs consistently. Recent years are often left off the X-axis, and it often is difficult to quickly identify individual years. For example, in Figure 4.2, it is not clear which tick mark represents 2014 (and other tick values). The graphs should be improved and have consistent X-axes to improve interpretation of the data.

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

Appendix B provides 127 tables (compared to 108 tables in CSS 2018) with SAR data supporting the results presented graphically in Chapter 4. The new tables in the 2019 draft report pertain primarily to wild subyearling fall Chinook and Upper Columbia Chinook, steelhead, and sockeye groups. In addition, previously reported SAR estimates were updated using new data and methods.

The ISAB has no substantive comments.

Editorial
Table B.93 heading "2018" should be "2016."

IV.5. Chapter 5. SARs and productivity

In this chapter, graphical analyses of the relation between smolt-to-adult survival (SAR) and realized population productivity of wild Snake River steelhead are updated with new data. Individual brood year productivity estimates are plotted against brood year SARs by population, and a logarithmic trend line is plotted for each population. Distributions of observed productivity over all populations are compared by brood-year SAR category using boxplots. The realized steelhead population productivity is defined as the natural logarithm of recruits to spawning grounds divided by number of spawners (ln Rsg/S). The SARs are defined as survival from smolt at Lower Granite Dam to adult back to Lower Granite Dam (LGR-GRA).

Another brood year of data (2012) is added to the steelhead series from Fish Creek (B-run, a major tributary of the Lochsa River Population, Clearwater River MPG); Rapid River (A-run, a major tributary in the Lower Salmon Population, Salmon River MPG); Pahsimeroi River (A-run, Salmon River MPG); and Joseph Creek (A-run, Grande Ronde River MPG).

The number of steelhead populations analyzed was expanded from four to six populations. The two new populations are Big Bear Creek (A-run, Potlatch River drainage, part of the Lower Clearwater population, Clearwater MPG) and Big Creek (B-run, a major spawning area in the Lower Middle Fork Salmon population, Salmon MPG).

Analyses for Snake River spring/summer Chinook were not updated or repeated in this report because run reconstructions are not complete (updated only on a five-year schedule for NOAA ESA status assessments). The ISAB commends the CSS for submitting a manuscript for peer-reviewed publication that compares SARs to population productivity for Snake River spring/summer and John Day River spring Chinook salmon, based on data shown in previous CSS reports.

Overall, the analysis of the 2018 data and two additional sites supported previous analyses that indicate that 2%-6% SARs are required to maintain or increase steelhead populations. The Big Creek site had low SAR values, averaging 1.8, and exhibited negative productivity. A new conclusion in this year's report is that the "relationship of SAR with steelhead population productivity is less precise than for Chinook Salmon and varies among populations." The authors should be explicit about the causes of the lack of precision; i.e. is it a sample size issue, due to residualization, etc.?

The ISAB appreciates that the analyses in this chapter address past ISAB review comments, and we encourage continuation and further expansion of analyses to additional populations and MPGs having adequate data time series.

Substantive comments

The CSS investigators speculate that differences in population productivity among populations might be due to age-related differences in juvenile mortality in freshwater and adult prespawn mortality and sex ratio. The ISAB suggests that population-specific differences might also be due to age- or size-related differences in estuary and ocean mortality. Evaluation of these and other potential factors in future CSS analyses is warranted.

Editorial comments

Table 5.1. There are some minor changes in some of the results that are not explained. Some of the SAR values for earlier years are different from the previous report. The ISAB suspects that some of these are rounding/truncation artefacts, but some of the more recent years have larger changes presumably due to older ages coming back. Are any of the changes related to the new methods used to estimate SARs (described in Chapter 4)? These changes need to be explained.

IV.6. Chapter 6. Delayed Mortality Review

This chapter reviews the evidence supporting the delayed mortality hypothesis. This chapter proposes that three factors related to juvenile passage through the hydrosystem could be responsible for subsequent mortality of smolting salmonids during early ocean residency. First, Budy et al. (2002) proposed that stress events experienced by smolting salmonids caused by their passage through dam turbines, juvenile bypass systems, and spillways will induce delayed mortality. The cumulative effects of such stressors are expected to increase vulnerability to predation and pathogens, plus reduce energy reserves needed for saltwater adaption and early marine growth. Second, Muir et al. (2006) note that the hydrosystem has substantially changed the migration rates of smolts emigrating from the Columbia River and therefore may be destabilizing previously established ocean entry timing. Such alterations, referred to as the match/mismatch hypothesis may reduce subsequent survival. Finally, it is suggested that transportation of smolts through the hydrosystem may be leading to size selective mortality in the lower river by northern pikeminnow and in the estuary and ocean plume by Pacific hake. It is argued that in-river migrants increase in size by 5-8 mm on average while transported fish do not change in size and therefore are likely subject to size-selective mortality (Muir et al. 2006).

The chapter assumes that the delayed morality hypothesis is substantiated by past studies. Among others it cites Haeseker et al. (2012) who found that freshwater and marine survival rates were correlated and concluded that “a portion of the mortality expressed after leaving the hydrosystem is related to processes affected by downstream migration conditions.” Additionally, it references Schaller et al. (2014) who compared survival rates of upriver and downriver salmonid populations and concluded that “delayed hydro-system mortality increases with the number of powerhouse passages and decreases with the speed of outmigration.” The chapter also makes it clear that the exact mechanisms responsible for delayed mortality are not yet known.

The CSS review concludes by stating that increases in water transit time and spill may reduce delayed mortality rates and cause a corresponding increase in SARs of upriver stocks of Chinook and steelhead. Consequently, the proponents suggest that new spill agreements under negotiation may provide a useful opportunity to evaluate delayed mortality under a new spill regime—one that is hypothesized to increase survival.

Substantive comments

The CSS's review briefly mentions several studies that refute the importance or existence of delayed mortality. For completeness more of this information should be included in this chapter, for example, investigations by Rechisky, Welch, and colleagues: Welch et al. 2008; Rechisky et al. 2014; replies to Rechisky et al. (2013a) by Haeseker (2013); and Rechisky et al. (2013b). Explanations of why the results from these papers (and other papers) are or are not applicable to the Columbia River system are needed

The chapter highlights the role of timing on subsequent survival, but it would help to specifically link the timing to the data reported in Scheuerell et al. (2009). There might also be some link between delayed effects of barging on homing/straying.

The CSS review indicates that new spill agreements may provide useful opportunities to evaluate delayed mortality. There are several different experimental designs that are possible, but in past reports, the ISAB/ISRP recommended that the CSS **not** conduct upstream/downstream comparative studies. For example, see ISAB/ISRP 2007-6: "The ISRP finds that the fourth objective (Upriver/Downriver Comparisons) does not meet scientific review criteria, because of inevitable confounding from other factors in establishing cause(s) of upriver/downriver differences that may be detected, regardless of sample size and detection power that could be achieved." Consequently, proposed spill experiments need to be evaluated carefully prior to implementation to ensure they avoid confounding effects.

Minor comments

This was a new review, but context is missing. Was this chapter prepared as background for a proposed study/experiment alluded to in the final paragraph? Please add context for the review.

The review needs to be updated with more recent references such as Gosselin et al. (2018).

Editorial

A number of references are missing (e.g., Budy et al. 2002, cited often, and Scheuerell et al. 2009). Other references (e.g., Buchanan) are spelled wrong in the text or missing from the references, so a close check is needed.

IV.7. Chapter 7. Adult salmon and steelhead upstream migration

The integrated model developed to estimate the probability of adult survival over time (e.g., from one dam to the next) seems reasonable and carefully thought out. The conclusions of the model also seem to generally correspond to empirical observations. The proponents plan on refining the model in the future. However, there are several aspects of the results which need a more substantive discussion and some aspects of the modeling that need refinement to improve this chapter.

Substantive comments

For each of the species and stocks, juvenile transport history affected adult migration rate, yet this was not mentioned in the Discussion, nor was it among the Conclusions. It would seem that some discussion of this is warranted. It might also be worth noting the relationship between transportation and homing and upriver migration rate reported by Bond et al. (2017).

In the discussion, the authors conclude that adult fish migrants were subjected to a higher migratory cost between Bonneville and McNary dams compared to McNary and Lower Granite dams because the slope of the relationship between survival probability and travel time was steeper. For example, from Table 7.1, the slope for travel time was -0.19 (SE 0.015) for BON-MCN, and from Table 7.2, the slope for travel time was -0.04 (SD 0.007) for MCN-> LGR. But some of this steeper slope may be an artefact of the truncation of the intercept at values > 3 (on the logit scale) to force the survival probability to be 1 at 0 travel time. This may force a steep slope in the first reach because the posterior plots show a posterior distribution bunched at 3 for some stocks. A better comparison would be among the models for each reach with unfettered intercepts.

Also, is it appropriate to compare the two populations (i.e., the population of adults at BON to those at MCN)? The population at MCN is equal to the population at BON minus the individuals lost to disease, predation, etc., so it may be reasonable to expect the MCN population to have better survival.

The current modeling approach separates the modeling of the two reaches. A better model would also combine the models over both reaches and directly compare the two slopes within the same model.

Any modeling effort requires model assessment. The authors used R-hat, the effective sample size, trace plots, and plots of simulated vs observed data. However, a common goodness-of-fit test is to use posterior-predictive plots. These can be tailored to assess the overall goodness-of-fit for any individual aspect of the model. For example, on page 141, the authors showed a single comparison of two distributions. A goodness-of-fit measure could be constructed for each of the 2000 posterior comparisons and the posterior predictive plots constructed as a summary. These posterior predictive plots need to be constructed.

Minor comments

p.121. The authors need to be careful when converting between instantaneous mortality and survival because the former is instantaneous while the latter is over an interval of time. For example, the equation in the footnote of page 121 is not quite correct. Survival probabilities are found as the integral of the instantaneous mortality rate over some interval and do not refer to a point in time. The equation given on page 121 would be the survival the interval *t* to *t+1* assuming that *Z* was constant over that interval and not for the instant *t*. Similarly, the explanation of the conversion from the cumulative survival to the daily instantaneous mortality probability needs to be improved. For example, on page 125, you have the individual daily survival approximated as the ratio of the fitted values of S(t+1) and S(t), and then the approximate instantaneous mortality rate for that day is the -logarithm of this ratio. However, all the daily survival probabilities are a function of the slope (on the logit scale), and so once the slope is estimated, the instantaneous mortality rate can also be found directly. This direct estimate should be used in place of the approximation on this page.

Figure 7.2 There are several points that don't fall close to the line. These should be explored in detail. For example, do they belong to a single year or to a small group of fish with particular characteristics?

A careful reading of the chapter is needed to ensure that all symbols are defined. See the editorial section for several instances of symbols not defined in the text.

A backward elimination procedure based on AIC was used to select the model for travel time. A better procedure would be to fit all subset models and see how much support is given for each model. The ISAB would like to see if the model chosen by backward elimination actually has a majority of support or if support is very diffuse.

p.133. The authors claim that *ad hoc* conditions of the model affected results and possibly biased estimates but give no further details. For example, is the truncation of the prior for the intercept at 3 one of these *ad hoc* conditions? How did this affect the reach-comparison for this stock? What basis is there for assuming that biases are common across all species—for example, not all species/stocks have the same bunching of the posterior close to 3. This issue needs to be explored in more detail.

Editorial

p.124. *Ftt* is never defined (fish travel time?) in Equation [1]. Presumably "*Ftt*" is the same as "*ftt*". Be consistent.

p.124. "Conversion probability" is never defined.

p.124. The *t* distribution used in the report appears to have three parameters. Presumably this is a generalized version of the standard t-distribution (which is centered at 0) and only has 1 parameter. What are the parameters (presumably df, mean, and ?)?

p.124. The prior for gamma_0 appears to be t(3,5,2.5) but is also truncated at values >3? Is this true? This should be explicit.

p.124. The sigma_{year} prior is a t-distribution, but what keeps it positive? Is there also a truncation occurring at 0?

p.124. "We began with a full model" for which variable?

p.125. R_i is never defined. What keeps sigma positive given the t-distribution priors? Is truncation occurring as well?

p.125. Here and elsewhere qualify "time" using "travel time" to distinguish from calendar time.

p.126. Equation 4. *S* was earlier defined with subscript *i* to represent the *ith* fish, but now has subscript x to refer to refer to time. This part of the manuscript needs to be reworked based on earlier comments.

p.126. Here and elsewhere, round days to achieve certain conversions to 1 decimal place, i.e. 4.2 days rather than 4.224 days.

p.126. Why does the conversion probability for which a travel time is needed change among species from 0.9, 0.85, 0.7, and 0.9 over the four species/stocks?

p.127. Figure 7.4 and elsewhere. The shading is misleading because higher densities are not represented by darker colors. If the number of posterior samples is increased, the width of the shaded areas will also increase. The 95% CrI should be plotted at selected points to show the uncertainty in a manner that is independent of the number of posterior samples.

p.135. Table 7.1 and 7.2. In both Tables values in the 5^{th} column represent the "Eff size" and those in the sixth column represent the R-hat values. Currently these columns are mislabeled. Tables 7.3 to 7.8 have the correct headings for these columns. It is not clear if the values for "R-hat" are rounded to integer values (in which case R-hat could be as large as 1.4999) or they are all very close to 1 (i.e., 1.03). Report R-hat values to 1 decimal place. Left justify the parameter values. There are two parameters labelled at intercepts. This should be clarified.

p.136. Table 7.2. Effective sample size for last two parameters is a bit low. Perhaps this is due to autocorrelation indicating that more thinning is needed.

p.137. Table 7.11 (and other tables). "… posterior distributions generally follow prior assumptions about student t-distributions." There is no reason why the prior distribution should predict the posterior distribution unless the data are uninformative. The meaning of this phrase is unclear.

IV.8. Chapter 8. Preliminary development of an approach to estimate daily detection probability and total passage of spring-migrant yearling Chinook salmon at Bonneville Dam

This chapter is an update of last year's chapter, incorporating some of the ISAB's recommendations. In particular, non-linear models were developed to try to explain some of the over-estimation. Fortunately, results were similar to those from similar models. Additional model diagnostics were provided. This chapter will continue to evolve over time and will provide very useful information.

Substantive comments

In our previous review, the ISAB recommended some alternative estimators (e.g., Petersen type estimator, Bayesian Time-Stratified Population Analysis, BTSPAS, models) and inclusion of additional data. There is no mention of these alternatives in the report. Were they investigated and found to be lacking? Details are needed.

Minor comments

p. 169. The forward selection method was questioned in the previous review. In the CSS response, they explained that results were similar to an all-subsets approach. The explanation from their response should be included here.

IV.9. Chapter 9. A Multistate Model to Estimate Upper Columbia River Spring Chinook Life Cycle Survival from Passive Integrated Transponder Tagging and Detection

This is a sophisticated analysis that allows modeling the capture histories of some 93,000 tagged and recaptured spring Chinook salmon from the upper Columbia River tributaries (Wenatchee, Entiat, Methow). As such, it is a pioneering effort that makes use of a very large data set to fit a large number of parameters of interest to managers.

The take-home message appears clear and is sobering. Smolt-to-adult returns (BON-to-BON) are below management goals of 4% for most estimates, and SAR estimates for smolts tagged in their natal streams to adults returning to those streams were <1%. It is possible that tagging effects also cause lower survival, but this bias seems unlikely to be the main reason for such low survival.

Substantive comments

This is an interesting chapter but needs considerable work to make it understandable to the reader. For example, Figure 9.2 shows the flow diagram which could be very useful, but the various symbols are not defined. There does not appear to be a set of explicit equations for the model, and the various models are explained by text (page 193 onwards) rather than equations and reference to Figure 9.2. Actual model equations that use the symbols in Figure 9.2 would be helpful.

It would also be helpful to show several capture histories and the associated probability statement for the histories to illustrate how Figure 9.2 comes into play.

Minor comments
p.191. Equation 2 for parr overwinter survival requires more explanation. Over what period or reach are the parr and smolt survival estimates made?

p.193. At what level was the Deviance Information Criteria (DIC) computed, i.e., the focus? This is a tricky issue with hierarchal models—refer to Quintero and Lasaffre (2018) for details.

p.193. The description of the various models would be strengthened by reference to Figure 9.2. For example, in cases where *p* comes from a hierarchical model, what parameters are being modeled?

p.195. "lack of fit in 44% of the release groups…" It is possible to compute the posterior predictive plots to focus on particular aspects of the model rather than a simple omnibus lack of fit. This should be explored in more detail to assess various violations of assumptions such as those listed on page 200.

p.196. Compare the estimates from your model to the CSS values to see if there are any major discrepancies. The report indicates on page 199 that "The observed Rocky Reach … SARS … are consistent with ... McCann et al" which is the CSS report, but no actual comparison is presented. These could easily be overlaid on any plots.

Editorial
This chapter needs careful editing to address items including spelling mistakes, missing words, incomplete sentences, acronyms that are not defined, incorrect years for references, as well as to improve the flow.

p.191. "The probability for each unique capture history …" is incorrect. The capture-history consists of 0/1 and other codes for the state of the fish. The probability is modeled separately.

p.191. "The probability of each unique … capture (rho symbol used here)" Replace rho by p.

p.191. The "chi" term is a complex expression of p and phi and not a separate parameter.

p.193. Figure 9.2. Different notation used. Now S=survival rather than phi? "The probability of …. are the statistics from ..." This makes no sense. "Survival is estimated…" should read "Cumulative survival …" Notation t_1, t_{21} and such not defined in legend.

p.192. "target for the number of independent samples" should read "target for the number of independent samples from the posterior distribution."

p.193. “reported posterior distributions were accurate.” “Accurate” is the wrong word here (accuracy = combined bias and precision; but, bias from model misspecification or other sources is unknown). Is the intent to discuss uncertainty here (i.e. the credible intervals)?

p.194. “… we would expect the SAS estimates would shrink to the grand mean and not capture the annual SAS variability.” It is unclear what is meant by this. Presumably, the shrinkage will “reduce” the apparent variability in the raw SAS values. Is this what is meant here?

p.196 “Since the reach survival estimates … are multiplicative …” Reword – the estimates are not multiplicative, but the overall survival is found by multiplying the individual estimates.

p.197 Figure 9.3. Y axis legend needs to indicate the error bars are 95% credible intervals. Or are they 90% credible intervals as shown in Table 9.2?

p. 198. Why 90% (rather than 95%) credible intervals?

p.199. “…the amount of shrinkage depends on the variance of the parameters.” True, but augment this sentence with “… variance of the estimates of parameters which is a function of the sample size, i.e. smaller sample sizes tend to have larger uncertainty.”

IV.10. Appendix A: Survivals (SR), SAR, TIR, and *D* for Snake River Hatchery and Wild Spring/Summer Chinook Salmon, Steelhead, Sockeye, and Fall Chinook

This is an update from the previous year’s report. The ISAB has no comments.

V. ISAB Appendix: Suggested Topics for Further Review 2011-2018

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.
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 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

VI. References

Bond, M.H., Westley, P.A.H., Dittman, A.H., Holecek, D., Marsh, T., and Quinn, T.P. (2017) Combined Effects of Barge Transportation, River Environment, and Rearing Location on Straying and Migration of Adult Snake River Fall-Run Chinook Salmon, Transactions of the American Fisheries Society, 146:1, 60-73

Budy, P., G.P. Thiede, N., Bouwes, C.E. Petrosky, and H. Schaller. 2002. Evidence linking delayed mortality of Snake River salmon to their earlier hydrosystem experience. North American Journal of Fisheries Management. 22:35-51.

Gosselin, J. L., Zabel, R. W., Anderson, J. J., Faulkner, J. R., Baptista, A. M., & Sandford, B. P. 2018. Conservation planning for freshwater–marine carryover effects on Chinook salmon survival. *Ecology and evolution 8*(1):319-332. doi: 10.1002/ece3.3663

Haeseker, S.L., J.A. McCann, J. Tuomikoski, and B. Chockley. 2012. Assessing freshwater and marine environmental influences on life-stage survival rates of Snake River spring-summer Chinook salmon and steelhead. Transactions of the American Fisheries Society 141:121-138.

Haeseker, S. 2013. Nonrepresentative fish and ocean migration assumptions confound inferences in Rechisky et al. Proceedings of the National Academy of Sciences USA 110 (37) E3464.

Muir, W.D., D.M. Marsh, B.P. Sandford, S.G. Smith, and J.G. Williams. 2006. Post-hydropower system delayed mortality of transported Snake River stream-type Chinook salmon: Unraveling the mystery. Transactions of the American Fisheries Society. 135:1523-1534.

Quintero, A, and E. Lesaffre. 2018. Comparing hierarchical models via the marginalized deviance information criterion. Statistics in Medicine 37:2440–2454.

Rechisky, E.L., D.W. Welch, A.D. Porter, M.C. Jackobs-Scott, and P.M. Winchell. 2013a. Influence of multiple dam passage on survival of juvenile Chinook salmon in the Columbia River estuary and coastal ocean. Proceedings of the National Academy of Sciences USA 110 (17):6883-6888.

Rechisky, E.L., D.W. Welch, A.D. Porter. 2013b. Reply to Haeseker: Value of controlled scientific experiments to resolve critical uncertainties regarding Snake River salmon survival. Proceedings of the National Academy of Sciences USA 110 (37) E3465.

Rechisky, E.L., D.W. Welch, A.D. Porter, J.E. Hess, S.R. Narum. 2014. Testing for delayed mortality effects in the early marine life history of Columbia River Basin yearling Chinook. Marine Ecology Progress Series 496:159-180.

Schaller, H.W., C.E. Petrosky, and E.S. Tinus. 2014. Evaluating river management during seaward migration to recover Columbia River stream-type Chinook salmon considering the variation in marine conditions. Canadian Journal of Fisheries and Aquatic Sciences 71:259-271.

Scheuerell M.D., Zabel, R.W., Sandford, B.P. (2009). Relating juvenile migration timing and survival to adulthood in two species of threatened Pacific salmon (Oncorhynchus spp.) Journal of Applied Ecology, 46, 983-990.

Welch, D.W., E.L. Rechisky, M.C. Melnychuk, A.D. Porter, C.J. Walters, S. Clements, B.J. Clemens, R.S. McKinley, and C. Schreck. 2008. Survival of migrating salmon smolts in large rivers with and without dams. PLOS Biology 6:2101-2108.