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MEMORANDUM

To: Bob Naiman, Chair, ISAB
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Michele DeHart

From: Michele DeHart

Date: November 30, 2015

Re: Response to ISAB comments on the Draft 2015 Comparative Survival Study Annual Report

Attached, please find the Comparative Survival Study (CSS) Oversight Committee responses to ISAB comments on the draft 2015 Comparative Survival Study Annual Report. As in past years the ISAB comments are insightful and have improved the report overall. The original comments are presented in italic font followed by the responses in standard font.

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Independent Scientific Advisory Board
for the Northwest Power and Conservation Council,
Columbia River Basin Indian Tribes,
and National Marine Fisheries Service
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Review of the Comparative Survival Study Draft 2015 Annual Report

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ISAB 2015-2
October 16, 2015

Review of the Comparative Survival Study (CSS) Draft 2015 Annual Report

Contents

Review of the Comparative Survival Study (CSS) Draft 2015 Annual Report

I. Background

The Northwest Power and Conservation Council's 2009 amendments to the Columbia River Basin Fish and Wildlife Program called for a regular system of independent and timely science reviews of the Fish Passage Center's (FPC) analytical products. The 2014 Program continues to call for these reviews, which include evaluations of the Comparative Survival Study's draft annual reports. These ISAB reviews began five years ago with the evaluation of the CSS's draft 2010 Annual Report (ISAB 2010-5), followed by a review of the draft 2011 Annual Report (ISAB 2011-5), the draft 2012 Annual Report (ISAB 2012-7), the draft 2013 Annual Report (ISAB 2013-4), and most recently the draft 2014 Annual Report (ISAB 2014-5). This ISAB review of the draft 2015 CSS Annual Report is the ISAB's sixth review of CSS annual reports in response to the Council's 2009 Program.

These reports are extremely valuable to many stakeholders in the Basin for many different purposes, and the data collection and reporting should be continued.

II. Summary

This ISAB review begins with an overview of the latest report (this section); then moves to suggesting topics for further CSS review (Section III), general comments on each chapter of the 2015 CSS Annual Report (Section IV), and ends with specific queries and suggestions (Section V).

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 detailed response of the CSS to suggestions provided in previous reviews. We do not expect that the CSS would necessarily respond immediately to new requests for further analyses.

Chapter 1 is similar to previous years with the 2013 results added. The report now disaggregates results for Snake River wild steelhead and Chinook to the major population group (MPG) level. The results in Chapter 1 appear to show a natural experiment involving the effects of mainstem discharge on salmon survival with the proportion of downstream transportation of juveniles and *proportion of spill being roughly constant since 2006, but total flow in the river differing among years. The ISAB suggests that focused analyses (graphs and formal analyses) be conducted on this natural experiment to test statistical relationships between flow and salmon population parameters such as survival, smolt-to-adult-return rate (SAR), and other response variables.*

In Chapter 2, an updated Life Cycle Model (LCM) is presented that relates juvenile survival of transported and untransported cohorts of juvenile fish and a PIT-tag based indicator of powerhouse passage. This is useful refinement of the LCM, and the ISAB looks forward to additional refinements such as the inclusion of additional terminal areas and further partitioning of survival. The LCM was used to investigate the long-term impacts of increased salmon productivity and reduced dam effects on the long-term persistence of salmon populations. It would be helpful to reverse this analysis and evaluate what combinations of increased productivity and reduced dam contact might lead to sustainable populations.

Chapter 3 is mainly an update with the latest information on in-river effects on juvenile travel time, instantaneous mortality, and survival. A key finding is that there is large variation in the results among years and among cohorts. The variation among years is understandable; the variation within a year less so. Many figures (e.g., Figure 3.2) show a consistent pattern in fish travel time and survival over cohorts as the year progresses. The discussion lists potential explanations for the effect of "day." Can planned or natural experiments be designed to distinguish among these hypotheses and is it worthwhile to do so? For example, do these relationships provide information on optimal timing of releases for hatchery fish? It is also not clear if these cohort effects continue to the final performance measures (e.g., SARs). Data are clearly too sparse to investigate this question for individual cohorts, but can a more gross separation be used (e.g., a simple split of cohorts into two parts – early vs. late)?

Chapter 4 described overall annual SARs and was updated with new data; details are presented in Appendices. Additionally, the authors investigate relationships between SARs and salmon population productivity (return per spawner) and inter-stock correlations among SARs. These chapters and appendices will continue to expand over time. Is there a better way to present the results than in an ever-expanding set of graphs and sets of tables? As indicated in the report, different SAR objectives will require different accounting locations (e.g., finer geographic locations) and methods (e.g., for persistence at local or basin levels). The current tables and plots are generally well done, but as can be imagined, this chapter could become overwhelming. The ISAB suggests that consideration be given to how to present these results in the future to best serve the various stakeholders. Perhaps an electronic report that can be customized for a particular interest group may be more useful than a static paper document?

CSS Response: The CSS continues to strive to present the SAR data set in as simple a form as is possible. Thus we have moved many of the data tables into appendices of the Annual Report. Also, we continue to provide these data via the web and encourage the readers to explore the Fish Passage Center web site for the many ways in which the data can be summarized and/or downloaded. We are in the process of upgrading the web interface to make the data more easily accessible for users to download.

The CSS report could then focus on unexpected findings or relationships (such as that between SAR and productivity or inter-cohort relationships).

Chapter 5 is mostly an update on Snake River subyearling fall Chinook. As with Chapter 4, some consideration is needed on the best way to present an ever-increasing amount of data so that the results of the data analyses are useful for stakeholders.

CSS Response: We agree that the volume of data presented can be overwhelming, that is why much of the data is reported in appendices. We also allow access to the data via the web at www.fpc.org. We are continuing to explore ways to best provide these data to stakeholders and the public.

This chapter also includes a new power analysis indicating how much additional tagging is needed for fall Chinook above Lower Granite Dam (LGR). Is it feasible to tag the required number of fish? Also, these additional tagged-fish will provide added information on down-river detection rates – does this lead to improvements elsewhere in the CSS domain of study?

CSS Response: Feasibility of marking is somewhat beyond the control of CSS, since we, generally, can identify groups and provide tags for said groups. Feasibility must be determined by the agencies marking fish. In this case, we are working with the Nez Perce Tribe to provide them with tags for marking. The NPT would better understand what is feasible. However, a COE-funded transportation study marked over half a million fall Chinook from the Snake River Basin in recent years. That effort demonstrated the feasibility of marking large numbers of fall Chinook. Often feasibility is limited by funding. Increased marking would improve the precision of estimates in all life phases for fall Chinook. In cooperation with NPT the CSS is currently providing marks for two releases of fall Chinook as a pilot program. It is anticipated that NPT and others will need to seek additional funding to mark other fall Chinook groups as well as to coordinate which agencies could provide marking assistance.

We understand that Chapter 6 in the 2014 report (PIT-tag versus CWT survival estimates) is currently in preparation for the next iteration of the CSS report. Rather than report on *incomplete analyses, it was removed from this year's report. We look forward to its inclusion next year. Evaluating potential bias in survival rates of PIT-tagged fish is an important topic.*

III. Suggested Topics for Further Review

In 2013, we recommended these topics (ISAB` 2013-4, Page 1):

1. *Hypotheses on mechanisms regulating smolt-to-adult survival rates (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, and*
5. *Publication of a synthesis and critical review of CSS results*

In 2014, we recommended these topics (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 2013 review]*
3. *New PIT/CWT study to further investigate differential survival among these tag types*

The CSS group has incorporated many of our suggestions into the current document. For example, the current report has a substantial discussion of correlations among SARs from different regions or effects of transport on SARs (#1 in 2013; #1 in 2014). The life cycle modeling now allows for variation in stream productivity and hydrosystem survival and simulates the correlative impacts of these changes on predicted future population abundances (#2 in 2013; #2 in 2014). Members of the CSS have now published many peer-reviewed articles synthesizing the results (#5 in 2013). The ISAB appreciates the CSS efforts to respond to our queries which in turn leads to further questions as noted below.

However, some of the recommendations from the ISAB appear to be beyond the scope of the CSS. For example, the ISAB identified several data gaps such as fish body mass metrics (#3 in 2013), but limited resources and questions about which agencies should collect this information have prevented acquisition of these data. The CSS expends considerable effort to coordinate PIT-tagging in the basin with other groups but does not feel that it is the appropriate body for a full rationalization of the PIT-tagging effort (#4 in 2013) along the lines recommended by the IEAB report (2013-1). Resolution of these issues may require higher-level policy discussions among the stakeholders in the Basin.

CSS Response: While the CSS seeks to economize by utilizing tags from fish marked in other studies, we do not think the CSS would have the mandate to determine which of those studies should be funded. Many of the studies we cooperate with have different objectives in terms of the scale and specificity of the study. In other words, a study of tributary productivity, that evaluates things such as habitat improvement, could have merit at a subbasin scale, while the CSS might have many tags in nearby subbasins that could make up for those tags that were not funded by a specific study. But the CSS uses the presence of such studies to bolster tag numbers where it is possible to do so because tags from many individual sub-basins provides a more representative group of tagged fish for use in the CSS study.

The update of Chapter 6 from last year (#3 in 2014) has been deferred until the next report.

In 2015, we recommend the following four topics for future reports:

1. *Use SAR data to examine both intra- and interspecific density dependence during the smolt out migration and early marine periods.*

ISAB (2015-1) found relatively little direct testing of density dependence during the smolt outmigration period when many natural and hatchery salmonids may co-mingle as they migrate toward the ocean. Would it be possible to use CSS SAR data to examine both intra- and interspecific density dependence during the smolt out migration and early marine periods? The potential for compensatory density dependence was suggested by bioenergetic estimates of numerous prey consumed by spring/summer Chinook as they migrate from Lower Granite Dam to Bonneville (ISAB 2011-1). Also, there was some evidence of depensatory mortality of smolts in the Snake River caused by foraging birds (see Fig. VII.1 of ISAB 2015-1).

2. *Propose actions to improve SARs to pre-1970s levels.*

The Chapter 4 Discussion provides a good summary of key information, leading to the conclusion that pre-harvest SARs of ~4-7% are needed to improve productivity to pre-1970s levels. Given the range in observed survivals at sea (S.oa), to what extent might actions in the mainstem Columbia and Snake rivers allow this to occur? What are the key actions predicted to influence survival to reach SARs of 4-7%? For example, can the Life Cycle Model simulation study be run in "reverse" to help evaluate the relative benefit of alternative management actions? These evaluations might support an actual test (like a spill-experiment).

3. *Explore additional potential relations between SARs and climate and ocean conditions*

The authors should consider further exploration of potential relationships between SARs and indices of climate and ocean conditions that have not been previously evaluated by CSS, e.g., the North Pacific Gyre Oscillation (NPGO; see Kilduff et al. 2015; Miller et al. 2014), NOAA local biological indices (e.g., copepod biodiversity, northern copepod anomalies, biological spring transition, winter ichthyoplankton, juvenile catch-June), and Alaska Marine Ecosystem indicators. Similarly, can methods similar to Chapter 2 be used where years that are "similar" to those expected under future climate change scenarios are used to simulate the predictions for survival, SARS, and other population parameters under future climate scenarios.

4. *Consider ways to explore the variability of inter-cohort responses*

Finally, the CSS report has studied effects on the "mean" response to various factors. For example, fish travel time reductions improve "mean" survival, but as noted, there is high inter-cohort variability. Perhaps a lower average survival with less inter-cohort variability would be more beneficial, i.e. a more robust response. Are there management actions that could reduce this intra-cohort variability? The current time series is now approaching a length where this could be investigated in the future. Some planning is required to ensure that data collected now are stored in a format that will be suitable for future investigations along these lines.

CSS Response: Thank you for these topics to consider. We will seriously evaluate the feasibility of these ideas for inclusion in the 2016 CSS Annual Report. The CSS will meet in February to begin planning next year's report, and we will fully consider these topics at that time.

IV. Comments on the draft CSS 2015 Annual Report by Chapter

Chapter 1. Introduction

This chapter is similar to previous years with the 2013 results added. The report now disaggregates results for Snake River wild Steelhead and Chinook to the MPG level.

It is interesting to note (Figure 1.6) that 2013 had a high spill proportion (around 40%) with a low discharge and is similar to conditions in 2010 and 2007. Since 2006, spill percentages have been relatively constant, the proportion of juvenile salmon transported has been relatively constant, three of the years have been low total flow years, and five of the years have been higher total flow years. This appears to be a natural experiment (but power may be limited with only 8 years of data when spill was mandated) on the impact of total flow on survival. The ISAB suggests that some focused analyses (graphs and formal analyses) be done on this natural *experiment to see if the results provide some empirical evidence the association between year-to-year total flow and salmon population parameters such as survival, SAR, and other response variables.*

Chapter 2. Life cycle modeling approach to estimating in-river and early ocean survival

This chapter presents an update on Life Cycle Modelling development. The model now (1) increases separation of life stages, including juvenile migrants split into transported and untransported fish, which allows transported and untransported fish to have different survivals once they enter the ocean; (2) adds a PIT-tag based indicator of powerhouse passage, (3) adds an index of the proportion of fish transported and of water transit time through the hydrosystem, and (4) integrates empirical in-river survival and SAR data into the statistical fitting procedures. The ISAB is pleased with the progress so far and looks forward to the evolution of the LCM.

The key findings of the CSS analyses are:

(a) survival is sensitive to hydrosystem operations where the power house contact index appears negatively related to survival in both the hydrosystem and early ocean stages.

(b) some MPGs appear to be in the region of limited capacity for production (assuming Beverton-Holt density dependence).

The CSS used the life cycle models to ask two questions about the potential for increases in long term abundance:

(1) What happens with improvements in the productivity in freshwater spawning and rearing (typically as a result of habitat improvements)? This was modelled by varying the productivity from 50 to 250 smolts/spawner.

(2) What is the impact of changes in survival in the mainstem as a function of hydrosystem operations modeled by using values of 50 to 100% of the historical powerhouse contact rate?

Not unexpectedly, improvements in early life productivity are positively correlated with direct improvements in forecasted abundance, but improvements in productivity run into apparent density dependence effects for several watersheds (Imnaha, Minam, Lostine; p.44 and Figure 2.9). Similarly, changes in powerhouse contact rate are associated with (near linear) changes in abundance because density dependence was not modelled in the main stem. For example, according to the LCM, if the powerhouse contact index was reduced to 50% of historical value, a 40-400% increase (!) in returns is predicted (Figure 2.10). In ISAB (2015-1), it was noted that an *increase in survival across the lifecycle would increase the number of returning fish which, assuming all else remains the same, moves the equilibrium abundance to the right on the density-dependence curves. Was this shift in the equilibrium also observed in the simulation studies?*

CSS Response: Simulated long-term average abundances reflected a sensitivity to either change in productivity, change in capacity, or change in PITPH, at a fixed value for the sensitivity term, but allowing for variability in the remaining parameter values. For example, if a simulation was performed for productivity with a fixed value of 200 smolts per spawner, the capacity term for each simulation would have taken on different values for capacity (drawn randomly from the MCMC chain), and therefore the equilibrium point on a density-dependent curve would have been different for each capacity value. However, the range of variability in capacity parameters is limited to the range of the MCMC posterior. In general, an increase in productivity would translate to a shift to the right on the density-dependent curve, but there could be cases where a simulation would have drawn a low value for capacity, making the equilibrium abundance limited at a lower abundance than for a lower productivity/higher capacity combination.

Additional commentary about the Powerhouse Contact Index is recommended. Can it be predicted/measured reliably for a cohort of fish given observed or forecasted spill conditions? Does a cohort with 50% having no dam contact and 50% with 1 dam contact experience the same response as a cohort with 75% having no dam contact and 25% with two dam contacts; i.e., is there a non-linear effect of powerhouse contact index at the individual fish level?

CSS Response: The revised Annual Report includes Appendix J, which describes the methods for calculating the powerhouse contact index. Available validation data indicates that the index provides an accurate and reliable measure of powerhouse contact at each dam. The index is calculated based on the environmental conditions that occurred at each dam, namely the proportion spill, flow level, and the presence of spillway weirs. At each dam, we generate an estimate of the expected proportion of the population that passed through the powerhouse, which includes the smolt collection/bypass passage proportion and the turbine passage proportion. The overall index is the sum of the eight, project-specific estimates of the powerhouse passage proportions. To date, we have used the powerhouse index only as a linear predictor of survival, similar to the other indices (water transit time, upwelling, and Pacific Decadal Oscillation).

When modelling effects of productivity and improvements to hydrosystem survival, the effects of productivity bump into density dependence in several sites. There is support for this density dependence from Figure 2.8 and from studies outside the model, as described in ISAB 2015-1 *and the references within. How do improvements in habitat over time feed into the LCM model given that these improvements alter the density dependence relationship?*

CSS Response: The LCM model is intended to provide a sense of how much change in productivity and capacity would be required to bring about increase in abundance. The results are presented relative to a historical baseline. The results reflect a hypothetical case where the rate is assumed to take on a new value instantly. They do not reflect the time it takes for habitat improvements to alter the magnitude of the parameter value. Fine-scale habitat and juvenile abundance data would need to be collected to empirically test a temporal prediction of response to habitat improvements. Alternatively, a temporal time lag assumption could be implemented.

The association of hydrosystem improvements and subsequent abundance examined in the model are "theoretical" (i.e., not a function of flow or other factors). Can the statistical models be used to propose hypotheses about how much hydrosystem operations could improve salmon abundance; e.g., what levels of spill and/or fish travel time are predicted to lead to "75% of current impact of hydrosystem operations"? Could these hypotheses be tested in a spill experiment?

CSS Response: Yes, the statistical models can be used to propose hypotheses about how much hydrosystem operations could improve salmon abundance and survival. Because the models use water transit time and powerhouse passage indices to explain the historical patterns in salmon abundance and survival, these models can also be used in a prospective manner to identify hypotheses about how various hydrosystem operations (i.e., changes in powerhouse passage proportions and water transit time) could improve salmon abundance and survival. These hypotheses could then be tested in a spill experiment. A spill experiment, with increased spill beyond the historical levels, would reduce the number of powerhouse passage experiences (i.e., reduce the levels of the PITPH index) and would be expected to increase salmon abundance and survival. The models can be used to identify hypotheses about the levels of increase in salmon abundance and survival that would be expected for a given set of hydro-system operations.

Will the life cycle modeling effort eventually be extended to include other species and populations? Interior steelhead (separate models for A and B runs) should be a priority given recent lower than expected returns.

CSS Response: The life cycle model was developed to examine life cycle survival tradeoffs and recovery potential. It is currently targeted at spring Chinook in the Grande Ronde and Imnaha river basins.

The proposed modifications of the LCM tool to add a time perspective and accommodate climate change hypotheses should be pursued. For climate change hypotheses, additional climate variables related to US West Coast/Columbia River Basin salmon survival should be considered, including the North Pacific Gyre Oscillation (NPGO; http://www.o3d.org/npgo/), and local and remote biological indices from the area of known ocean distribution at each life stage.

CSS Response: These modifications have been noted and will be considered for future implementations of the LCM.

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

This chapter is mainly an update from previous years. Most of our comments relate to improvements in presentation and/or justification.

Table 3.1 indicates that Fish Travel Time (FTT) is estimated well for individual cohorts, but there is wide range among cohorts. Are the data sufficiently dense to explore the relationships of other variables to this variability in the responses among cohorts? The data are likely too sparse for individual cohorts, but, for example, could cohorts be divided into low, medium, and high FTT (based on simple partitioning) to see if the variability in FTT then translates into similar variability in SARs?

CSS Response: The high levels of variability among cohorts are mainly due to variation in the environmental conditions (e.g., water transit times, spill percentages) that were experienced by those cohorts over time. To illustrate this, we have added summaries of the relative variability in Water Transit Time and Spill percentages across cohorts to Tables 3.1 and 3.2. The primary purpose of this chapter is to explore the relationships between environmental variables and Fish Travel Time. See Haeseker et al. (2012) for analyses on the relationships between environmental variables and SARs.

From Tables 3.1 - 3.2, it appears that the biggest issue controlling precision and coefficients of variation (CVs) in two reaches (McNary Dam-Bonneville Dam, MCN-BON; and Rock Island Dam – McNary Dam, RIS-MCN) is sample size and detection rates. We agree that there are tradeoffs in changing both of these metrics. The ISAB agrees that further work is needed to evaluate where spillway detection would be most beneficial for these two particular reaches but also throughout the system. The Independent Economic Analysis Board (IEAB) conducted a general study investigating tagging rates for various locations (IEAB 2013-1) – their expertise could be helpful in this more focused evaluation.

CSS Response: Low sample size and detection rates limit precision in the RIS-MCN and MCN-BON reaches. However, through coordination with other tagging efforts and monitoring programs (e.g., the Smolt Monitoring Program), our goal is to maximize precision under these historical and existing constraints.

The overall conclusion is that "improvements to fish travel time, mortality rates and survival may be possible through management actions that reduce water transit time (WTT) and increase spill percentages. There are only two approaches for reducing WTT: reducing reservoir elevations and/or increasing flow rates." Some suggestions are provided regarding an experiment to confirm this statement. The CSS is encouraged to continue to discuss such an experiment with the Basin stakeholders.

Chapter 4. Patterns in Annual Overall SARs

Chapter 4 provides very useful analyses that should be updated each year. The ISAB agrees that it is important to continue the CSS time series for both hatchery and wild salmonids for the reasons noted in the report. The data patterns raise many questions, some of which we raise here.

ISAB (2015-1) found relatively little direct testing of density dependence during the smolt outmigration period. Would it be possible to use CSS SARs data to examine both intra- and interspecific density dependence during the smolt out migration and early marine periods? The potential for compensatory density dependence was suggested by exceptionally high prey consumption requirements by spring/summer Chinook in the mainstem river that might lead to density dependent growth (ISAB 2011-1). Alternatively, there was some evidence of depensatory mortality of smolts in the Snake River caused by foraging birds (see Figure VII.1 of ISAB 2015-1).

CSS Response: As addressed above in *III. Suggested Topics for Further Review* it may be possible to examine this question in the future. CSS oversight committee will discuss this topic in planning sessions for 2016.

Recent analyses indicate SARs from smolts originating at Rocky Reach Dam were about 60% of the SARs for smolts originating at McNary Dam or that about 40% mortality is occurring in the upper river reach. To what extent might dam passage versus movement through the reservoirs account for the 40% mortality? We agree that it is important to continue to evaluate SARs from the upper Columbia River, e.g., Rocky Reach Dam.

The ISAB agrees that evaluation of PIT-tag related mortality and tag loss should be a priority research topic, and we look forward to seeing results of the ongoing evaluation.

CSS Response: The PIT-tag sample size in the upper Columbia is relatively small, limiting our ability to separate the direct mortality from dam passage from that of movement through the reservoirs. Some information on dam passage direct survival is available from acoustic tag studies in this reach; however, these studies are problematic and do not currently provide reliable estimates of direct passage survival at the dams. Problems include (1) the non-representative nature of study fish, (2) the inflation of overall and route-specific survival estimates attributable to the study design, and (3) that information required for a full review has not been made publically available (Tuomikoski et al. 2013, Appendix G). Because SARs are a function of both direct and delayed mortality, dam passage survival rate estimates alone will not reflect the full effect of dam passage on SARs (e.g., Ferguson et al., 2006; Haeseker et al. 2012, Petrosky and Schaller 2010, Schaller et al. 2014).

Ferguson, J.W., R.F. Absolon, T.J. Carlson and B.P Sandford. 2006. Evidence of delayed mortality on juvenile Pacific salmon passing through turbines at Columbia River dams. Transactions of the American Fisheries Society 135:139–150. DOI: 10.1577/T05-080.1

The Discussion provides a good summary of key information, leading to the conclusion that pre-harvest SARs of ~4-7% are needed to improve productivity to pre-1970s levels. Is this sufficient to enable a self-sustaining natural population at spawning densities that exceed minimum abundance thresholds shown in Appendix Table B.70? Given the range in observed survivals at sea (S.oa), to what extent might actions in the mainstem allow this range in survival to occur? What are the key actions? For example, can the LCM simulation study be run in "reverse" to evaluate what actions may have higher priority? This could provide justification for an actual test (like a spill-experiment).

CSS Response: SARs need to increase substantially to improve life cycle productivity, and the CSS information indicates pre-harvest SARs in the range of 4%–7% would achieve pre-1970s levels of productivity. Pre-1970s productivity levels do appear sufficient to enable self-sustaining natural populations at spawning densities that exceed minimum abundance thresholds (MAT) defined by the ICTRT (2007). We summarized the geometric mean of pre-harvest recruits from Snake River spring/summer Chinook populations for this base period in Table 1, below. Pre-harvest recruits to the Columbia River in this period ranged from 140% to 900% of the MAT, providing considerable buffer for harvest and upstream passage survival for most populations. Key actions to increase SARs include reducing powerhouse passage and increasing water velocity (e.g., Chapters 2 and 3, and 2013 CSS workshop proceedings). The CSS is continuing to work on documentation of prospective analyses for spill experimental management considerations, and will consider the ISAB recommendation to also use the LCM simulation study to evaluate priority actions in future work plans.

Table 1. Preharvest Recruits to the Columbia River from Snake River spring/summer Chinook populations.

Region, MPG	Population	Pre-1970 geomean recruits	MAT	Pre-1970 recruits as % MAT
Snake River				
Middle Fork Salmon (MFS)	Bear Valley	5623	750	750%
	Marsh	4512	500	902%
	Sulphur	2040	500	408%
	Big	1760	1000	176%
South Fork Salmon (SFS)	Mainstem	4461	1000	446%
	East Fork South Fork	1443	1000	144%
	Secesh	1067	750	142%
Upper Salmon (USR)	Lemhi	4774	1000	477%
	Upper Salmon	8673	1000	867%
	East Fork	5069	1000	507%
	Valley	1895	500	379%
Grande Ronde/Imnaha (GRIM)	Imnaha	6133	1000	613%
	Big Sheep	1942	500	388%
	Wenaha	5382	750	718%
	Lostine	4378	1000	438%
	Minam	3149	750	420%
	Catherine	4207	1000	421%
	Upper Grande Ronde	2042	1000	204%

Chapter 5. Estimation of SARS, TIRS, and D for Snake River Subyearling Fall Chinook

This chapter is mainly an update from previous years. It updated estimates of the effects of holdovers on SAR and other metrics. It also includes a new power analysis that indicated about 40,000 subyearling fall Chinook need to be tagged in the Snake River above LGD to detect a 50% difference in SAR between transported and in-river groups with an 80% power. Is it feasible to tag the required number of fish? Elsewhere in the document, the importance of spillway detectors was noted. If these were installed, would the power analysis change? If this number of fish are tagged, they will provide additional information on down-river detection rates – does this lead to improvements elsewhere in the CSS domain of study?

CSS Response: Population size is a critical variable in determining the power of comparative T_x vs C_0 SARs or TIRs. Higher detection probability would not directly affect that. However, improvements in the precision of reach survival, S_R, would likely result from increased detection probability at any or all of the dams. Beyond improving detection probability, spillway detectors could provide new analytical tools, by allowing CSS to separate out fish that only passed via spill. This data could be used to help improve the precision of estimates of C_0 and the probability of fish being guided by screens. There are likely some additional possibilities for use in estimating delayed effects of bypass systems.

Appendix A: (SR), SAR, TIR, and D for Snake River Hatchery and Wild Spring/Summer Chinook Salmon, Steelhead, and Sockeye

This appendix is an update from previous years. We have no comments other than some consideration should be given on the best way to present these results for different audiences in the future as the number of tables and size of each table continues to grow.

V. Specific Comments on each Chapter

Chapter 2

A key objective of this chapter is to evaluate "the two different alternatives of how population trends could have been different than empirically observed trends," but the chapter never articulates clearly what the two alternatives are. Are these the two "key aspects of the system" mentioned elsewhere in the chapter?

CSS Response: Chapter 2 updated to reflect the key aspects which are productivity, capacity and hydrosystem operations.

An index (PTRANS) is mentioned here, and it is described as being reported in the 2014 CSS report. How is this index calculated? Referring to the previous CSS report is rather cumbersome for the reader to find where the calculation of this index is described. While it makes the report more bulky, it may be helpful to include technical excerpts from previous reports in appendices to make the documents more self contained.

CSS Response: Transportation is a fairly involved topic of its own, and is addressed in detail in Chapter 1. Limited additional description of transportation has been added to Chapter 2.

The chapter investigates a range of changes in productivity and changes to hydrosystem operations. How were these ranges chosen? Is it feasible to make such changes in the current system? Some justification for these ranges is needed.

CSS Response: Justification provided in updated Chapter 2.

Figure 2.4. The effect of transportation on ocean survival is only available indirectly, e.g. the readers need to "manually" compare the posteriors for γ_H and γ_T. It would be easier to show the posterior directly for the difference or ratio of these two values.

CSS Response: Figure 2.4 shows the MCMC posterior samples. Unfortunately, showing the ratio of γ_H and γ_T will not provide a sense of the relative impact, since ocean survival of in-river and transported fish are subject to the effects of PDO, UPW, and PITPH in the case of in-river migrants.

Chapter 3

p. 61. The six environmental factors include a linear and quadratic effect of day. All possible subset regressions were used. Some care is needed as models with a quadratic effect of day but no linear effect of day are not very sensible. They presumably will have very low support as measured by Akaike information criterion (AIC) values and will not be suitable fits to the data; they should not be fit as they are unrealistic biological models.

CSS Response: We have revised our approach for evaluating the quadratic effect of day of release in the fish travel time models. Based on an examination of model results across species, only yearling Chinook salmon demonstrated a consistent improvement in model fit when the quadratic effect of day was included. The models with both the linear and quadratic effect of day typically had AIC values 20–80 points lower than models with only the linear effect of day. There were no cases among the top fitting models where only the quadratic effect was included. Based on these results, we revised our approach and only evaluated the quadratic effect of day for the yearling Chinook salmon fish travel time models. We have added text stating that evaluations of the quadratic effect of day were limited to the yearling Chinook travel time models.

p. 62, Table 3.4 and Figure 3.5 may need some clarifications. Are the "model forms" MY, MY +Day just composed of those variables as random effects or are the other variables with high relative importance values (Figures 3.5-3.6) also part of the models? If the answer is "no," it seems that the MY+Day models with $R^2 > 0.90$ are all that are needed and the other variables (e.g. WTT, Surface shown in Figure 3.5 top right) must not contribute to the model despite the relative variable importance = 1.0. The effect of Julian Day is treated as a random effect, but many of the graphs show a near linear relationship with time – is a random effect appropriate in these cases? Equation 3.5 seems to indicate that Julian day occurs both as a random effect and a fixed effect in the model, so there is some ambiguity in exactly what the model My + Day *actually means (i.e., is Day the random or fixed effect?). Some careful editorial review is needed on these pages.*

CSS Response: Model forms MY and MY+Day include all of the environmental variables, but are mainly influenced by the variables with high relative variable importance values. The full (i.e., most complex) models with both Migration Year (MY) as a random intercept and Julian Day (Day) as a random slope for the Day variable are presented in Equations 3.5 and 3.6. We also considered simpler, reduced, mixed-effects models that omitted the random slope for the Day variable and linear regression (LR) models that omitted both the MY random intercept and the random slope for the Day variable. In addition to the linear effects of the other environmental variables (e.g., water transit time, spill proportion, water temperature), most species showed a linear effect of Day on fish travel time, as indicated by the high relative variable importance values for the Day variable (see Figure 3.5). The MY+Day mixed-effects models include a random slope for the Day variable in addition to the fixed slope for the Day variable, so in these models the Day variable is defined as both a fixed and a random effect. Table 3.4 indicates where models that included both the fixed and random effects for the Day variable (MY+Day) improved model fit over models that included Day only as a fixed effect (i.e., the MY and LR models). We have added text to help clarify these issues.

Figures 3.5-3.6 need to define x-axis terms (e.g., Day, Day2, WTT) in the caption and each of the graphs need y-axis labels. Computing variable importance when a linear and quadratic relationship is present is a bit tricky because if the quadratic term is present, the linear term MUST be present.

CSS Response: We have defined x-axis terms in the captions and added y-axis labels. As discussed above, we have limited the evaluation of the quadratic effect of day to only the yearling Chinook fish travel time models, where there was large support for the quadratic effect. Models with both the linear and quadratic effect of day had AICc values that were 20-80 points lower than models with only the linear effect of day. Models with only the quadratic effect of day fit much more poorly and did not influence the results.

Chapter 4

p. 82. How was it determined that most differential delayed mortality is expressed during the early marine stage? If this is an assumption rather than direct estimation, then please write the statement as an assumption rather than fact. It would be helpful if the authors could provide a brief summary (or at least citations to published literature) of scientific evidence both for and against this hypothesis.

CSS Response: The text was changed to "Although this differential delayed mortality is ~~mostly~~ likely expressed primarily during the early marine stage…" to clarify that it is an assumption.

Numerous papers identify the early marine life stage as critical to establishing year class strength (e.g., Ricker 1976, Pearcy 1992, Mueter et al. 2002, Pyper et al. 2005, Rupp et al. 2012), and marine survival rates and life cycle survival rates of Columbia River salmon and steelhead have been linked to conditions during the year of ocean entry (e.g., PDO, upwelling), as well as to river conditions experienced during the outmigration (Schaller and Petrosky 2007, Petrosky and Schaller 2010, Haeseker et al. 2012, Schaller et al. 2014). The CSS has also found evidence that at least some of the differential delayed mortality (expressed as *D*) occurs during the upstream migration, due in part to disruption of homing (e.g., Tuomikoski et al. 2012).

Mueter, F.J., Peterman, R.M., and Pyper, B.J. 2002. Opposite effects of ocean temperature on survival rates of 120 stocks of Pacific salmon (Oncorhynchus spp.) in northern and southern areas. Can. J. Fish. Aquat. Sci. 59(3): 456–463. doi:10.1139/f02-020.

Pearcy, W.G. 1992. Ocean ecology of North Pacific salmonids. University of Washington Press, Seattle, Wash.

Pyper, B.J., Mueter, F.J., and Peterman, R.M. 2005. Across-species comparisons of spatial scales of environmental effects on survival rates of northeast Pacific salmon. Trans. Am. Fish. Soc. 134: 86–104. doi:10.1577/T04-034.1.

Ricker, W.E. 1976. Review of the rate of growth and mortality of Pacific salmon in salt water, and noncatch mortality caused by fishing. J. Fish. Res. Board Can. 33(7): 1483–1524. doi:10.1139/f76-191.

Rupp, D.E., Wainwright, T.C., Lawson, P.W., and Peterson, W.T. 2012. Marine environment-based forecasting of Coho salmon (Oncorhynchus kisutch) adult recruitment. Fish. Oceanogr. 21: 1–19. doi:10.1111/j.1365-2419.2011.00605.x.

p. 82. The authors state: "S.o1 is back-calculated from the age-structured recruits to the Columbia River mouth, assuming 80% annual survival of sub-adults. This is consistent with other cohort-based Chinook modeling studies (e.g., Pacific Salmon Commission 1998), and assigns all ocean survival rate variability to the S.o1 life stage." The reference list in the report does not include the cited reference (Pacific Salmon Commission 1998). It would be helpful if authors could briefly explain how the PSC's (and other) cohort-based Chinook modeling studies determined that the annual survival rate of sub-adult Chinook in the ocean is constant across post-smolt age groups and equal to 80%. It is true that this is an almost universal assumption in cohort-based modeling studies that has never been thoroughly evaluated.

CSS Response: The PSC's value of 80% annual survival of sub-adult Chinook is a standard assumption in cohort-based modeling (e.g., PSC 1988, Zabel et al. 2006), which is difficult to evaluate due to annual variation and confounding of maturation and survival rates, and a general uncertainty in ocean exploitation rate estimates. The initial source of this assumption was Ricker (1976). The PSC reference was added.

Ricker, W.E. 1976. Review of the rate of growth and mortality of Pacific salmon in salt water, and noncatch mortality caused by fishing. J. Fish. Res. Board Can. 33(7): 1483–1524. doi:10.1139/f76-191.

p. 83. SARs "based on reconstruction for earlier years." Please clarify. Do you mean years prior to 1994 or 1997 or is it separate for the two species? If so, please specify the time period.

CSS Response: We changed the wording to specify years prior to 1994 (Chinook) and prior to 1997 (steelhead).

p. 83. When did Big Sheep spring/summer Chinook become extirpated? It is worth highlighting this important information.

CSS Response: We changed the term "extirpated" to "functionally extinct" with reference to the Interior Columbia Technical Recovery Team's (ICTRT) observation that the population was less than 1% of the minimum threshold abundance of 500, based on a 10-year geometric mean of natural spawner abundance through brood year 2005 (http://www.nwfsc.noaa.gov/trt/trt_documents/big_sheep_chinook3_10_07.pdf). During brood years 1979 and 1980 no natural-origin adult (age 4–6) spawners were observed in Big Sheep Creek for the first time since surveys began in 1964. From brood years 1981 through 1989, estimates of natural-origin adult spawner abundance ranged from 13 (1989) to 238 (1983). No natural-origin adult spawners were observed during 1990; no spawners were observed during 11 of the subsequent 19 years through brood year 2009. The mean natural-origin spawning abundance (1990–2009) was 13 natural-origin adults (Beamesderfer et al. 1997; ODFW unpublished data).

Beamesderfer, R. C. P., H. A. Schaller, M. P. Zimmerman, C. E. Petrosky, O. P. Langness, and L. LaVoy. 1997. Spawner–recruit data for spring and summer Chinook salmon populations in Idaho, Oregon, and Washington. Section 2, Article 1 in D. R. Marmorek and C. Peters, editors. Plan for analyzing and testing hypotheses (PATH): report of retrospective analysis for fiscal year 1997. ESSA Technologies Ltd. Vancouver.

p. 83/84. In the recruitment equation, how was period (T) determined? Is it simply before and after 1970 as suggested on the top of the next page – if so this should be more clearly defined. There have been many changes to the system over the years – is there any evidence that more than two periods would be needed? The equation also needs some revisions. If T is the period effect (a parameter) it needs to be multiplied by an indicator variable which indicates the period for year j and cannot stand on its own.

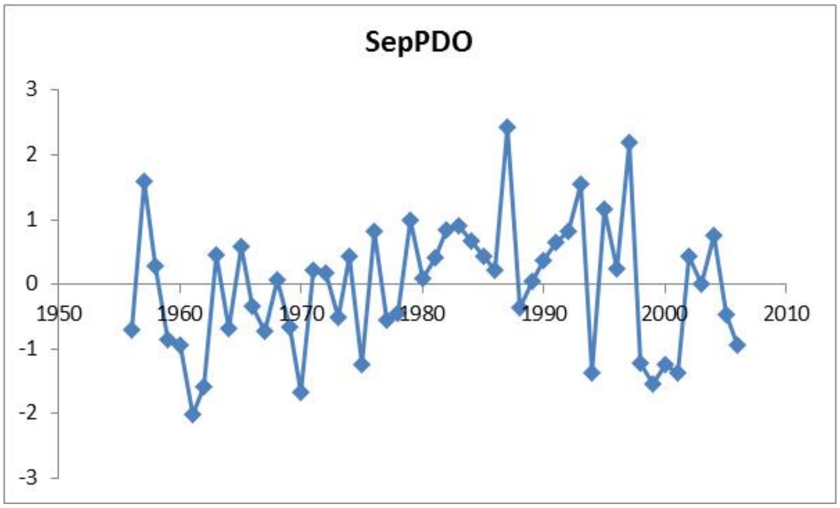
CSS Response: The time periods were explained more thoroughly in Schaller et al. (2014), which was cited as the data source:

> "Survival rate indices provide estimates of changes in life-cycle survival rates over time, and they are the deviations of observed recruits/spawners from those expected for a period before completion of the FCRPS (see below). We analyzed survival rate indices for different periods and populations in the Snake and mid-Columbia River regions, updating and expanding the analysis of Schaller et al. (1999) and Schaller and Petrosky (2007). For each population, SR data were classified into two primary periods defined by FCRPS development and operations affecting the threatened Snake River populations (Schaller et al. 1999). The first period, pre-1970 brood years, was before completion of the final two Snake River dams. The second period, post-1974 brood years (1975–2004), was characterized by completion of the full eight dam complex, collection and transportation of smolts around dams in barges and trucks, turbine screening programs, and other management actions to improve passage at the dams (Budy et al. 2002). The 1970–1974 period was excluded from fitting of the recruitment functions because it was a period of construction and of changing operations in the Snake River that caused extremely high levels of atmospheric gas supersaturation in high-flow years (Raymond 1979) before mass transportation of smolts had begun."

Examination of SARs and SR residual patterns (Figures 4.21–4.23) does not strongly suggest the need for more than two periods. This question can be more formally evaluated once the spawner-recruit data sets are updated. The comment that the period effect, T_i , needs to be multiplied by an indicator variable is not clear to us; the brood years (j) are pre-assigned to the period (i). The ANCOVA approach in SAS defines a common slope (spawners, Ricker *B*), a common intercept (Ricker 'a'), and a period effect (T_i) for period i. The intercept for period i is calculated simply as a + T_i.

The period effect (T) might also reflect non-stationarity caused by long-term ocean effects.

CSS Response: We have found that ocean effects help explain the variation in SARs and SRIs, but we did not see an abrupt shift in ocean conditions (see September PDO figure below) that was consistent with the non-stationary pattern that resulted from hydrosystem construction and operation (Petrosky and Schaller 2010, Schaller et al. 2014).

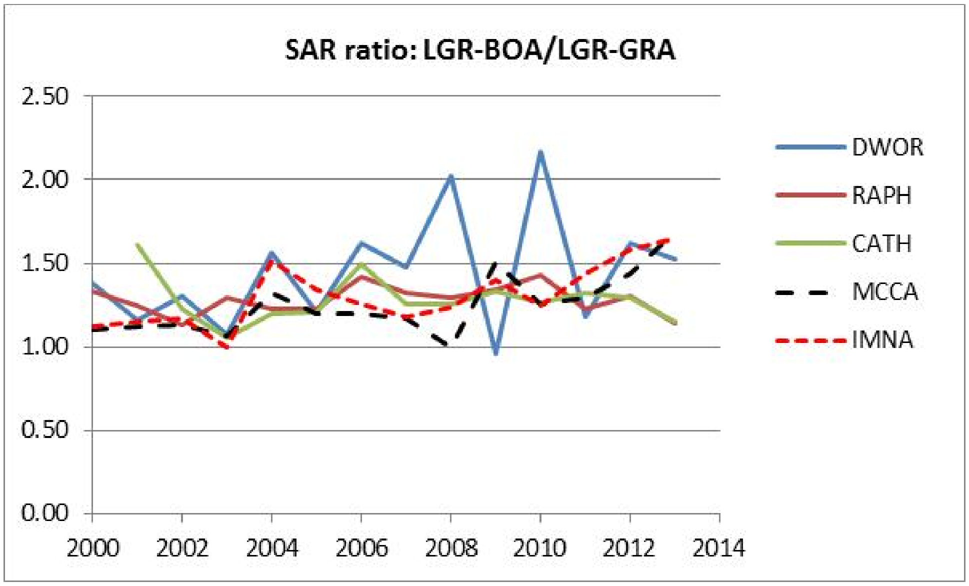


p. 84. When estimating the pre-harvest SARs for John Day spring Chinook, how was survival rate of adults returning through the fisheries determined? Was this approach also used for the upriver stocks? Was pinniped predation in the lower river considered?

CSS Response: Pre-harvest SARs for John Day Chinook were estimated by dividing the JDA-to-BOA SARs by the survival rate of adults returning through the lower river fisheries. In recent years the fishery impact rate on unclipped spring/summer Chinook has been capped at around 2% (depending on run size) to protect ESA listed populations. The same approach was used for upriver stocks in this analysis. Pinniped predation in the lower river was considered to be natural mortality (in both SARs and SR residuals).

p. 87. Summer Chinook reportedly have higher SAR to Lower Granite Dam adult fish ladder (GRA) than spring Chinook, an interesting finding. Previously, it was reported that SARs to Bonneville Dam adult fish ladder (BOA) were about 26% higher than those based on returns to GRA in response to in-river harvests, dam loss, and straying. Is this 26% value consistent for both spring and summer runs?

CSS Response: We calculated the ratio of SARs to BOA and GRA for three hatchery spring Chinook populations (Dworshak, Rapid River, Catherine Creek) and two hatchery summer Chinook populations (McCall, Imnaha) for smolt migration years 2000–2013 (see figure below). Considerable annual variation in the ratios was evident, especially for the Dworshak group. The geometric means of SAR ratios for the three hatchery spring Chinook populations were 1.41, 1.28, and 1.27 for Dworshak, Rapid River, and Catherine Creek, respectively. The geometric means of SAR ratios for the two hatchery summer Chinook populations were 1.23 for McCall and 1.29 for Imnaha.



Figs 4.1 and 4.5 provide important SAR time series, which the authors relate to dam construction in the Snake River Basin. It would be helpful if the year in which each Snake River dam began to impact the SAR values could be shown on the time series.

CSS Response: We added the sequence of dam construction to Figures 4.1 and 4.5.

p. 89. SARs for wild A-run steelhead was approximately 40% greater than that for B-run steelhead. To what extent might this be caused by the additional year spent at sea by B-run versus A-run steelhead or to factors related to the smolt stage?

CSS Response: The additional year at sea for B-run steelhead would likely contribute to lower SARs, however the extent is uncertain. Population-specific differences in age, size and timing of juvenile migration may also contribute to SAR differences.

p. 92. Why is it not possible to estimate sockeye SARs in 2010 when no PIT-tagged sockeye were transported (Table B.47)? It seems that a SAR could be calculated though it would represent in-river fish only.

CSS Response: In-river SARs of PIT-tagged hatchery sockeye for 2010 were calculated and presented in Appendix A (Tables A.28 and A.29). In Chapter 4 we have focused on overall SARs, which for Snake River sockeye include both in-river and transported juveniles. In 2010, 33% of the run-at-large juvenile sockeye were transported (FPC 2014); numbers of incidentally transported PIT-tagged sockeye were insufficient to estimate a transport SAR or an overall SAR (LGR-to-GRA).

p. 93. "SARs of John Day and Yakima River wild spring Chinook averaged (geometric mean of ratio; based on BOA returns) 3.4 times and 2.4 times, respectively, those of Snake River wild spring/summer Chinook (Table B.2), and the wild SARs were correlated (average r = 0.73) between regions during the period 2000–2013." This is an interesting finding that indicates much greater mortality for Chinook smolts migrating through the Snake River. Does this differential mortality disappear if SARs are calculated for BON to BOA for all groups, i.e., survival in the ocean only?

CSS Response: The differential mortality does not disappear if SARs are calculated from BON to BOA. We addressed a similar question in the CSS response to the 2013 ISAB review: Assuming juvenile survival for mid-Columbia stocks was 0.80,

> "…the marine survival rate for John Day and Yakima Chinook would be 3.1 times and 2.3 times, respectively, that of Snake River Chinook. Assuming juvenile survival for mid-Columbia stocks was 0.70, the marine survival rate for John Day and Yakima Chinook would be 3.6 times and 2.6 times, respectively, that of Snake River Chinook."

Figure 4.10 caption. How can the release to BON survival be greater than 1.0 (100%)?

CSS Response: Low detection numbers downstream of BON have in some years resulted in wide confidence intervals and, occasionally, release-to-BON point estimates greater than 1.0.

Figure 4.15. This graph indicates SAR of subyearling Chinook is equal to or perhaps greater than that of yearling Chinook. This is surprising given that yearlings have already undergone significant mortality during the previous year. It would be good to address this pattern. Is it related to differences in hatchery and wild Chinook SARs? How were the mixed-stock estimates calculated?

CSS Response: It is not currently possible to compare hatchery and wild Chinook SARs from the Rock Island Dam (RIS) sampling. The hatchery versus wild origin of Chinook (and sockeye) is largely unknown during the PIT-tagging at RIS due to limited adipose clipping of these hatchery stocks.

Figure 4.15. If hatchery and wild steelhead SARs are not correlated, then it may not be appropriate to combine the two stocks. SAR differences by A-run and B-run and by hatchery wild stocks could affect the time trend depending on how the data were analyzed.

CSS Response: We will explore estimating separate SARs for hatchery and wild steelhead for a future report. The vast majority of hatchery steelhead above RIS is marked with an adipose clip, CWT, and/or other visual mark. Steelhead that are PIT-tagged at RIS are coded as 32H or

32W, which means that we could estimate separate overall SARs for hatchery and wild fish in future reports. Sample sizes are generally >1000 per group per year so estimating SARs may not be too much of an issue, particularly since we estimate the SARs from release to BOA. All upper Columbia steelhead groups are classified as A-run.

p. 103. S.oa (survival from BON to BON) declined five- or six-fold after 1970 for spring/summer Chinook and steelhead respectively. To what extent has in-river survival changed between these two periods? Maybe this is the subject of a different chapter, but it would be interesting to compare the shift in survival at sea with changes in in-river survival.

CSS Response: The estimates of in-river survival for the years 1964-1993 (Chinook) and 1964-1996 (steelhead) are available in Tuomikoski et al. (2012, Tables 4.40 and 4.41). Pre-1970 in-river survival rates estimates averaged about 44% for both Chinook and steelhead. CSS analysis indicates that recent values of *S.oa* and SARs are affected by both direct and delayed mortality. Petrosky and Schaller (2010) found that generally, regression model results were similar for SAR and *S.o1* indices. This result provided evidence that river conditions that influence survival rates during seaward migration are also influential after smolts reach the estuary/ocean. Schaller et al. (2014) extended previous studies to elaborate and further test the hypothesis (consistent with recommendations of the ISAB 2007) that increased delayed mortality in the Snake River Chinook salmon populations occurs as a consequence of outmigration through the hydropower system. The SRI regression approach for Snake River populations indicated that reduced survival rates are associated with slower water velocities, multiple powerhouse passages, and a high proportion of transported juvenile fish. These results supported the notion that the outmigration experience results in an accumulation of injuries and stress events and alters estuary arrival timing, which are mechanisms that explain these consistent observations of delayed mortality (Budy et al. 2002; Scheuerell et al. 2009; Marmorek et al. 2011).

Scheuerell, M.D., Zabel, R.W., and Sandford, B.P. 2009. Relating juvenile migration timing and survival to adulthood in two species of threatened Pacific salmon (Oncorhynchus spp.). J. Appl. Ecol. 46: 983–990. doi:10.1111/j.1365-2664. 2009.01693.x.

p. 105. The value of correlating S.oa with S.01 is not clear given that S.01 is calculated assuming 80% survival each year after the first year at sea, rather than as an independent measure of S.01. We encourage the investigators to explore alternative approaches that more directly estimate year-to-year variation in early marine versus late marine mortality.

CSS Response: We removed the reference to correlations between *S.oa* and *S.o1*.

For the upper Columbia stocks, the report compares differential SARs of fish from the upper Columbia versus McNary Dam, as a means to highlight mortality of smolts in the upper reaches. For comparison, what is the mortality in the Snake River Basin, i.e. the upper reaches for those fish?

CSS Response: We summarized LGR-MCN juvenile survival estimates for individual cohorts of wild Chinook and hatchery and wild steelhead for the years 1998 through 2013 (available on FPC web site). This represents the same time frame and a similar length reach as presented for upper Columbia stocks. The geometric mean LGR-MCN survival for wild spring/summer Chinook cohorts was 72% (range 26% to 96%). The geometric mean LGR-MCN survival for wild/hatchery steelhead cohorts was 58% (range 8% to 92%).

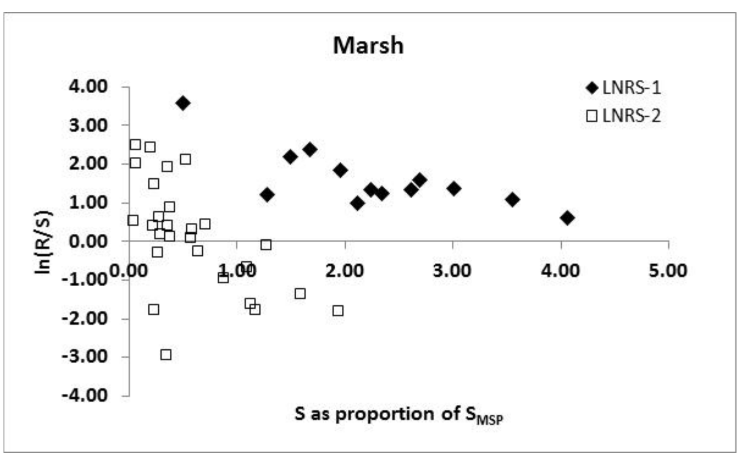
p. 107. The authors state "large declines in life cycle survival rates associated with development and completion of the FCRPS in the 1970s as well as with other environmental change." Does "environmental change" refer to the 1976-77 climate regime shift? It would be useful if the CSS could provide a more thorough evaluation of potential factors related to the declines in the 1970s. For example, have the authors considered other major factors (beyond FCRPS and environmental changes) that may have contributed to declines in the 1970s? For example, there were many major changes in fishery management/regulatory processes that might also be associated with the decline in the 1970s (e.g., U.S. vs. Oregon 1969, increases in mitigation hatchery production in the Columbia River Basin, start of Alaska hatchery programs in 1971, lack of US-Canada harvest quota agreements in the 1970s, Marine Mammal Protection Act 1972, U.S. vs. Washington 1974, and implementation of the Fishery Conservation and Management Act [FCMA] and 200-mile fishery conservation zone 1976).

CSS Response: The environmental change refers primarily to the changes in ocean conditions associated with the 1976–1977 climate regime shift. Potential factors related to this decline were evaluated in Schaller et al. (2014). Ocean factors associated with reduced life cycle survival included warmer ocean (September PDO) and reduced spring upwelling or fall downwelling. Migration conditions associated with reduced life cycle survival included increased number of powerhouse passages and decreased water velocity.

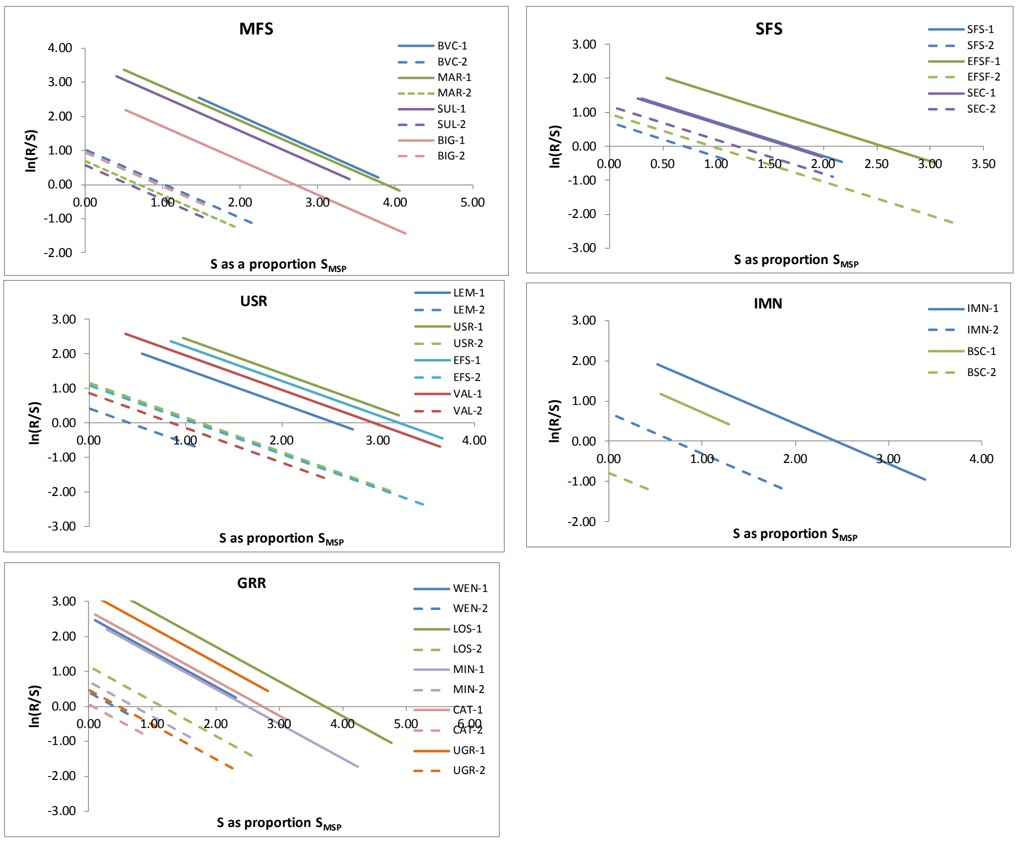
Regarding many of the fishery management/regulatory process changes noted in ISAB comments above, the effect on spring/summer Chinook life cycle survival rates would be minor, because we are estimating pre-harvest recruits as the response. Ocean exploitation of Snake River spring/summer and Columbia River spring Chinook is negligible, estimated at less than 1% based on CWT catch sampling of hatchery stocks (Schaller et al. 2014). While U.S. v. Oregon management directly affects mainstem and terminal harvest rates of these stocks (and thus recruitment to spawning grounds), we account for these harvest rate changes in our calculations of pre-harvest recruits. The Marine Mammal Protection Act might have affected recruitment of Snake and mid-Columbia populations used in these analyses (and salmon populations, generally); we have not attempted to isolate these effects due to a paucity of data. Increases in hatchery mitigation programs potentially might affect pre-harvest recruitment of both Snake and mid-Columbia populations through competition in tributaries or some out-of-basin compensatory mechanism. Schaller et al. (2014) found little evidence that the presence of hatchery spawners in Snake River populations significantly influenced the survival rate patterns compared to populations with few hatchery spawners. In addition, the magnitude and patterns of survival rate change were similar for Middle Fork Salmon populations which had no hatchery influence. Because the hatchery mitigation programs were in direct response to increased impacts of the hydrosystem on survival rates, separating the potential out-of-basin effect of mitigation hatcheries on recruitment may be problematic.

Figure 4.20 is interesting but complicated because the Survival Rate Index (SRI) is correcting recruits per spawner (R/S) for spawner density while also adjusting values relative to the pre-1970 period. It might be informative to show intermediate steps and to plot the recruitment curves for the two periods, so one can see the range in spawners and recruitment associated with the two periods.

CSS Response: Note that the recruitment functions for the two periods were presented in Table 2 of Schaller et al. (2014). We illustrate the relation of ln(R/S) to S (with S scaled to proportion of S_{MSP}) for one of the Snake River populations (Marsh Creek) below. LNRS-1 represents ln(R/S) for the pre-1970 period, and LNRS-2 represents that for the post-1974 period. Although spawner levels were much lower in period 2, the values of S overlapped for the two periods. Observed ln(R/S) values in period 2 were lower than in period 1 for given levels of S.



We present the fitted relations of ln(R/S) versus S from Schaller et al. (2014) for all 18 Snake River populations in the figure below. Populations are arranged by MPG with the range of spawners (scaled as a proportion of S_{MSP}) illustrated for each period. MPGs are Middle Fork Salmon (MFS), South Fork Salmon (SFS), Upper Salmon River (USR) and Grande Ronde/Imnaha (IMN and GRR—plotted separately). All populations demonstrate a lower intercept in period 2, supporting a non-stationary shift in productivity.



Given the relationships shown in Fig. 4.20 and 4.21, how much increase in hydrosystem survival is needed to achieve the SAR target of 4-6% or 4-7% that is associated with restoring productivity to the pre-1970s level?

CSS Response: Increasing SARs will require decreasing both direct and delayed hydrosystem mortality. Simulations performed for the CSS 2013 Workshop (Tuomikoski et al. 2013; Appendix I) indicated that SARs of 4% were expected at in-river survival rates of about 85%. This was generally consistent with empirical observations of SAR and juvenile survival rates for mid-Columbia populations. The CSS anticipates continuing to look at this question in future evaluations. Experimental spill manipulations could provide perturbations to test this response.

p. 110. We agree that it will be useful to update the relationships between SARs and SRI with data after the 2006 migration year. These data will include values with higher SARs.

CSS Response: Updating the SAR and SRI relationship with data from recent years, including some with higher SARs (2008), will also allow exploring the ISAB question about multiple time periods (p. 83/84 ISAB question).

Chapter 5.

Beginning in the caption to Table 5.10 thru 5.12, the authors state "All reach survival estimates are of combined T and R groups." What are the T and R groups? If these are transported and in-river groups then it makes no sense to combine them as the transported should have a vastly higher survival than the in-river. Appendix A indicates what T and R represent, but readers shouldn't have to go there to find these definitions. Please include more information in the legend.

CSS Response: The terms T and R refer to the pre-assignment groups for PIT-tagged Snake River smolts at the time of release. Those pre-assigned in the T group, will be collected for transportation if captured in the bypass during periods when the transportation program is operating. Those fish in R group, will be returned to river if captured in the bypass during transportation operations. Those fish remaining in-river from each of the groups will be used to estimate in-river survival. R group fish will generally always be available for survival estimation. However, T group fish are available under two circumstances: either fish are collected in the bypass during periods when transportation is not occurring—in which case the fish are returned to the river; or transport fish pass one or more of the transport dams undetected. In that case the fish can be used to estimate in-river survival.

p. 163 the authors refer reader to Chapter 4 for methods of TIR and D, which is OK. But at the end of the paragraph they say that "…D values were less than one.." it would be good if they provided a sentence as to what D values mean relative to transported or in-river migrants. They do provide this at the bottom of page 163, but the reader has to guess up to that point.

CSS Response: We added the following sentence to the end of the paragraph on page 163 to reiterate how to interpret D values: "D values significantly less than one indicate higher survival probability for in-river migrants from below Bonneville Dam to adult return to Lower Granite Dam compared to transported fish."

Editorial Comments

The text would be improved by using a more consistent notation referring to between dam movements of fish. Sometimes the document uses "to" (e.g. JDA-to-BOA) and sometimes the "to" is omitted (e.g., JDA-BOA).

CSS Response: The CSS will attempt to standardize notation.

Some of the figures seem to have low resolution (e.g., Figure 4.14). Please ensure that all graphs are created at a sufficiently fine resolution (e.g. 300 dpi+) for inclusion in reports.

CSS Response: The CSS have updated those figures with higher resolution figures.

p. 9. The term "rates" at the end of the first paragraph should be "probabilities"? The CSS made similar changes from the previous draft, but there may be a few places in the report where the old language is still used.

CSS Response: The CSS replaced rates with probabilities in this Chapter where appropriate.

p.10, last sentence. The phrase "the electronics at the dam were used…" needs clarification. There must be a combination of a sensor and some sort of sorting device to route the fish? Perhaps a better choice of wording is needed here.

CSS Response: CSS updated the paragraph to read…

> This 2006 management change coincided with the CSS change in methods that pre-assigned fish to bypass or transport routes, rather than forming transport and in-river cohorts at Snake River collector projects as was done through 2005. The new CSS approach facilitated evaluation of the 2006 change in transportation strategy. Prior to 2006, computers at the dams selected which fish were to be routed to transportation during the out-migration based on order of passage; an example would be one of every four fish detected would be routed to transport. This would occur when the transportation proportion was 0.25 and then every fourth fish was chosen to be transported while the other three were returned to river. The new method randomly pre-assigns the tagged fish to two different study groups prior to their emigration through the hydrosystem.

p. 11. A schematic to show what is described in words about how Group R, Group T and Group CRT fish are determined would be helpful.

CSS Response: R and T group fish are pre-assigned at marking. How those pre-assigned groups get utilized depends on their route of passage at the dams. We added a sentence to the paragraph referred to above that reads as follows: "See Appendix A for a detailed description as well as diagrams showing how R and T group assignments are used in computations." This reference should point readers to the location where figures, descriptions and formulas provide greater detail about the R and T group data are utilized. We think the appendix is the most appropriate place for these detailed descriptions.

Figures 1.2/1.3/1.4/1.5 – These figures are improved from the previous draft. The use of grey scale can lead to difficulties if the resolution of the figures is too low – as noted elsewhere as well.

Please standardize the legend across figures and improve the display when multiple symbols overlap. For example, an open circle is a sockeye release site in Figure 1.4 and 1.5, but is a Chinook release site in Figure 1.2 and 1.3. Some care needs to be taken when multiple symbols are combined. For example, in Figure 1.5, there are many white squares, white circles, and black dot locations which is a sockeye tag site (legend says black square), sockeye release site (legend says black circle), and a steelhead release site (black dot). Does a combined steelhead and sockeye release site have a different symbol?

CSS Response: In Figure 1.5 there is a combined steelhead/sockeye release site at Rock Island Dam in the Columbia River. The symbol for that type of site is a filled triangle. We do appreciate that there are a lot of release sites and species combinations. We try to use the same symbols to represent release sites and mark sites while switching species between figures.

p. 26, lines 28-30. How is the normalization of the environmental time series done?

CSS Response: Where not specifically addressed below, a revised Chapter 2 reflects changes made in response to comments.

Figure 2.1. Add the definition of the abbreviations for the environmental conditions to the figure legend.

Figure 2.3. The figure uses BH (a1,b1), BH (a2,b2), BH(ap,bp). This notation is not used elsewhere. It presumably means a Beverton-Holt relationship as outlined in equation 2.1, but this should be clarified in the legend.

p. 32, lines 6-14 and Equations 2.9-2.12. The parameters mentioned in these lines are not explicitly shown in Figure 2.3 and must be inferred from the definition of x in the Figure, but x in Figure 2.3 only refers to H and T – what happened to R? The left hand side of Equations 2.12 should also have a "hat" on it because it is a function of other estimates.

Table 2.1. Where do the "fixed" values come from for s_2, s_3 and m_1?

CSS Response: The PSC values of the survival parameters were 0.7 and 0.8 respectively for ocean-type Chinook. Since stream-type Chinook were expected to survive at a slightly lower rate, we lowered the rate by 0.1. The majority of the ocean mortality occurs in the first year in the ocean, and since the PSC values don't account for additional mortality during in-river spawning migration, the small reduction likely does not introduce any significant bias. The maturation rate was set to a small fraction roughly consistent with the age class structure of spring/summer Chinook.

p. 35. Some care is needed in describing how the Bayesian Markov Chain Monte Carlo (MCMC) algorithms work. For example, MCMC does not automatically lead to improvements in fit. The Metropolis-Hastings MCMC approach evaluates the ratio of the likelihood x prior at the current and proposed new values and chooses a move probabilistically. So it is possible that on a specific iteration for the fit to actually be worse. It is true, looking at the entire chain, that the MCMC algorithm tends to move towards parameter values that fit the data better than the initial conditions, but this is not true on a particular iteration. Some careful editing is needed on this page.

CSS Response: The intended meaning was that the relative likelihoods affect the probability of accepting or rejecting a new value. This has been amended.

Figure 2.4. The legend refers to the productivity and capacity parameter (generally) – give the actual symbols in the legend used in the model (presumably the a and b parameters)

CSS Response: Figure caption updated with parameter and scale information, but legend would be inconsistent with notation if a and b included.

This figure is very busy, but some units for some of the parameters would be helpful.

p. 39, Lines 1-5. Some of these terms have hats on them or the adjective "predicted" in front of them – consistency in usage may be in order.

p. 44. The units on R-bar are presumably just numbers of fish. Are changes to productivity and capacity simply changes to the a and b parameters in the model – it would be helpful to clarify these points.

CSS Response: These points are clearly stated on page 36 of the draft, but will be reiterated where necessary in the revised Chapter 2.

Figure 2.9. Add units to the axis for productivity (smolts/spawner) and abundance.

p. 47, Lines 34-37: The statement here implies that it would be possible to get a perfect fit to the models with the right data. It is unlikely that a perfect fit would be obtained, even if data from the Grande Ronde/Imnaha MPG were available.

Figure 2.11. Add units to the axis for capacity (spawners) and abundance. Some clarification is needed that capacity refers only to single species and not the aggregate of all species using the watershed.

p. 49, line 13. "…survive fish at a higher rate." Please reword.

Figure 2.12. Units are needed for all axes (see earlier comments on previous figures).

p. 52, line 32 (and elsewhere in this chapter). Some careful editing required because the results obtained are "statistical," so it is difficult to infer causality. Another example is, p.47, l.25 where it is asserted that the PITPH "affects" early ocean survival rather than "is related to" or "strongly related to."

p. 57, l.5. What is meant by "production fish"?

CSS Response: "Production fish" are those fall Chinook salmon that are raised to a subyearling size by hatcheries as part of the Lower Snake River Compensation Plan. We have deleted "production fish" and now state that these fish are subyearling fall Chinook salmon tagged at hatcheries.

p. 57. It may be helpful to add/move the info on the temporal size of the cohorts (e.g. 1-week or 2-week, etc.) to Table 3.1/3.2 to make it easier for the reader to know the temporal size of each cohort.

CSS Response: We have revised Tables 3.1 and 3.2 to include the temporal size of the cohorts (termed the "cohort period").

Table 3.1 and Table 3.2. Shouldn't the captions say "1998-2014" instead of "1998-2013"?

CSS Response: Revised as suggested.

p. 58. In the phrase "observed travel times will be truncated to some degree", would "underestimated" be a clearer substitution for "truncated"?

CSS Response: Revised as suggested.

p. 60, l.34. This link appears to be stale and needs to be updated.

CSS Response: The link has now been updated.

p. 61, l.34. Clarify that "Julian day of release" is related to fish release rather than water release of some sort.

CSS Response: Clarification added.

p. 63, l.25. The phrase "due to the loss of individuals with long travel times," may need some rewording. Does "loss" refer to "mortality" or simply "not counted"?

CSS Response: The phrase has been revised to: "the observed travel times will be underestimated to some degree due to the loss (i.e., mortality) of individuals with long travel times (i.e., those with slower migration speeds)."

p. 64, l.18. Change wording after S_i hat to "both increased and decreased" rather than "either".

CSS Response: Revised as suggested.

Figures 3.2 – 3.4 need y-axis labels and in general the relations between solid dots and circles and the SEs are difficult to read because of the sizes. It seems that the authors are just interested in the general relations, but, if it is important to see the individual relations, perhaps the report could present larger figures in several more pages or use judicious offsetting of fitted and observed values to make the figures easier to read. Captions should read 1998-2014 – please check all other Figure legends as well.

CSS Response: Y-axis labels have been added to Figures 3.2–3.4. We have made adjustments to the margins and axis boundaries to make these figures easier to read.

p. 68, l.38. Are the model coefficients provided somewhere, perhaps in electronic format for the interested reader?

CSS Response: Model coefficients are available upon request.

p.73, l.27. (related to p.52, l.32 comment): Suggest changing wording to "We found some evidence that the increased number of dams with surface passage structures in the spillways may be related to reduced mortality rates" to change wording from causal to relational.

CSS Response: Wording was changed to "For sockeye in the LGR-MCN reach, the increased number of dams with surface passage structures was associated with a reduction in mortality rates."

p.75, l.3. What reach is referred to as "this reach"? The previous sentences talked about several dams so it's unclear.

CSS Response: The sentence has been revised to state that it is referring to the MCN-BON reach.

p. 76. NPCC 2003 missing in reference list.

CSS Response: Reference added.

p. 82. ISAB/ISRP (2008) missing in reference list.

CSS Response: ISAB/ISRP (2008) was changed to ISAB/ISRP (2007).

p. 82. Pacific Salmon Commission (1998) missing in reference list

CSS Response: Reference corrected to PSC (1988) and added to reference list.

p. 77. Change "an SAR" to "A SAR"

CSS Response: Change made.

p. 101. Stiefel et al. (2015) is not in references.

CSS Response: Reference added.

p. 113. What is "S.r"? Is this the same as S_R (in river survival)?

CSS Response: S.r is the same as S_R used in other Chapters.

p. 165. "Finally, overall SARs (LGR to GRA) for wild Snake River subyearling Chinook were less than 1% for all years, when jacks were excluded (Table 5.16)." This should be Figure 5.20.

CSS Response: We fixed the reference. The sentence now ends: "when jacks were excluded (Table 5.20)." Note that Figure 5.20 does not exist as your comment suggested.

VI. References

Independent Scientific Advisory Board. 2015. Density dependence and its implications for fish management and restoration programs in the Columbia River Basin. ISAB Document 2015-1. Northwest Power and Conservation Council, Portland, Oregon: www.nwcouncil.org/fw/isab/isab2015-1

Independent Scientific Advisory Board. 2011. Columbia River Basin food webs: developing a broader scientific foundation for fish and wildlife restoration. ISAB Document 2011-1. Northwest Power and Conservation Council, Portland, Oregon: www.nwcouncil.org/fw/isab/isab2011-1

Kilduff, D.P., E. Di Lorenzo, L. W. Botsford, and S. L. H. Teo. 2015. Changing central Pacific El Niños reduce stability of North American salmon survival rates. PNAS 112 (35): 10962–10966

Miller J.A., D.J. Teel, W.T. Peterson, A.M. Baptista. 2014. Assessing the relative importance of local and regional processes on the survival of a threatened salmon population. PLoS ONE 9(6): e99814. doi:10.1371/journal.pone.0099814