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04 April 2008

Re: Comments on the NWPCC Amendment Process

Dear Council Members & Staff:

As Council begins their debate on amending the Fish & Wildlife program, I would like to specifically request that Council explicitly consider the importance of ocean survival to the management and conservation of Columbia River salmon stocks, *including their role in freshwater management*. My reasons are simple: it is my belief that many ocean impacts on salmon stocks have been wrongly mis-identified as being due to freshwater factors, which has resulted in significant distortions to salmon management and conservation programs coast-wide. In at least some cases remedial actions advocated in freshwater may in fact be hurting rather than help salmon conservation efforts. I expand on these points below.

The call to comment on the amendment process comes at an important time, with ocean processes being identified as part of the cause of the dramatic decline in abundance of many salmon stocks coast-wide, including (most recently) the closure of the California salmon fishery in 2008. In addition, the coast-wide decline in eulachon (smelt) stocks and apparently similar declines in abundance of lamprey highlight the need to clearly delineate the impacts on anadromous fish stocks of both freshwater and ocean factors; otherwise the Council's best efforts to recover Columbia R salmon stocks may be inefficient or unsuccessful.

These changes in fortune for anadromous fish stocks all have as important features the possibility that ocean climate changes play a large and possibly dominant role, and that sharp declines in abundance can come about even without hydropower systems in operation. The United States Congress was thus quite prescient in it's earlier dictate that the effect of ocean conditions on the recovery of Pacific salmon in the Columbia River should be considered when the (then) Northwest Power Planning Council made its project recommendations to BPA[1].

Our comments below should not be construed as intending to downplay the need to protect and improve freshwater habitat where possible, but should be taken as emphasizing the need to recognize that the major limiting factors to salmon abundance may actually be in the ocean, not freshwater, as was thought true for many years. There is still great uncertainty about why the declines in ocean survival have occurred, and the

[1] Bisbal,GA; McConnaha,WE (1998): Consideration of ocean conditions in the management of Pacific salmon. Canadian Journal of Fisheries and Aquatic Sciences 55, 2178-2186.

contributory role that multiple factors play is as yet unclear. However, I believe that real progress in salmon conservation and restoration will not occur until many of these factors can be clearly and precisely delineated. Hatchery programs, disease, pesticides & nutrient inputs from land, ocean net pen rearing of salmon (aquaculture), and changes in the marine abundance of predators and prey of salmon are all likely of some importance, but as yet we cannot say which are of greatest importance.

As Council is aware, Kintama Research has been pursuing the development and construction of an acoustic array that can measure the movements and survival of salmon stocks in both freshwater and the ocean. When complete, the array will also allow the unambiguous discrimination between mortality occurring in freshwater and mortality that occurs later, during the marine phase, as well as provide the ability to conduct direct scientific tests of critical theories such as Schaller *et al*'s theory[2,3] that the hydrosystem causes delayed mortality that is only expressed in the ocean or lower river. Several papers have now been submitted by Kintama and our colleagues to peer-reviewed primary journals or will be in the next few months on these issues. In this submission, I shall simply summarize the key findings from the 2006 study to highlight the importance of the ocean to the Council's mandate. (Results from the 2007 study are still in preparation).

A. Measuring Time to Exit the Hydropower System

A striking omission in much of the Columbia R research & monitoring efforts involves the failure to account for the amount of time that smolts are observed within the hydropower system. Typically, survival measured using the PIT tag system is simply measured to Bonneville Dam and is not scaled by the time the smolts took to reach there. For example, 2006 was reported as the second highest flow year on record, and one with "better than average" survival. On the face of it, increased flows therefore promote better survival, and such conclusions are widely drawn and reported in the Columbia region. However, these observations fail to make the critical next step that in high flow years reduced time spent migrating through the hydrosystem means more time spent in the environments below Bonneville—the lower river and ocean.

Technically, it only makes sense to conclude that survival to Bonneville is better in high flow years either if survival below the hydrosystem is perfect (so that smolts moved out of the hydrosystem faster don't subsequently encounter additional mortality) or if survival is scaled by the time that the smolts are observed in different years. As a rough example, our 2006 tagged Snake R spring Chinook smolts reached Bonneville Dam in slightly over 2 weeks[4], about half the time expected from prior year's experience using

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2 Schaller, H. A., C. E. Petrosky and O. P. Langness (1999). Contrasting patterns of productivity and survival rates for stream-type chinook salmon (*Oncorhynchus tshawytscha*) populations of the Snake and Columbia rivers. Canadian Journal of Fisheries and Aquatic Sciences 56: 1031-1045.

3 Petrosky, C. E., H. A. Schaller and P. Budy (2001). Productivity and survival rate trends in the freshwater spawning and rearing stage of Snake River chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 58: 1196-1207.

4 *In 2006, Kintama's releases of two groups of tagged Snake R spring Chinook smolts reached Bonneville dam from the Kooskia fish hatchery in 20 and 14 days.*

PIT tags. So, although survival in 2006 was somewhat better than in other years—and was widely reported as such—if survival in 2006 was scaled by the much briefer time the fish spent in the hydrosystem, one may conclude that survival scaled by time was worse in high flow years!

My point here is not to argue that this latter conclusion is necessarily true, as this should be done using all years of data available, but rather to make the case that the widespread tendency to concentrate on absolute survival measurements and to ignore the varying amounts of time that animals spend in the hydrosystem in different flow years (or from different release points) can lead to potentially serious policy errors:

(1) By assuming that higher flow necessarily helps salmon survival;

(2) By assuming that smolts moved out of the hydrosystem and into the ocean faster (e.g., by transport or by river drawdown to minimum operating pool levels) necessarily results in lower mortality rates being experienced in the other environment.

(3) By assuming that the additional mortality incurred by smolts that migrate farther in-river to PIT tag monitoring sites (and thus are exposed to mortality agents for a longer period of time) is not also experienced in the ocean by smolts that migrate shorter distances, and thus leave the hydrosystem more rapidly..

B. Survival Below Bonneville Dam (Estuary & Ocean)

Relative Survival: in-Hydrosystem, below Hydrosystem, and Ocean

It is often assumed in the Columbia R region that survival is lowest during migration down the hydropower system and higher "below Bonneville". As a consequence of this assumption, large-scale transport (barging) of salmon smolts was initiated to bypass the dams and to speed the movement of smolts to the sea, but with rather mixed results. The failure to realize much of the projected gains from transport has been variously ascribed to transport-related stress causing higher mortality after release, disoriented smolts becoming easy prey for predators soon after release, or rapid transportation down the river which places them into the ocean before they are ready to adapt to seawater.

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An alternative view is possible; however, namely that *for smolts of a given size*, survival rates outside the hydrosystem may be similar to survival experienced while migrating through the hydropower system.

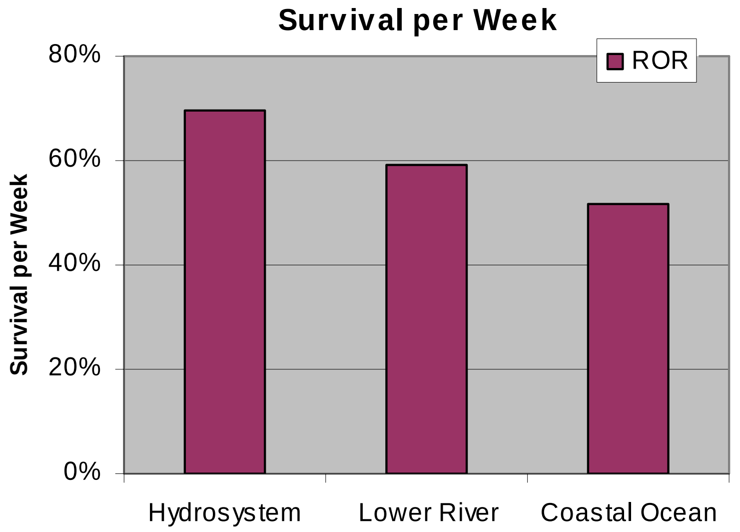

Figure 1. Survival per week of migration time in three environments. Results are based on the 2006 releases of Snake R spring Chinook over the POST array.

An unspoken assumption in many of the efforts to protect and rebuild endangered salmon stocks is that survival below Bonneville must be better than in the hydrosystem, but this has never been formally assessed. Our 2006 results found that survival per week of life for Snake R spring Chinook smolts was highest in the hydrosystem, lower in the lower river, and lowest in the ocean (Fig. 1). (Initial size at release had no consistent influence on survival over the size range examined (≥140 mm), which corresponds to roughly the upper half of the size distribution). Although we caution that our 2006 survival results are based on two release groups of 200 POST-tagged smolts each, they demonstrate that survival is not necessarily higher once smolts are past the hydropower system.

If correct, this result has profound implications for the management and conservation of Columbia R salmon:

(1) Transportation (barging) of salmon may expose smolts to a higher mortality environment (the ocean) for a longer period of time than if they migrated through the hydropower system;

(2) The operation of the hydrosystem may play relatively little role in determining the poor returns of adult salmon (something already fairly clear, given that 1 in 2 Snake River spring Chinook survives to reach Bonneville Dam, but only 1 in 100 of the survivors reaching Bonneville returned from the ocean in the 1990s).

(3) Less obviously, if there is a shifting window of time that the ocean is conducive to smolt entry, then natural selection may be (a) strongly selecting for smolts with either different run timings or (in the case of fall Chinook) (b) may be strongly selecting against ocean entry during the first year, and thus selecting for fish that hold over for a full year and enter the ocean as yearling smolts, delaying exposure to ocean mortality agents.

C. Delayed (Latent) Mortality

Virtually every aspect of Columbia R salmon management is potentially affected by the widely held belief that delayed (or latent) mortality occurs after salmon smolts leave the hydrosystem[2,3]. This theory is of critical importance in the Columbia (e.g., see the ISAB 2007 report[5], which reviews the issue). Unfortunately, it is also impossible to disprove the theory that greater dam passage (and especially Snake River dam passage) increases salmon mortality after migration past the hydrosystem if only the freshwater component of the life history is studied., because it can always be argued that delayed mortality does occur, but just after whatever was the last studied point in the river! In order to definitively establish if delayed mortality due to the dams really does exist, we must also study the marine phase because it is plausible that delayed mortality is only expressed after migration into full-strength seawater. The alternative hypothesis that different stocks of salmon have different SARS because of their ocean life history is crucially important to Columbia River salmon management because this could be the reason for the poor survival of Snake R salmon stocks rather than the Snake R dams.

For example, if Snake R spring Chinook do not show different survival rates to the mouth of the Columbia River when compared with other stocks that have higher smolt to adult return rates, then it can still be argued that delayed mortality due to the dams does occur, but just beyond the last point of measurement—perhaps because of difficulty adjusting to seawater just beyond the Columbia R plume (a comparatively low salinity environment). If work on the plume environment was initiated to study whether survival differed there, then ultimately if no evidence was found to support delayed mortality from the dams occurring in the plume, the next logical argument would be that delayed mortality due to the dams is expressed, but only once the smolts leave the dilute plume environment for full strength seawater. And so it would go—unless a proper observation system is put in place to measure survival at places too distant from the river in time and space for delayed mortality to be a credible explanation for the elevated mortality that clearly occurs before adult return.

Our work, measuring survival of Yakima versus Snake R spring Chinook smolts down the Columbia R and up the coast found no difference in survival as far along the coast as the northern tip of Vancouver Island. (Survival rates to the Willapa Bay line just north of the Columbia River were 28±7% for both stocks, inconsistent with the five-fold difference in historical SARs; survival estimates to the northern tip of Vancouver Island (reached one month after release) and then to SE Alaska (reached two months after release) also favoured better survival of Snake R smolts, although the numbers remaining were too low to allow strong statistical conclusions[6,7]). If this work is validated, it will

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[5] I. S. A. B. (2007). Latent Mortality Report. Review of Hypotheses and Causative Factors Contributing to Latent Mortality and their Likely Relevance to the "Below Bonneville" Component of the COMPASS Model. Portland, Oregon. , Northwest Power and Conservation Council.: 28p.

[6] Welch, D.W. 2007. "Pacific Ocean Shelf Tracking (POST) Project; Results from the Acoustic Tracking Study on Survival of Columbia River Salmon", 2005-2006 Annual Report,

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provide a direct demonstration of the need to measure survival well beyond freshwater[8] in order to resolve a long-standing policy conundrum concerning the role of the Snake R dams in determining the conservation status of Snake R salmon.

D. Survival Through the Hydrosystem—Comparison with the Fraser River

Effect of the Dams on Smolt Survival.

Our early results using components of the POST array suggest that survival ***per week of time*** is highest during migration in the hydrosystem, poorer in the lower river ("Below Bonneville"), and poorest during the initial coastal migration up to Vancouver Island. Although the number of tagged fish surviving to reach Vancouver Island from release in the Snake and Yakima Rivers was low (i.e. the uncertainty about mortality rates in the ocean is higher than in freshwater), the results raise important questions about the conventional wisdom that moving smolts out of the hydrosystem rapidly (whether by barging or increased river flow) will increase adult returns.

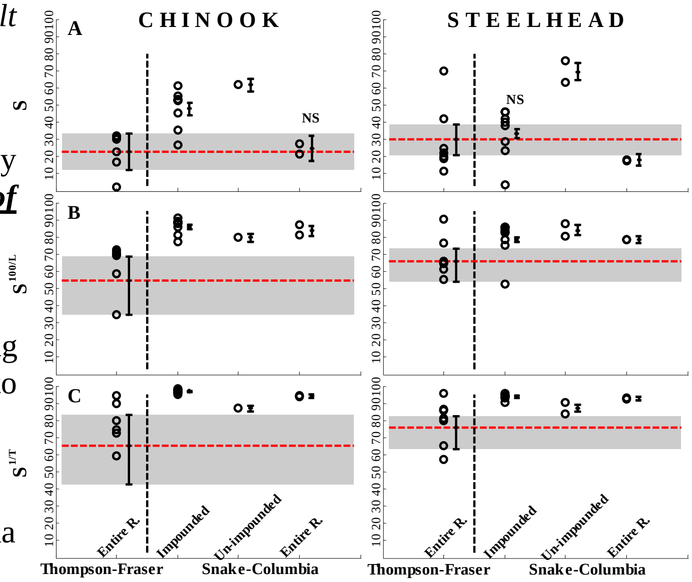

Figure 2. Annual survival estimates (%) for Thompson & Snake R spring Chinook and steelhead. (A) Estimated survival. (B) Survival scaled per 100 kilometers traveled, S100/L. (C) Survival scaled per migration day, S1/T. To the left of the vertical dashed line survival of migrating Fraser R stocks is shown; to the right Snake R stocks migrating down three sections of the Columbia River are shown: Impounded (upper river; 8 dams), Un-impounded (lower river; undammed), and Entire river. Horizontal line and surrounding band show Fraser R survival and 95% confidence interval, averaged across all available data

More importantly, when all survival measurements using acoustic tags in the Columbia R are compared with similarly made survival estimates in the Fraser using the Fraser R components of the

Project No. 00311400, 98 electronic pages, (BPA Report DOE/BP-00021107-1), Available at: http://www.efw.bpa.gov/Publications/H00021107-1.pdf

7 Rechisky, E.L., D.W. Welch, A.D. Porter, M.C. Jacobs, A. Ladouceur, C.J. Walters. (In Prep). Experimental measurement of differential mortality in Columbia River spring Chinook salmon using a large-scale acoustic array, POST. (To be submitted to the Proceedings of the National Academy of Sciences in April 2008).

8 Salmon travelled from Bonneville Dam to Willapa Bay, 274 km distant, at a speed of about 60 km/day, indicating that the smolts spent very little time in either the lower river or plume environments.

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POST array, survival rates to the mouth of the two rivers are similar, and ***higher*** in the Columbia-Snake R when scaled to compare survival per week of travel or per hundred kilometres of migration[9]. Although this latter measurement is a comparison of freshwater mortality in two rivers, the key point here is that—as with the comparison above and below Bonneville—a broader perspective on mortality is clearly useful in the debate on the appropriate conservation policy for Columbia R salmon smolts. Our results suggest that survival during migration through the hydrosystem may be higher than in either the lower Columbia R, out at sea, or in the Fraser R.

Summary

With survival from the start of smolt migration to adult return as low as 0.5% for some Columbia River salmon stocks during the 1990s, the collective results summarized above point to the survival problem as occurring more in the ocean than as a result of the operation of the hydropower system. We are not claiming that our initial results using this early "Mark I" version of the POST array definitely resolve these long-standing and important policy issues, but they do demonstrate that a broader perspective on the role of the ocean in Columbia R salmon conservation is called for.

There are many important policy questions whose effectiveness is directly tied to questions of measuring relative salmon survival in both the ocean and freshwater; I conclude by re-iterating some of them here:

1) **Is survival in the ocean higher or lower than survival in the hydrosystem, for smolts of a given size?**

    a. If survival is poorer in the ocean, then expensive transportation programs may not be effective in attaining their intended goal of boosting adult returns.

    b. If survival is poorer in the ocean, then arguments that reducing reservoir levels to minimum operating pool levels to speed smolt migration rates may not be effective.

2) **Is freshwater survival in the Columbia hydrosystem significantly reduced by the presence of dams relative to either other river systems (e.g. the Fraser) or the lower Columbia, both of which lack dams?**

    a. If not, then hydropower and salmon conservation may not be as incompatible as had previously been thought.

[9] Welch, D.W., E.L. Rechisky, M. Melnychuk, A.D. Porter, C.J. Walters, C. Schreck, S. Clements, B.J. Clemens, and R.S.McKinley. (Submitted). "Survival of Migrating Salmon Smolts in Large Rivers With and Without Dams". PLoS Biology

b. If not, then further efforts to improve salmon survival at the dams may realize little benefit—but cost a great deal because of diminishing returns.

c. If not, then the impact on survival of other factors (such as predators) needs to be better assessed, requiring a clear understanding of where and when this mortality occurs.

3) Are there periods of time when ocean survival is better?

a. If the timing of plankton blooms or predator presence is changing because of climate change, then strong natural selection may be occurring to select for different run-timing characteristics than in the past.

b. If survival is better at certain times in the ocean, then salmon returns might be boosted by transport and hatchery release programs keyed to release smolts at that time (or, more radically, by modifying rearing strategies and changing the genetic make-up of the fish) to have smolts reach the ocean at the most favourable times.

A final comment: If survival is now worse in the ocean than formerly, and some time periods for ocean entry have better survival than others, then there should be strong natural selection operating to select against salmon behaviours that on evolutionary time scales were formerly beneficial. Simply put, historical behaviours that served salmon well may now be seriously mal-adaptive under the much poorer ocean survival seen for many stocks of salmon coast-wide. For example, the large-scale shift in Columbia R fall Chinook to a life history where many of the smolts remain in freshwater for an entire year may reflect strong selection against the formerly dominant behaviour of entering the ocean soon after hatching as sub-yearlings—because entering the ocean may significantly reduce the chances of surviving to spawn. If this theory is correct, then the large-scale climate changes affecting salmon survival in the ocean will have profound impacts on the genetic structure and behaviour of many salmon stocks.

Sincerely,

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