Independent Scientific Advisory Board
for the Northwest Power and Conservation Council,
Columbia River Basin Indian Tribes,
and NOAA Fisheries
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Dr. Richard Whitney will present the ISAB's recommendation to study the effects of load following on juvenile salmon migratory behavior and survival as described in the ISAB's memo attached below.

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April 29, 2005

To: Melinda Eden, Chair, Northwest Power and Conservation Council
Olney Patt, Jr., Executive Director, Columbia River Inter-Tribal Fish Commission
Usha Varanasi, Director, NOAA-Fisheries Northwest Fisheries Science Center
D. Robert Lohn, Regional Administrator, NOAA Fisheries

From: Eric J. Loudenslager, Chair, Independent Scientific Advisory Board

Re: Recommendation to Study Effects of Load Following on Juvenile Salmon Migratory Behavior and Survival

The ISAB recommends to the Council, NOAA Fisheries, and CRITFC that during 2005 there be a study of the effects of load following (flow interruption) on survival of outmigrant smolts in the Snake River and perhaps the lower Columbia River. We understand that there is a new Biological Opinion (BiOp) that bears on flow management, that this new BiOp is being challenged in court, and that there is a specific legal challenge seeking an injunction to increase flow in the Lower Snake River. Any or all of these may constrain the ability to manage flow during the period of outmigration of salmonid smolts this year. Nevertheless, 2005 presents an opportunity to answer critical questions concerning the effects of *flow interruption*, brought about by load following by the hydrosystem, on survival of migrating juvenile chinook and steelhead during extreme low flow conditions. This critical question is not explicitly discussed in the BiOp or the present challenges to it. The prospects for "no spill" this summer would simplify the design of the experiment. We are sorry that our recommendation comes so late in the season. The timeliness of inspiration cannot always be regulated. Although it is probably too late to include spring chinook and steelhead in the study, and estimating survival of fall chinook with sufficient precision to detect an effect of load flow interruption may be problematic, nevertheless the study should proceed, at least as a pilot study. At the very least it will provide useful information on whether flow fluctuations do or do not affect migratory behavior.

The ISAB views the question of fish survival during exceptionally low flow years as an important one. Although managers tend to think of extreme drought years as climatic anomalies that occur infrequently, recent evidence suggests that drought years tend to be somewhat clustered and that multiple low-flow years can occur over a short time period. Gedalof et al. (2004), using tree ring data to model Columbia River flows, concluded that

low flow episodes have happened a number of times since 1750. The following figure from their paper illustrates the distribution of drought years.

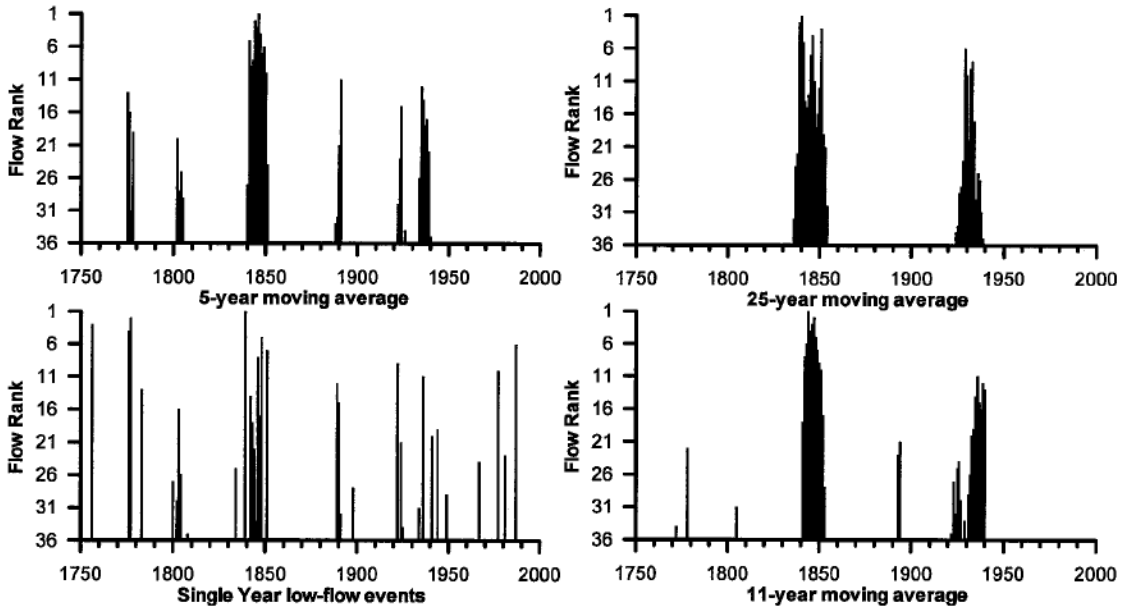

Figure 5. The Distribution of n-Year Moving Average Mean Flow for the Lowest 15th Percentile Over the Period of Reconstruction. Low rankings are indicated by longer bars, and represent lower flow events.

As these authors point out, the period 1950-1987 is unusual in the context of this flow record in having no multi-year drought events. Yet the Columbia River experienced a severe drought in 2001 and is apparently experiencing another in 2005. If we are entering a period of drought-prone years (especially one as severe as in 1835-1850), the issue of migrant survival during exceptionally low flows, with and without load following, becomes particularly important.

The neglected question, which could be addressed in this experiment, is whether low in-river survival rates and migration speeds often observed during extreme low flow conditions are in large part a consequence of abnormal cycles of flow interruption (and possible within-pool flow reversal) induced by load following at the dams, or a consequence of low flow itself (other effects such as temperature and season aside). The essential hypothesis justifying the experiment is that a pattern of relatively constant low flow would prove less damaging to in-river survival rate and migration speed than would the pattern of load following imposed on the same average flow. This issue was most recently discussed in the ISAB's report, *Review of Flow Augmentation: Update and Clarification* (ISAB 2003-1), which was an examination of flow augmentation. More detailed information is given there. The essential design of the experiment would involve temporal switching from "treatment" flow management (load following) to "control" flow management (constant flow with the same average flow), and back, at intervals of time that are long enough to satisfy the requirements of the fish marking method identified as being most likely to produce the "best" survival estimates. PIT tags and radio tags are the two marking technologies that we know are available. The choice of

method for the existing circumstances would best be selected by agreement among the contractors presently engaged in studies in the Snake and Columbia rivers that could be modified to collect the relevant data. Information we have available at this time suggests that radio tagging would be most likely to produce the desired results this year. We discuss this suggestion further below.

The essential design issues are:

1. Obtaining a good enough match between "treatment" time blocks and "control" time blocks so that extraneous environmental factors (other than the treatment with load following or the control with stable flows) that might operate differently at those times do not confound the results. Possible confounding factors include temperature, turbidity, average flow, smoltification status, and condition of the released fish. The match (and the effects of mismatch) will be affected by the choice of the time period for the experiment and the number of treatment/control pairs that can be established.
2. Providing a large enough sample size of releases to allow survival rates and migration speed estimates to be made with sufficient precision from the recoveries so that the treatment effect can be resolved against the noise of sampling variation and the possible effects of confounding factors (time block effects).

Existing information about survival rates, migration rates, detection rates, and the variation in these rates should be adequate for arriving at a design with useful anticipated statistical performance (power). It would not be worthwhile to proceed with an expensive experiment bearing on a possibly controversial management issue, unless the design shows prospects for delivering reasonably conclusive results.

The goal of the experiment is to obtain data that would inform the region whether flow interruption substantially affects survival or migration behavior of tagged smolts migrating in the river(s). The study objectives would include description of behavior and if feasible estimation of relative survival of tagged groups of hatchery chinook and/or steelhead: 1) with flow interruption and 2) without flow interruption. We assume that hatchery fall chinook during summer would be the best test fish and time period for the study this year. Prediction of the effects on wild populations would only require the assumption that the relative rates estimated for the two tagged groups are approximately the same. If the hypothesis is correct, the experiment would benefit all in-river migrants, including any wild fish migrating in-river. The design we outline does not specifically attempt to generate estimates for unmarked fish migrating in river. Carrying out the experiment should not raise any ESA issues.

We suggest the design use fixed alternating periods (e.g., with a length of one week), following a random start to avoid the possibility of clumping of particular test or control groups at the beginning or end of the study. This would take into account, insofar as possible the known fact that survival shows a trend with time due to temperature and other factors, including degree of smoltification, turbidity, and volume of flow.

Although PIT tagged fish might be used to estimate survival, there is a possible complication in that as a batch of test fish moves through the hydrosystem they tend to migrate at different rates. This is particularly true for fall chinook. Thus, the PIT tagged fish in a batch may not all be subject to the same treatment or control. We suggest using radio tags for the survival estimates, because their use would make it possible to regroup the fish into treatment and control groups based upon their known locations through the study period. In any case, the information provided on their migration routes will indicate whether there is an effect of the different flow conditions.

We understand that NOAA Fisheries, the USFWS and NPT will be conducting a transportation study in the Snake River and will be making weekly survival estimates through the period of outmigration, using recoveries of PIT tagged fish at detectors located at the dams. These estimates may be useful as is, but NOAA Fisheries scientists should be consulted. In addition, we understand that other agency employees will be conducting radiotracking studies of juvenile salmonids during the migration period. It would be necessary to bring key agency scientists together to formulate and approve an appropriate study design. We foresee little additional costs associated with this study beyond existing budgets, except in two areas: 1. Responsibility for submitting to the Council a written study design, and a completion report providing an analysis of results should be assigned to one or more of the participating agencies; 2. Monitoring of flows between the dams included within the study reach should be done with the objective of detecting any unusual effects of flow interruption on downstream movement of the river, such as the seiches observed in the ISAB 2003-1 report. We know of no existing study that might add this to their list of tasks, so a new project might need to be established.

We have thought of the Lower Snake River as a logical location for this test. The four lower Snake River hydropower projects are operated more or less as a unit because of their limited storage capacity combined with limitations of fluctuations in reservoir elevations specified in the BiOp. That being the case, to accomplish the study objectives in that reach would require close cooperation of Idaho Power Company in the operations of the Hells Canyon complex to provide storage and release of water according to the schedule in the study design.

Action Steps:

1. Assign agency personnel currently involved in survival or behavior studies of juvenile salmonids the task of developing a detailed study plan to accomplish the objective of measuring the effect of flow fluctuations associated with hydrosystem load following.
2. Commence discussions with the hydrosystem operators to develop a schedule for load following alternating with no load following to fit the study design.
3. Fund a project to monitor hydraulic conditions in the reservoirs for the purpose of detecting any unusual patterns of flow that might result from flow fluctuations due to load following.
4. Fund, if necessary, a project specifically designed to coordinate the collection of necessary data and to provide a summary report focused upon the question whether flow fluctuations affect survival, and if so to what degree.

References Cited

Gedalof, Z., D. L. Peterson, and N. J. Mantua. 2004. Columbia River flow and drought since 1750. Journal of the American Water Resources Association, December 2004:1-14.

ISAB 2003. Independent Scientific Advisory Board. (11 members). Review of Flow Augmentation: Update and Clarification. Report to the Northwest Power Planning Council, Portland, OR. ISAB 2003-1, February 10, 2003. 69 pp. www.nwcouncil.org/library/isab/isab2003-1.htm

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