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**UNITED STATES DISTRICT COURT  
FOR THE DISTRICT OF OREGON**

NATIONAL WILDLIFE FEDERATION, et. al.,  
Plaintiffs,  
And State of Oregon, Intervenor Plaintiff  
v.

NATIONAL MARINE FISHERIES SERVICE  
and  
UNITED STATES ARMY CORPS OF  
ENGINEERS

Defendant,

and

NORTHWEST IRRIGATION UTILITIES,  
PUBLIC POWER COUNCIL, WASHINGTON  
STATE FARM BUREAU FEDERATION,  
FRANKLIN COUNTY FARM BUREAU  
FEDERATION, GRANT COUNTY FARM  
BUREAU FEDERATION, and INLAND PORTS  
AND NAVIGATION GROUP,

Intervenor-Defendants.

Civ. No. CV 01-640-RE (Lead Case)  
Civ. No. CV 05-23-RE  
(Consolidated Cases)

**DECLARATION OF  
ROBERT HEINITH  
(Summary Judgment Reply)**

I, ROBERT HEINITH, STATE AND DECLARE AS FOLLOWS:

1. My name is Robert Heinith. My declaration responds to and discusses several exhibits submitted to the record by the Defendant Intervenor (Consolidated Plaintiffs) Irrigation

Associations and the summary judgment reply declaration of Dr. James J. Anderson on behalf of the Defendant- Intervenors BPA Customer Group.

### QUALIFICATIONS

2. I am the Hydro Program Coordinator with the Columbia River Inter-Tribal Fish Commission (“CRITFC”). CRITFC is comprised of the elected and appointed officials of the Yakama Nation, the Nez Perce Tribe, the Confederated Tribes of the Warm Springs Reservation of Oregon and the Confederated Tribes of the Umatilla Indian Reservation.

3. I hold a B.S. in Fishery Biology from Colorado State University and an M.A. in Integrated Science from Western Oregon State College/Oregon State University. Upon receiving my master’s degree in 1987, I was employed by the Confederated Tribes of the Warm Spring Reservation of Oregon as a fisheries habitat biologist. Prior to joining CRITFC, I was employed by the Point-No-Point Treaty Council as a fisheries biologist. During my 18-month tenure with the Treaty Council, my principal responsibilities involved salmon-related impacts of three major and one minor Federal Energy Regulatory Commission (FERC) licensed hydroprojects in northwest Washington. In 1995-1997 I was employed as a consultant for the Canadian Columbia River Intertribal Fisheries Commission for which I provided technical advice on international salmon passage and habitat issues.

4. Since January 1991, I have been employed by CRITFC as a salmon biologist with primary responsibilities directed toward improving fish passage and habitat impacted by federal and private hydroprojects throughout the Columbia Basin. My responsibilities in this position include assignments to the Mid-Columbia Coordinating Committees under the Federal Energy Regulatory Commission and the Fish Passage Advisory Committee of the Columbia Basin Fish and Wildlife Authority. I also participate in various groups and activities associated with the

Adaptive Management Process established by the National Marine Fisheries Service (now NOAA Fisheries) to address implementation of operational and structural measures to protect Columbia and Snake River salmon during migration down these rivers and past the projects of the Federal Columbia River Hydropower System (FCRPS). These groups include tribal, state, and federal representatives and were established by the National Marine Fisheries Service's Adaptive Management Process to address implementation of operational and structural measures to protect Columbia and Snake River salmon during migration down these Rivers and past the projects of the Federal Columbia River Hydropower System (FCRPS). I have represented CRITFC on the Technical Management Team, the Implementation Team, and the System Configuration Team. I have also been the project manager of a cooperative tribal, federal and state fishery agency effort to quantify juvenile fall chinook losses in the Hanford Reach from hydropower induced flow fluctuations.

5. In my official capacity, I have reviewed and provided technical comments for the State, Federal and Tribal Fishery Agencies Joint Technical Staff and CRITFC on: 1) the 2004 Biological Opinion on Operation of the Federal Columbia River Power System including the 19 Bureau of Reclamation Projects in the Basin ("2004 BiOp"); the Updated Proposed Action ("UPA") prepared by the U.S. Army Corps of Engineers, Bureau of Reclamation and Bonneville Power Administration and related documents. I have also reviewed the Second Declaration of James L. Buchal with Exhibits and the Declaration of James J. Anderson in support of the Defendant-Intervenors BPA Customer Group's Response to Motion for Summary Judgment.

## DISCUSSION

6. Mr. Buchal's Declaration contains eight exhibits. I will respond to Exhibits 1-3 and Exhibit 6 in order. As I discuss below, the exhibits introduced with Mr. Buchel's

Declaration and relied upon by the Irrigator's Association either (a) consist of relatively old studies that have been reviewed and discredited by fish managers or (b) are studies that have not been reviewed by fish managers but contain fundamental errors. My review is offered to assist the court understand the technical and complex subject matter at hand and determine the weight of the information that has been offered.

7. **Exhibit 1. Survival of Marked Juvenile Chinook and Steelhead Migrants in the Columbia Basin by William J. McNeil, Ph.D for Direct Services Industries. December 10, 1994.** This report, which is over ten years old, attempts to quantify the survival per kilometer for migrating wild and hatchery juvenile salmon. The report's premise is that there is not much of a survival difference between a river with dams and reservoirs and a river without dams and reservoirs. There are several major flaws in this report. In 1992, both Dr. Philip Mundy of CRITFC and the Fish Passage Center identified these flaws and criticized Dr. McNeil's approach in a similar study (*see* NPPC Minutes of Dr. Mundy's Review of Dr. McNeil's work (Attachment 1 to this declaration));(Fish Passage Center Comments, 1992 (Attachment 2 to this declaration)). The same flaws exist in the 1994 study and cause Dr. McNeil's analysis to be seriously flawed:

A) Dr. McNeil utilized data that are over a decade old and largely based upon freeze brand marking methodologies which are no longer utilized because of their technical limitations and limited utility. The data base for the analysis contains different mark groups from different river reaches, different tagging sources consisting of hatchery and run-of-river fish, marked at traps and dams, and over several decades.

B) Dr. McNeil chose to disregard important variables influencing survival in the data set, and failed to recognize and account for the fact that individual stocks react differently to

environmental variables, e.g. location of origin. His simplistic conversion and combination of the available reach survival estimates to “per-mile” survival while disregarding the salient driving factors is illogical and erroneous and manifest into invalid conclusions.

C) Dr. McNeil primarily utilizes hatchery release groups to draw conclusions about survival-per-mile in partially inundated river reaches relative to run-of-river fish in more inundated river reaches. Dr. McNeil erroneously draws conclusions that the survival from these direct-from-hatchery releases is representative of run-at-large survival in river reaches with minimally inundated waters. Significant losses of fish have been consistently observed upon direct releases from hatchery into the natural environment; failure to account for these losses results in reach survival estimates that are biased low.

D) Dr. McNeil fails to account for significant temporal effects such as increase rate of travel with progression downstream, and for the fact that downstream groups represent a group that has been “high-graded”, with weaker individuals removed from the group by previous passage and mortality through the hydrosystem.

**8. Exhibits 2 and 3. Inter-Basin Comparison Study. Columbia River Salmon Production Compared to Other West Coast Production Areas. Phase II Analysis. D. Olsen and J.Richards. Sponsored by the U.S. Army Corps of Engineers. October 1994 (Exhibit 2), and Pacific Northwest Project Working Paper 1.1 West Coast Salmon Production Trends (Working Paper). D. Olsen March 7, 2005 (Exhibit 3).** CRITFC responded to Phase I of the Exhibit 2 report in 1994. Phase II (Exhibit 2) and Exhibit 3 (a March 2005 working paper) carry over many of the methodological and other flaws contained in the Phase I report that CRITFC responded to. As CRITFC noted in its comments regarding the Phase I report, the Inter-Basin Comparison Study proposed to examine inter-basin differences in production, but did not

compute or use production of any stock or basin. The analysis was simply based on comparisons of escapement and catch data readily available from the two compilations cited. Although the Phase I efforts were to focus on "data collection," it did not appear that any additional effort was directed at data collection, compilation, or computation beyond copying these two existing reports. The second objective of Phase I of the study was to complete an initial analysis of production trends, but as stated above, no production data was presented. The usefulness of their analysis appeared limited by serious oversimplification, comparison of "apples and oranges," undocumented methods of data selection, and questionable applicability of results. CRITFC also commented that the Phase I analysis's use of catch and escapement as "indices" of production was flawed<sup>1</sup> and that the Phase I analysis gives no indication of how "key" rivers and basins were selected. Because Phase II of the Olsen report and his March 2005 working paper both stem from and expand upon the Phase I results, they carry forward and suffer from the same flaws as the Phase I analysis.

9. Olsen's Phase I analysis has also been called into question by findings under the PATH process.<sup>2</sup> Differences in productivity between Snake River spring chinook and those down river, and therefore less affected by the hydrosystem, were well documented during the PATH process (Marmorek et al. 1996). The centerpiece for the PATH process was an analytical

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<sup>1</sup> CRITFC commented that the use of total catch as an index of west coast production is invalid due to the substantial variation in fishery harvest rates, fishing methods, and fishing regulations, as well as the different effect El Nino has on southern and northern areas of the ocean. Also, the few chosen correlations between escapement, terminal run size and river mouth run size for specific basins are not enough to indicate a common production trend.

<sup>2</sup> PATH (Plan for Analyzing and Testing Hypotheses) was formed as part of Idaho vs. NMFS lawsuit in 1995. The process was formed at the behest of the Federal agencies with oversight by NMFS through its Implementation Team (IT). PATH was comprised of scientists representing Federal, State and Tribal agencies. In addition it included three technical advisors and four additional scientists who comprised a dedicated Scientific Review Board (SRB) chosen by the Federal Parties to the suit.

framework that compared a group of Snake River spring/summer chinook stocks with a group of stocks from lower in the system. The purpose of the framework was to quantitatively estimate differences in productivity (recruit-per-spawner) between the two groups after “common-year-effects” had been mathematically explained. Common-year-effects refer to the extent to which all the stocks went up or down together and removing the effects was desirable because it took out the variability associated with ocean cycles that would otherwise obscure differences in productivity. Results indicated substantial differences in productivity between the two groups apparently due to the hydrosystem. Results have since been validated in two peer reviewed journal articles (Schaller et al. 1999 (AR B.221); Deriso et al. 2001). The analysis was updated in 2004 and results indicate that the disparity continues (Marmorek et al. 2004 (AR B.130)).

10. **Exhibit 6. Historical Analysis of PIT Tag Data for Transportation of Fish at Lower Granite, Little Goose, Lower Monumental and McNary Dams. Task 1: Analysis of In-River Environmental Conditions. J.J. Anderson, R.A. Hinrichsen, C.Van Holmes and K.d. Ham. .2005. Final Report to U.S. Army Corps of Engineers.** This report provides an analysis of smolt-to-adult returns (SARs) for hatchery and wild transported and in-river spring, summer and fall Chinook and steelhead. The report attempts to analyze 1998-2000 SARs with various environmental factors including temperature. The report concludes, among other things, that Snake River spring and summer Chinook have better returns when transported than when left in river. The State, Federal and Tribal Fishery Agencies Joint Technical Staff submitted a detailed critique on the 2004 draft of this report (SFTFA 2004 (Attachment 3 to this declaration). Among other things, SFTFA (2004) found that: 1) the methods used to summarize the environmental variables and project operational data used as covariates in the report regression analysis do not reflect the influence of the covariates in question on the smolt-adult survival

rates, 2) when explaining the reduction in stock SARs, the report provided no rationale or data justifying the use of a “length selectivity” hypothesis over a “bypass stress” hypothesis, 3) the report contained no mechanisms for establishing the causal relationships between the SARs that were compared and that SAR estimates were assumed to be free of error, which is not the case, 4) the results of the covariate analyses of the transport to inriver ratios “demonstrate a lack of consistency among years within species, instilling little confidence in the results as they relate to management decisions.” With respect to the report’s attempt to isolate temperature from flow as a causal mechanism for SAR reduction, the SFTFA (2004) noted that the report’s results suggests that three variables were important (day, temperature and flow), thus, the report is confusing and logical with respect to its treatment of flow. The SFTFA (2004) summarize their critique by stating,

although the statistical methods (in the report) utilized in the were sophisticated, the simplistic way that the environmental variables were created for this analysis still leads to a non-robust analysis ... because of the problems with the improper definition of environmental variables across the in-river migration season, we find the quality of the analyses lacking and therefore find the results insufficient for management decision making.

SFTFA (2004) (Attachment 3).

11. In the final report, the data indicates that in some years, such as 2000, there is virtually no difference between transport SARs and in-river SARs for spring and summer Chinook (NOAA Fisheries, unpublished data 2005 (Attachment 3 to this declaration)). A key point that the report omits is that the SARs for Snake River spring and summer Chinook in recent years are poor whether they are transported or not. SARs for spring and summer Chinook from 2000-2002 ranged from 0.56-1.57 (NOAA Fisheries, unpublished data 2005(Attachment 4)). A 2-6% SAR goal necessary for recovery of these listed stocks was established through extensive analysis in the PATH

process (Marmorek et al. 1998) and subsequently adopted by the Northwest Power and Planning Council in their 2000 Fish and Wildlife Program. Given the added survival benefits from a current favorable ocean environment (see 2004 BiOp at 5-52), spring and summer Chinook should be achieving higher SARs for recovery. Increased standards for salmon protection through the hydrosystem are likely necessary even during periods of high ocean productivity in order to maintain and expand genetic and life history diversity to withstand subsequent ocean productivity troughs (ISG 1996 (AR B.114)). This indicates additional measures such as increased flow and spill to provide better in-river conditions are needed now.

12. **Comments on Declaration of James J. Anderson in support of the Defendant Intervenors BPA Customer Group's Response to Motion for Summary Judgment.**

13. Historical Patterns in Stock Abundances. In her declaration (Oosterhout 3<sup>rd</sup> Decl.), Dr. Oosterhout provided a quantifiable, detailed analysis showing that: 1) if NMFS had utilized a 2000 FCRPS BiOp population growth analytical framework in the 2004 FCRPS BiOp, the survival improvements necessary to avoid jeopardy to the ESUs are still very large for most ESUs (Oosterhout 3<sup>rd</sup> Decl. at 21) and, 2) the statements in the 2004 FCRPS BiOps from the Fisher and Hinrichsen (2004) analyses regarding trend increases in the ESUs in recent years are “[n]ot scientifically accurate because their analysis does not actually capture changes to long-term population growth trends (Oosterhout 3<sup>rd</sup> Decl. at 52). Other sources indicate that recent spawning escapements for most ESUs are below recommended interim delisting levels from the Biological Requirements Workgroups. For example the Upper Columbia Biological Requirements Workgroup (Ford et al. 2001) recommended in interim delisting level of 6,250

adult upper Columbia spring chinook. The combined hatchery and wild adult returns were used to calculate the 1997-2004, 8 year geometric mean which was reduced by 80% based on the fact that about 80% of the 2001 spring chinook adult return to the Methow River was from supplementation adults. This resulted in a geometric mean of 2137 adults, far below the 6250 adults listed as the interim abundance target (Lohn 2002 in Reclamation 2005).

14. Dr. Anderson's "Daemon in the Ocean". Dr. Anderson claims that the PATH (Marmorek et al. 1998) conclusions were in error because gains in ocean productivity over the last few years have resulted in population growth of ESUs and that the hydrosystem effects on the ESUs are minimal (Anderson Decl. at 6-13). However, several recent analyses by the fishery managers indicate that 1) differential delayed mortality ("D") between transported and non-transported stocks is still considerable and, 2) considerable delayed mortality is still occurring under recent favorable ocean productivity conditions (Marmorek et al. 2004 (AR B.130); Schaller and Petrosky 2005 (Attachment 5 to this declaration)). Analyses that related juvenile salmon water travel time, ocean effects, 2000 FCRPS Biological Opinion flow targets and spawner to spawner rates by Marmorek et al. (2004) (AR B.130) and the State, Federal and Tribal Fishery Agencies Joint Technical Staff (SFTFA 2003 (Attachment 6 to this declaration)), indicate that predicted spawner to spawner rates approach or exceed replacement under average to good ocean conditions if flow targets are met, but decline if flow targets are not met under any ocean condition but good conditions. There is great risk to the survival and recovery of the ESUs if the direct and indirect hydrosystem mortality load is not immediately addressed, because ocean productivity will not likely remain favorable for long periods of time. In support of his hypothesis that smolt survival depends on the distance traveled and not the migration speed or travel time, Dr. Anderson (Anderson Decl. at 14) claims that smolts pass through a "gauntlet of

predators” and that smolt survival depends on the number of predators encountered. However, as described in SFTFA (2003) comments and analysis by Marmorek et al. (2004) (AR B.130) the prime consideration of predator impact on migrating smolts is the exposure time of smolts to predator populations that are concentrated in dam tailraces and forebays, not simply the number of predators encountered. The longer that smolts are exposed to these conditions, the greater reduction in smolts survival. Thus, increased flows and spill will reduce smolt exposure to predator populations.

## REFERENCES

- Deriso, R B., D. Marmorek and I. Parnell. 2001. Retrospective patterns of differential mortality and common year-effects experienced by spring and summer chinook salmon (*Oncorhynchus tshawytscha*) of the Columbia River. *Can. J. Fish. Aquat. Sci.* 58:2919-2430.
- Fish Passage Center. December 31, 1992. Review of the McNeil paper submitted November 8, 1992 to the Direct Services Industries, Inc: "Timing of passage of juvenile salmon at Columbia River dams". Memorandum to Bert Bowler, Idaho Department of Fish and Game. Portland, Oregon. (Attachment 2)
- ISG (Independent Scientific Group). 1996. *Return to the River*. Restoration of salmonid fishes in the Columbia River Ecosystem. Northwest Power Planning Council. Portland, Oregon. (AR B.114)
- Marmorek, D.R., M. Porter and C. Peters, eds. 2004. Comparative Survival Study Workshop, February 11-13, 2004; Bonneville Hot Springs Resort. Report compiled and edited by ESSA Technologies Ltd., Vancouver, B.C. for Fish Passage Center, Portland, OR and the U.S. Fish and Wildlife Service, Vancouver, WA. 137 Pages. (AR. B.130)
- Marmorek, D.R., C.N. Peters, and I. Parnell, editors. 1998. Plan for analyzing and testing hypotheses (PATH): final report for fiscal year 1998. ESSA Technologies, Ltd. Vancouver, B.C.
- Marmorek, D.M. and 16 other authors. 1996. Plan for Analyzing and Testing Hypotheses (PATH) Preliminary Report on Retrospective Analyses. ESSA Technologies Ltd. Vancouver B.C.
- Mantua, N.J., S.R. Hare, Y. Zhang, J.M. Wallace and R.C. Francis. 1997. Pacific interdecadal climate oscillation with impacts on salmon production. *Bulletin of the American Meteorological Society*. By Joint Institute for the Study of the Atmosphere and Oceans.

University of Washington, Seattle, WA.

National Research Council. 2004. Managing the Columbia River: Instream flows, water withdrawals and salmon survival. National Academies Press. Washington, D.C.

Reclamation (Bureau of Reclamation). 2005. Biological Assessment for Bureau of Reclamation Operations and Maintenance in the Snake River Basin above Brownlee Reservoir. Draft document. Boise, Idaho.

Schaller, H. and C. Petrosky. 2005. Effects of juvenile migration and ocean/climate conditions on smolt-to-adult return rates and recruitment for Snake River stream-type Chinook. Presentation to Oregon Chapter of American Fisheries Society. February, 2005. Corvallis, Oregon. (Attachment 5)

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*) population of the Snake and Columbia rivers. Can. Jour. Aquat. Sci. 56:1031-1045. (AR B.221)

SFTFA (State, Federal and Tribal Fishery Agencies Joint Technical Staff). June 29, 2004 comments on report entitled, "Historical analysis of PIT-tag data for transportation of fish at Lower Granite, Little Goose, Lower Monumental and McNary Dams" by Anderson et al. 2004. Fish Passage Center. Portland, Oregon. (Attachment 3)

SFTFA (State, Federal and Tribal Fishery Agencies Joint Technical Staff). February 26, 2003 comments on the Independent Scientific Advisory Board's (ISAB) draft document, "Review of flow augmentation: Update and Clarification" as it relate to the Northwest Power Planning Council's Draft Mainstem Amendments. Fish Passage Center. Portland, Oregon. (Attachment 6)

I declare under penalty of perjury that the foregoing is true and correct to the best of my

knowledge. Executed this 30<sup>th</sup> day of March at Portland, Oregon.

\_\_\_\_\_/s/\_\_\_\_\_  
ROBERT HEINITH

Attachments 1 - 6

## Review of Information on the Effects of Flow on Smolt Migration Timing

Nanci Tester of the Direct Service Industries, Inc. (DSI), introduced Dr. William McNeil, Oregon State University. (See Exhibit C for Dr. McNeil's handout and slides.)

Dr. McNeil defined migration timing as the date for a defined percentile of cumulative passage at one location and travel time as the difference in migration timing between two locations. Based on statements by fishery agency analysts, Dr. McNeil concluded that among-year variability in migration was the major concern. He said that analysts have typically focused on within-year variability rather than among-year variability and that confounding variables were typically ignored. Dr. McNeil presented various slides showing his findings.

Member Saxvik asked whether these results related to wild and natural fish or just to hatchery fish. Dr. McNeil replied that the migration timing estimates he has made were dominated by hatchery fish, since they make up the larger part of the migrating fish. However, information from the Yakima (Prosser Dam) showed no significant association between timing and flow. Member Saxvik said he was having trouble melding migration timing with travel time.

Dr. McNeil then discussed adult migration timing. He concluded that migrating adults were delayed by high discharge and that the impact of delayed migration needed to be evaluated.

Member Bottiger asked whether the study related to when the adult migration started or how long it takes. Dr. McNeil said that since there was not data on when the adults arrive in the estuary, the study simply shows arrival dates at a particular dam.

Member Hallock asked who commissioned the study, how it was funded, and how much work went into it. Dr. McNeil said the study was commissioned and paid for by DSI, Inc.

## Alternative Perspectives on the Effects of Flow on Smolt Migration

Chairman Grace then called on Dr. Phillip Mundy for a presentation on alternative perspectives on the effects of flow on smolt survival. Dr. Mundy referred to the Corps of Engineers' studies on the effect of impoundments on fish in the southeastern United States. Dr. Mundy explained that he was appearing on behalf of several organizations, including the Columbia River Inter-Tribal Fish Commission (CRITFC). He said we no longer have a river; we have a set of impoundments. Dr. Mundy said that salmon are adapted to cold water and spring freshets -- it is a species which responds to flow. He said that juveniles orient to flow, as do adults, even in the ocean. According to Dr. Mundy, we are not

providing the currents and temperatures this fish is adapted to. He felt it was reasonable to expect that the cold-water nature of the species and the fact that they respond to currents have had some disadvantaging effect due to the impoundments.

Slide one showed how the natural hydrograph has been changed by dams, reducing currents. Slide two showed how temperatures in the Columbia impoundment have moved from cold water to temperatures which are warm or lethal. Reservoirs are heat capacitors and cause additional heat to be absorbed into the water, increasing temperatures.

On the McNeil report, Dr. Mundy said that he looked first at the methodology. You must have a fair sample, unidirectional migration to assure that you only count individuals one time, and you must have a single, identifiable stock. The single stock is important because migratory behavior is unique to stocks. Using a chart showing changes in the composition of a migrating populations between two stocks can produce large changes in the perceived migratory timing. Dr. Mundy believes that Dr. McNeil's mixed-stock migratory data suffers from this flaw, and thus does not give meaningful information about migration timing. He said that to make sense out of these numbers, we need to have information about the relative abundance of the stocks.

Dr. Mundy criticized the McNeil report for failing to have a fair sample. Dr. Mundy also said that pre-spawning mortality may be a critical factor in the decline of the populations. In summary, he said that the methods of the McNeil report will not work for this kind of data. Even if the stocks are similar enough to be lumped together, you still must deal with the question of whether you are getting a fair sample. He did not think that it has been established that timing at the dams has anything to do with migration rate.

According to Dr. Mundy, the basic question was migration response associated with environmental variables. The model that biologists use was one of hormonal mechanisms initiating migration. You frequently see adult salmon milling around the mouth of rivers, but when the hormone clock was at a certain time, they migrate. At different times, behavior is induced by different physical cues in the environment. Flow will have different meanings and produce different biological cues for salmon.

Dr. Mundy said that given the biological information, flows must be important for salmon. A reasonable operating hypothesis is that the smolt migration rate closely parallels water particle travel time. Although this was not true in every case, the key was to start learning how to apply the flows to different kinds of salmon so that you can optimize the water to the needs of different salmon at different times. The data is unequivocal that high flows bring high survival rates

and low flows bring low survival rates. What was equivocal was the effect of flows in the middle.

Dr. Mundy said that a professionally designed and executed program of research was needed. There wasn't any reason technically that you shouldn't have these answers and at reasonable cost, if you want them. The key to finding out what was going on will be larger numbers of pit tags and detectors.

Member Trulove commented that the region has demonstrated time after time that it was willing to take the plunge on the basis of very little information to provide additional flows for fish. But, he asked, who has the power to make sure that these studies get started?

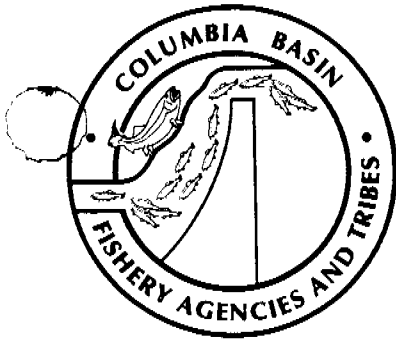
Dr. Mundy said Dr. McNeil and he reached different results because they asked different questions. He emphasized that the relationship between flows and survival was a working hypothesis, which was not disproved in the face of equivocal data. Member Trulove said he was willing to make any changes which would be appropriate, and that he was not ruling out corrections of any type. But on the other hand, the region was at the point where it needs to collect better information, with research in gridlock.

Member Duncan said he believed that the best scientific information available suggested a correlation between flows and survival. But he was far from comfortable in determining exactly where the tradeoff point was between flows and benefits. He urged efforts to start this year the experimental design and testing.

Member Webb asked about how many generations of salmon would be required to reverse the current trends. Dr. Mundy presented charts showing that of 292 spawning seeding surveys, 117 of the areas studied were under-seeded, with most of those well below 50% of historic capacity. Those populations which were in the 10% seeding level (35-40% of the less than 50% seeding stocks) were expected to go extinct in four or fewer generations.

At this the Council took a brief recess. During the recess, members, staff, and others at the meeting celebrated Chairman Grace's birthday with a cake.

Following the recess, Dr. McNeil presented additional comments using data from Alaskan stocks. He said that at the bottom line, he may not be that far apart from Dr. Mundy. He agreed that a number of other factors, including temperature, may have effects on migration.



# FISH PASSAGE CENTER

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## MEMORANDUM

Date: December 31, 1992

To: Bert Bowler, Idaho Department of Fish and Game

From: Michele DeHart, Fish Passage Center

RE: Review of the McNeil paper submitted November 8, 1992 to the Direct Service Industries, Inc.:  
"Timing of Passage of Juvenile Salmon at Columbia River Dams"

RECEIVED

JAN 11 1993

PUBLIC POLICY

In September 1991, the Fish Passage Center (FPC), in response to a request from Rob Lothrop (CRITFC), reviewed a draft paper developed by McNeil for the Direct Service Industries. Those comments are attached. At that time the FPC determined that the McNeil analysis had such serious fundamental errors that it lacked any potential application or validity.

In response to your recent request, we reviewed and developed the following comments on McNeil's November 1992 report. Unfortunately, McNeil carries some of the critical errors of his 1991 report into the 1992 version:

In the 1991 report, McNeil used migration timing of run-at-large smolts (unmarked) at key dams in the Snake and Columbia rivers as a basis for investigating how fast smolts migrated downstream. In that paper, McNeil and Kreeger considered the entire run-at-large for a given species as a single cohort. They compared dates of 10% and 90% passage of this inappropriately defined single cohort as it travelled down through the system of hydroprojects. Travel time between the various hydroprojects was estimated as the difference between the 10% dates and the 90% dates at the respective projects. Since 10% and 90% dates are highly influenced by hatchery release schedules and recruitment of additional fish from downstream sites, the fact that McNeil and Kreeger failed to observe an influence of flow on these estimates was not surprising. By erroneously analyzing the data as if it were a single cohort unaffected by recruitment of additional fish hatchery releases, these authors attempt to show no effect of flow. The November 8 paper by McNeil has again inappropriately used run-at-large smolts as a single cohort, and presents a different but equally faulty, approach to the analysis.

McNeil's November 1992 approach concentrates on the migration timing of a given species at a particular dam, and relies on the premise that migration timing should be earlier in years of higher flows if it is true that higher flows speed up the migration of smolts. Again, McNeil creates an analysis that completely misses the documented role of flow in smolt migrations. McNeil's premise, when considered carefully, would lead to the conclusion that the spring migration would take place in January, when flows are higher. McNeil's analysis completely ignores the life cycle and processes of smoltification, migration and the actual composition of the migration.



McNeil obtained the dates for the 10<sup>th</sup> through 90<sup>th</sup> passage percentiles of each species at three hydroprojects over a 6-year period (1985 to 1990). The three hydroprojects were Lower Granite, Rock Island, and McNary dams. He computed the average flow over the period from April 1 to the date of the respective percentile of interest. For a given percentile, species, and hydroproject, McNeil's analysis consisted of computing both non-parametric and parametric correlation coefficients between the average flow and respective serial date with six years of data. If the correlation coefficient was not significantly different from zero, then no effect of flow was concluded. If the correlation coefficient was significantly different from zero, then one of two conclusions were possible, depending on the sign of the coefficient. A positive sign indicated that the migration was later when flows were higher, and a negative sign indicated that the migration was earlier when flows were higher. He termed the latter condition the "flow hypothesis" of the agencies and tribes. McNeil presents a discussion of hypothesis testing in his paper, and presents an abundance of Spearman rank correlations and Pearson linear correlations including slopes corresponding to the regression's associated with the linear correlations. McNeil presents this as a statistically rigorous analysis. However, statistical tests, manipulations and jargon cannot give validity to a faulty premise; it doesn't matter how many statistics are espoused, the results are still just worthless. McNeil's premise that higher flows should result in earlier migration timing is flawed by the fact that he fails to consider any of the other key factors such as hatchery release timing, river temperatures, overwintering conditions, etc., that affect the smolts readiness to migrate. There is mention in the paper that smoltification development is important and that day length and temperatures greatly influence the smoltification process. So, he knowingly states that these other factors are influential in migration timing, yet he only considers flow alone in his analysis of run timing. He fails to recognize the difference between smoltification-related factors that predominantly influence **migration timing**, and flow that predominantly influences **migration speed** at a given time in the migration. So, with both a faulty premise and the lack of a single cohort to use, McNeil's new approach is even worse than his 1991 analysis. At least in his 1991 analysis he did not confuse migration timing with migration speed, and he attempted to look at flows influencing migration speed.

McNeil presents his sockeye salmon analysis as the most profound, but again his fundamental approach and premise is critically flawed. McNeil still considers the two mid-Columbia River stocks as a single cohort. As stated in our comments to his paper 15 months ago, everyone with the least familiarity with the data know that the timing of the Lake Wenatchee stock is different than that of the Lake Osoyoos stock, peaking about one month earlier, and that the relative magnitude of each run has changed over the years. The Lake Osoyoos stock had a stronger run in 1986 and 1987, while the Lake Wenatchee stock had a stronger run in 1985 and 1988-91. Since the Lake Osoyoos stock has made such a low contribution to the overall sockeye run in the lower flows years, thus causing the migration timing to appear shifted earlier, it is not surprising that significant correlation coefficients with positive signs were obtained in McNeil's analysis. However, McNeil's conclusion that this is evidence that sockeye actually migrate better under lower flows is totally ridiculous. In the sockeye analysis, McNeil successfully accomplishes earlier migration timing by eliminating the latter half of the migration.

McNeil presents a list of 10 potential sources of error that he states are inherent in using marked groups for estimating migration rates. Six of these so-called problems do not specifically relate to whether marked groups are used and equally apply to the indices he utilized in his analysis. Three of these so-called problems relate to the expansion of the sample number of marked fish to the passage index of marked fish, yet surprisingly McNeil doesn't consider these same expansions as problems when it comes to the run-at-large data. McNeil states that smolt removed for transportation in the Snake River can impact marked recoveries downstream at McNary Dam, but he fails to note that these same transportation removals can influence the resulting migration timing distribution of the run-at-large at McNary Dam. Three additional so-called problems given by McNeil are the need

for assumptions that migration rates are unrelated to release dates, distance from ocean, size, or smoltification development. McNeil is wrong; there is no need to assume that migration rates are unrelated to any of these conditions. In the Berggren and Filardo paper, we showed that both smoltification-related and flow-related factors were influential in smolt travel time. These three assumptions have nothing to do with whether or not smolts are marked. These can be viewed as assumptions when only bivariate relations between travel time and flow are made, but the same assumptions are inherent in McNeil's attempted analysis of bivariate correlations between serial passage date and flow. McNeil's attempt here to discredit the use of marked groups in travel time studies is without basis.

A major fallacy in McNeil's premise of an earlier migration timing in years of higher flow is due to the fact that migration timing in his analysis is based solely on proportion of fish passing at a given time, but he does not consider the magnitude of the fish migration. When low flow conditions occur during the late stages of the spring or summer migration, increased exposure to predation occurs due to slower migration rates through the reservoirs, thus resulting in a late truncation of the passage distribution. This would mean that the computed late percentiles, e.g. 70% to 90% dates, would be earlier than what would have occurred if the later portion of the passage distribution wasn't truncated. Conditions like this would make McNeil's analysis show that lower flows speed up the migration timing, rather than reduce the numbers of fish surviving, but this would not be apparent from the proportional data. McNeil would get earlier and earlier migration timing by killing the latter proportions of the migration.

After reviewing the McNeil and Kreeger paper 15 months ago, we were left wondering how this paper was relevant to the plans to rebuild wild stocks of chinook and sockeye in the Snake River. Since hatchery stocks dominate the total run of yearling chinook, and mid-Columbia River sockeye dominate the total run of sockeye to below Bonneville Dam, the use of passage dates for the entire species does not tell you much about the Snake River wild stocks. Today, the new McNeil approach still doesn't address the question of wild threatened and endangered stocks. What is worse is that McNeil's lack of understanding of the passage timing data, and his faulty premise to test, lead to erroneous conclusions. As we stated 15 months ago, and is true today, the recovery plan for wild stocks of chinook and sockeye must include actions that resource managers can work toward. Managers have no control over photoperiod and river temperatures in the tributaries where these wild fish rear, and to which these fish have adapted and evolved over millions of years, but they do have the obligation to try to improve flow conditions toward the levels these smolts experienced in historic years.

To summarize our review, we have the following conclusions:

- \* **The McNeil analysis has no scientific validity.**
- \* **The basic approach attempted by McNeil is critically flawed, based in part on his lack of knowledge of the data he attempted to utilize.**
- \* **All of McNeil's conclusions are erroneous.**
- \* **McNeil fails to differentiate between migration timing, which is brought about by environmental factors affecting smoltification, and flow which determines migration speed.**
- \* **McNeil continues to utilize passage of all stocks of a species as a single cohort. This was fatal flaw of his 1991 analysis, which he carried over into his 1992 analysis.**

- \* McNeil's statistical tests are meaningless, because he applied the statistics to the data based upon an erroneous premise. He failed to recognize separate stocks with separate timing, utilizing mixed stocks as a single cohort. He failed to recognize that hatchery release timing, size and myriad of other factors affect passage timing.
- \* McNeil fails to recognize that assumptions he discusses relative to mark groups also apply to passage indices which he utilized.
- \* McNeil fails to recognize that utilizing percentiles of passage will result in an erroneous conclusion of a speedy migration when high mortality occurs. Simply put, the 90% point of passage always occurs, regardless of the number of fish which make up the 90%. The earlier the 90% point of migration occurs, the smaller the number of fish in the migration and the higher the mortality.
- \* McNeil's approach to migration timing has no application to wild and endangered stocks, since their migration timing, *i.e.* the onset of smoltification in the natural environment, is determined by day length and temperature. However, their migration speed is determined by flow which is affected by the operation and regulation of the hydrosystem.

In accord with our usual procedures, we will provide a copy of these comments to the other state and federal fish and wildlife resource agencies and Indian tribal members of the Columbia Basin Fish and Wildlife Authority.

# State, Federal and Tribal Fishery Agencies Joint Technical Staff

*Columbia River Inter-tribal Fish Commission*  
*Idaho Department of Fish and Game*  
*Nez Perce Tribe*  
*Oregon Department of Fish and Wildlife*  
*Shoshone-Bannock Tribes*  
*US Fish and Wildlife Service*  
*Washington Department of Fish and Wildlife*

June 29, 2004

Mr. Scott Dunmire  
NWD Corps of Engineers  
201 North 3rd Ave  
Walla Walla, WA 99362

Dear Mr. Dunmire:

The state, federal and tribal fishery managers have reviewed the report entitled, “Historical Analysis of PIT Tag Data for Transportation of Fish at Lower Granite, Little Goose, Lower Monumental and McNary Dams,” and offer the following review comments for your consideration, in preparation of the final report.

## Methods: Covariates used in analysis

We have concerns regarding the characterizations of the independent variables used in the analyses. We believe that the methods used to summarize the environmental and project operational data used as covariates in the regression analysis do not reflect the influence of the covariates in question on the smolt-to-adult survival rate. The authors state on page 3.4 that they “avoid averaging covariates because doing so reduces contrast in the data, decreasing the power to detect significant effects of covariates such as temperature, flow, and spill.” Instead, as stated on page 3.12, they simply took the measurements at Lower Granite Dam occurring on the first day of detection, whether the covariate was day of detection, dissolved gas, temperature, flow, spill, turbidity, or distance from release site to Lower Granite Dam. For reflecting conditions at the time that the smolts first enter the hydrosystem at Lower Granite Dam, these single-day measurements are fine. However, most yearling Chinook and steelhead will take between two-weeks and a month to migrate in-river between Lower Granite and Bonneville dams. During these extended migration periods, the smolts encounter various spill levels and dissolved gas conditions at each dam traversed, changing flow and turbidity conditions, and a gradually increasing temperature regime. For the flow and spill-related covariates, the method of naively utilizing the measurements at Lower Granite Dam on the first day of entry into the hydrosystem does not capture the influence of these covariates on either in-river survival of smolts to Bonneville Dam or the overall SARs. It is accepted by the scientific community that SARs are a function of both in-river conditions (including project operations) and ocean conditions. However, the authors only examined the effects of in-river conditions, ignoring the confounding effects of the ocean environment on SARs. To make this

analysis sufficient for input on management decisions, the authors must incorporate covariates that reflect ocean conditions, which operate independent of the hydrosystem. It is well known that ocean conditions have resulted in improved, salmon survival rates during 1998-2000 compared to the prior three years analyzed in this report. Without accounting for the confounding effects of the ocean to tease out the effects of in-river conditions on SARs, there is little scientific basis for utilizing the conclusions of this report. Utilizing a sophisticated statistical modeling approach with overly simplistic covariates representing in-river conditions and without addressing ocean survival conditions make the conclusions untenable and does not result in a rigorous analysis.

### ***Results: Passage route and SAR***

On pages 4.5 to 4.6, the authors cite two different studies (Budy et al versus Zabel et al) that arrived at “differing conclusions as to the significance of bypass systems on adult returns. The Budy hypothesis is that bypass systems reduce survival; the Zabel hypothesis is that bypass systems preferentially collect fish that naturally have lower survival.” The authors acknowledge that both hypotheses may in part be true; however, they go on to conclude that “the length selectivity hypothesis is sufficient to explain a reduction in SAR of bypassed fish without invoking the passage stress hypothesis.” The authors provide neither rationale nor data justifying why they picked the “length selectivity” hypothesis over the “bypass stress” hypothesis as being sufficient in explaining the reduction in bypass SARs. It is at least equally plausible at this point in time that the “bypass stress” hypothesis is sufficient for explaining the reduction in bypass SARs without invoking the “length selectivity” hypothesis. Further separate examination of these two hypothesis is required before one can be discounted or rejected in favor of the other.

In Table 4.1, the authors present five hypotheses related to comparing the effectiveness of different passage routes. They downplay the importance of Hypothesis H1, which compares transported fish from Lower Granite and Little Goose dams to non-detected fish, because they argue that non-detected fish are unavailable for transportation. However, the Fishery Agencies and Tribes would view this as the most important of the five hypotheses listed because a primary management research interest is to compare transportation SARs to the best in-river conditions attainable through the provision of spill. This research interest would be addressed with Hypothesis H1. A discussion of this interest and the importance of this hypothesis to management decisions needs to be added.

### ***Results: Regression analysis method***

There are several problems with the regression approach to evaluating the hypotheses listed in table 4.1. First, there are no mechanisms for causal relationships between the SARs that are compared. For example, the LGR/LGS transportation SAR is not a function of the nondetected SAR or vice versa. Therefore the regression approach is not appropriate. A more appropriate approach would be to conduct t-tests on the ratios of the SARs to examine the null hypothesis that they equal one. Second, a primary assumption of the regression methodology is that the independent variable is measured without error. The assumption is clearly invalid in this application, as all SAR estimates are measured with error, which results in biased estimates of the slope parameter. Again, this argues for adopting the t-test approach, which does not require this assumption as errors in the SAR estimates could be incorporated into the error estimates of the ratio.

Aside from the problems with the regression approach used in this analysis the authors mistakenly state the alternative hypothesis acceptance slopes for two of the five bivariate regression analyses performed (the alternative hypotheses are presented in Table 4.1). The alternative hypotheses are presented in Table 4.1 as one-tail tests, yet the bivariate regression results in Tables 4.2 to 4.4 and the associated plots suggest that two-tail tests were performed. The authors should clarify the type of test performed in the text. The two alternative hypotheses with mistaken

acceptance slope are Hypothesis 1 (fish detected and transported from LGR/LGS) and Hypothesis 2 (fish detected and transported from LMN/MCN). The authors mistakenly state that the acceptance slope for Hypothesis 1 is “Slope<1” and Hypothesis 2 is “Slope>1”, when in actuality, the opposite is true. The acceptance slopes of the three remaining alternative hypotheses are correct as listed.

### **Results: Covariate Based Estimates of T:I**

The results from the covariate analyses of T:I demonstrate a lack of consistency among years within species, instilling little confidence in the results as they relate to management decisions. For example, for wild steelhead the day on which T:I = 1 varies from -94 to 139. These results are not useful in making management decisions on when to begin or end transportation. Similar inconsistencies and high variability among years is evident for nearly every species and environmental covariate examined. These results inspire little confidence in their validity or realism.

On page 4.21 the authors state that the variables “Day of arrival at LGR” and “Temperature at arrival at LGR” were the two variables most consistently chosen in the regressions with the covariates listed in Table 4.5 and the T:I ratio as the dependent variable. This was based on selecting the regression with the lowest AIC score. However, comparing AIC scores among non-nested models (i.e. across environmental covariates) is technically invalid. In addition, both of these covariates increase over time for both the springtime and summertime migrants. The T:I ratios also tend to increase over time. But do the authors believe that the mechanisms for higher SARs are simply a function of when the fish arrive at the start of the hydrosystem, and under the prevailing water temperatures that occur at the time of arrival? Clearly, this is not the case as SARs are a function of the passage experience throughout the hydrosystem and not simply conditions during the initial portion of their migrations.

On page 4.22 they present findings from published literature to support the importance of two variables (day and temperature) despite their own results suggesting the importance of three variables (day, temperature and flow). The authors’ rationale for subsequently ignoring flow is confusing, illogical and suggests a bias as to which mechanisms they believe to be important. In addition they overlook the link between smolt travel time between LGR and the estuary, which is affected by the flows occurring in a given year. Likewise, they overlooked that spill at a dam reduces fish delays in passing that dam and contributes to lowering predation encounters in both the forebays and tailraces of individual dams.

Additionally, the authors failed to note that they are working with an aggregate of PIT- tags from various stocks and that stock-specific effects may also contribute to the changing T:I ratios over time. A case in point is seen with PIT- tagged hatchery chinook. Hatchery chinook PIT tagged and released from Dworshak and Lookingglass (onsite releases discontinued after 1999) hatcheries have tended to be the earliest arriving stocks at Lower Granite Dam while McCall Hatchery chinook have tended to be the latest arriving stock. When stock specific SARs are computed the T:I ratios of the McCall Hatchery summer chinook stock has generally been higher than that of the Dworshak and Lookingglass spring chinook stocks. Therefore, covariates such as “Day of arrival at LGR” and “Temperature at arrival at LGR” may be benefiting from a stock effect, which is not included in the regression model.

Covariates such as flow influence how quickly the PIT- tagged smolts traverse the hydrosystem and arrive at the estuary, and simply utilizing the flow that occurs on the day that these fish arrive at Lower Granite Dam may be inadequate to reflect the importance of this covariate on subsequent smolt success upon ocean entry. In addition, the flows that occurred in each year analyzed by the authors, with the exception of 1995, were years of above average springtime flows and at or above BIOP mandated summertime flows during most of the summer migration.

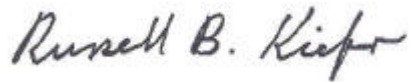
Therefore the data analyzed includes little contrast in flow, which would tend to minimize the importance of this variable on SARs. We expect to see quite a difference when low flow years such as 2001 are included in this type of analysis. Likewise, the flows during the summer migration would be changing less in the years analyzed by the authors than would have occurred in earlier years when only limited PIT- tag data are available for subyearling Chinook, or in the drought year of 2001 for which complete adult return data are not yet available for SAR analyses. These factors reduce the contrast in flow across years and limit the regression analysis to adequately evaluating the influences of flow on SARs and T:I ratios.

It is not unexpected that the covariate of spill did not remain in the authors' analyses because of the colinearity between spill and flow. This colinearity exists because as project hydraulic capacities are reached, the excess flow is spilled. Thus spill volumes and flows will tend to increase together (the spill proportion also tends to increase in these situations), making it difficult to separate the effects of these two variables in the same regression model. However, this does not diminish the effect of spill on in-river smolt survival. Dams provide three routes of passage: powerhouse bypass, powerhouse turbines, and spillways. Because route-specific survival is highest through the spillway route, the proportions of spill available at a dam will positively affect the survival of smolts at that specific project. Despite the difficulty in teasing out the effect of spill versus flow in regression-type analyses, the colinearity between spill and flow should not be used to diminishing the influence of one factor over the other. In addition, the simplistic use of spill measured only at Lower Granite Dam to reflect the effects of spill throughout the hydrosystem and therefore SARs, is a major shortcoming of this analysis.

### ***Summary***

While the Anderson et al. analysis, is interesting, it has limited utility for fish passage management decisions. Although the statistical methods utilized were are sophisticated, the simplistic way that the environmental variables were created for this analysis still leads to a non-robust analysis. Environmental variables need to be generated that best represent the cumulative manner in which the environmental and dam operational conditions influence the in-river and transportation survival of smolts, and their subsequent ocean survival. We understand that accounting for the integrated nature of these environmental variables involves considerable complexity, however it would result in a better reflection of reality and provide a more robust basis for management decisions. If a particular environmental variable is influential over the entire period that a smolt is migrating through the hydro system, then an average of that variable over the total time interval (or large portion of that interval) may be more representative of the smolt experience than simply the value obtained on the day the smolt entered the hydro system. Developing the environmental variables according to the timing of survival mechanisms may make the analysis more complex, but would result in reduced chances of making erroneous conclusions regarding variables unrelated to in-river survival. The old rule-of-thumb that the quality of the analysis is only as good as the data going into it is paramount in the type of investigation performed and conclusions reached in this report. Because of the problems with the improper definition of environmental variables across the in-river migration season, we find the quality of the analyses lacking and therefore find the results insufficient for management decision making.

Sincerely,



Russ Kiefer, IDFG



Dave Statler, NPT



Ron Boyce, ODFW



Keith Kutchins, SBT



Tom Lorz, CRITFC



Rod Woodin, WDFW



Dave Wills, USFWS

**Update on Transportation Studies in-progress**

**Preliminary**

| Snake River studies:   | Study year | Tagged at | Age of most recent adults | Number of adults |       |     | SAR   |       |      | T/l's   |         |             |
|------------------------|------------|-----------|---------------------------|------------------|-------|-----|-------|-------|------|---------|---------|-------------|
|                        |            |           |                           | T-Lgr            | T-Lgs | I   | T-Lgr | T-Lgs | I    | T-Lgr/I | T-Lgs/I | T-Lgr/T/Lgs |
| Spring/summer chinook: | 2000       | LGR       | Finished                  | --               | 255   | 379 | --    | 1.47  | 1.44 | --      | 1.02    | --          |
|                        | 2001       | LGR       | Finished                  | 157              | --    | --  | 0.95  | --    | --   | --      | --      | --          |
|                        | 2002       | LGR       | 2-ocn                     | 48               | 78    | 77  | 0.97  | 0.81  | 0.56 | 1.72    | 1.44    | 1.19        |
|                        | 2003       | LGR       | Jacks                     | 0                | 2     | 0   | 0     | 0.02  | 0    | --      | --      | --          |
| Steelhead:             | 2000       | LGR       | Finished                  | --               | 985   | 435 | --    | 3.98  | 1.85 | --      | 2.15    | --          |
|                        | 2001       | LGR       | Finished                  | 357              | --    | --  | 2.32  | --    | --   | --      | --      | --          |
|                        | 2002       | LGR       | 2-ocn (inc.)              | 126              | 250   | 118 | 2.58  | 1.79  | 0.77 | 3.37    | 2.34    | 1.44        |
|                        | 2003       | LGR       | 1-ocn (inc.)              | 35               | 49    | 10  | 1.03  | 0.41  | --   | --      | --      | 2.53        |

| Snake River studies: | Study year | Tagged at | Age of most recent adults | Number of adults |       |        |    |     | SAR   |       |        |    | T/l's |         |         |             |
|----------------------|------------|-----------|---------------------------|------------------|-------|--------|----|-----|-------|-------|--------|----|-------|---------|---------|-------------|
|                      |            |           |                           | T-Lgr            | T-Lgs | Fall-T | I  | H-I | T-Lgr | T-Lgs | Fall-T | I  | H-I   | T-Lgr/I | T-Lgs/I | T-Lgr/T/Lgs |
| Fall chinook:        | 2001       | LYFE      | 3-ocn                     | 42               | 13    | --     | 15 | 15  | 0.22  | 0.33  | --     | -- | 10.27 | --      | --      | 0.68        |
|                      | 2002       | LYFE      | 2-ocn                     | 89               | 5     | 89     | 67 | 24  | 0.72  | 0.20  | 3.56   | -- | 4.38  | --      | --      | 3.68        |
|                      | 2003       | LYFE      | Jacks                     | 6                | 4     | 34     | 3  | 1   | 0.04  | 0.05  | 1.33   | -- | 10.00 | --      | --      | 0.71        |
|                      | 2004       | LGR       | --                        | --               | --    | --     | -- | --  | --    | --    | --     | -- | --    | --      | --      | --          |

**Update on Transportation Studies in-progress**

**Preliminary**

| Columbia River studies:   | Study year | Tagged at  | Age of most recent adults | Hatchery     | Percent of tagging | Number of adults |              |            | SAR         |             |             | T/l's       |             |             |
|---------------------------|------------|------------|---------------------------|--------------|--------------------|------------------|--------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                           |            |            |                           |              |                    | T                | I            | F (B)      | T           | I           | F (B)       | T/I         | F (B)/I     | T/F (B)     |
| Fall chinook:             | 2001       | McNary Dam | 3-ocn                     | --           | --                 | 51               | 74           | --         | 0.22        | 0.19        | --          | 1.14        | --          | --          |
|                           | 2002       | McNary Dam | 2-ocn                     | --           | --                 | 144              | 211          | --         | 0.38        | 0.37        | --          | 1.01        | --          | --          |
| Spring chinook (Hatchery) | 2002       | Hatcheries | 2-ocn                     | <b>Total</b> |                    | <b>160</b>       | <b>415</b>   | <b>69</b>  | <b>0.32</b> | <b>0.32</b> | <b>0.40</b> | <b>0.99</b> | <b>1.25</b> | <b>0.79</b> |
|                           |            |            |                           | Leavenworth  | 77.47              | 128              | 301          | 52         | 0.33        | 0.29        | 0.39        | 1.10        | 1.31        | 0.84        |
|                           |            |            |                           | Entiat       | 17.27              | 25               | 70           | 13         | 0.28        | 0.34        | 0.44        | 0.84        | 1.30        | 0.65        |
|                           |            |            |                           | Winthrop     | 5.76               | 7                | 44           | 4          | 0.28        | 0.64        | 0.55        | 0.43        | 0.85        | 0.50        |
|                           | 2003       | Hatcheries | Jacks                     | <b>Total</b> |                    | <b>11</b>        | <b>84</b>    | <b>13</b>  | <b>0.04</b> | --          | <b>0.03</b> | --          | --          | <b>1.01</b> |
|                           |            |            |                           | Leavenworth  | 67.66              | 4                | 25           | 6          | 0.02        | --          | 0.02        | --          | --          | 0.81        |
|                           |            |            |                           | Entiat       | 16.87              | 2                | 8            | 0          | 0.03        | --          | 0           | --          | --          | --          |
|                           |            |            |                           | Winthrop     | 5.62               | 0                | 1            | 0          | 0           | --          | 0           | --          | --          | --          |
|                           | 2004       | Hatcheries | NA                        | <b>Total</b> |                    | --               | --           | --         | --          | --          | --          | --          | --          | --          |
|                           |            |            |                           | Leavenworth  | 65.66              |                  |              |            |             |             |             |             |             |             |
|                           |            |            |                           | Entiat       | 17.76              |                  |              |            |             |             |             |             |             |             |
|                           |            |            |                           | Winthrop     | 6.03               |                  |              |            |             |             |             |             |             |             |
|                           |            |            |                           | Methow       | 10.56              |                  |              |            |             |             |             |             |             |             |
| Steelhead (Hatchery):     | 2003       | Hatcheries | 1-ocn (inc.)              | <b>Total</b> |                    | <b>166</b>       | <b>2,322</b> | <b>147</b> | <b>1.08</b> | <b>1.18</b> | <b>0.75</b> | <b>0.92</b> | <b>0.64</b> | <b>1.44</b> |
|                           |            |            |                           | Ringold      | 19.57              | 63               | 1,198        | 58         | 2.12        | 2.11        | 1.54        | 1.01        | 0.73        | 1.37        |
|                           |            |            |                           | Chelan       | 6.82               | 15               | 116          | 15         | 1.31        | 1.03        | 1.20        | 1.28        | 1.17        | 1.09        |
|                           |            |            |                           | Eastbank     | 12.74              | 6                | 152          | 14         | 0.28        | 0.57        | 0.51        | 0.50        | 0.89        | 0.56        |
|                           |            |            |                           | Wells        | 50.59              | 81               | 834          | 59         | 1.01        | 0.94        | 0.58        | 1.08        | 0.62        | 1.76        |
|                           |            |            |                           | Winthrop     | 10.27              | 1                | 22           | 1          | 0.09        | 0.17        | 0.07        | 0.51        | 0.39        | 1.32        |
|                           | 2004       | Hatcheries | NA                        | <b>Total</b> |                    | --               | --           | --         | --          | --          | --          | --          | --          | --          |
|                           |            |            |                           | Ringold      | 20.18              |                  |              |            |             |             |             |             |             |             |
|                           |            |            |                           | Chelan       | 2.00               |                  |              |            |             |             |             |             |             |             |
|                           |            |            |                           | Eastbank     | 17.51              |                  |              |            |             |             |             |             |             |             |
|                           |            |            |                           | Wells        | 49.96              |                  |              |            |             |             |             |             |             |             |
|                           |            |            |                           | Winthrop     | 10.35              |                  |              |            |             |             |             |             |             |             |
| (2005)                    | Hatcheries | NA         | <b>Total</b>              |              | --                 | --               | --           | --         | --          | --          | --          | --          |             |             |

# Effects of juvenile migration and ocean/climate conditions

on smolt-to-adult return rates  
and recruitment  
for Snake River stream-type Chinook

Howard Schaller, USFWS  
Charlie Petrosky, IDFG



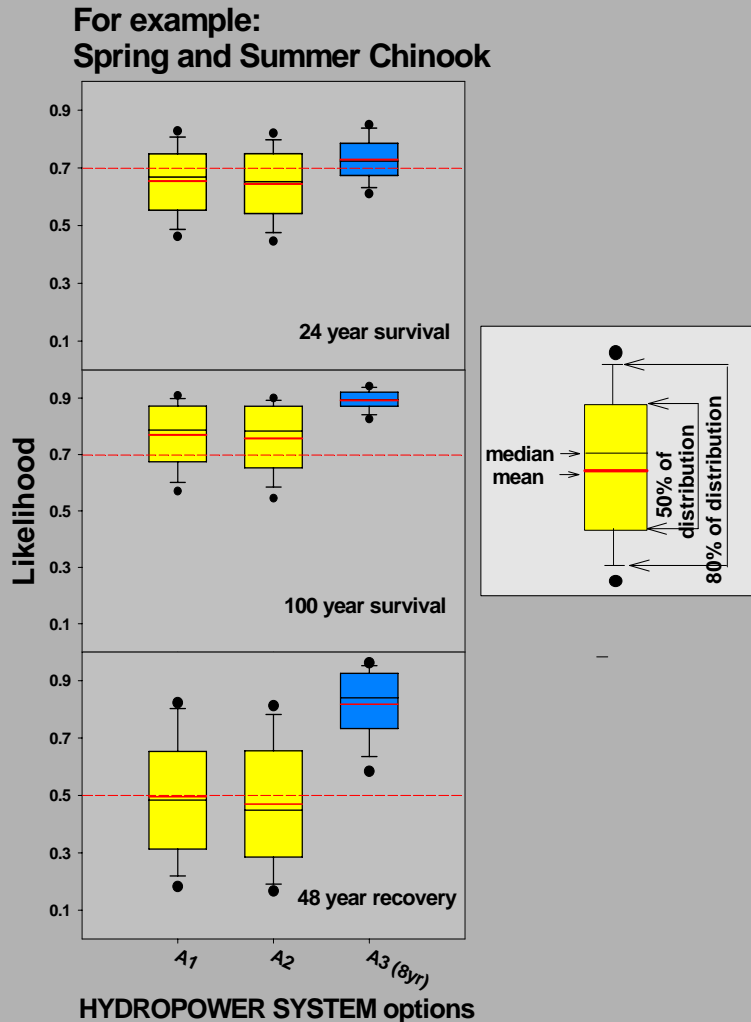
OR Chapter AFS  
ID Chapter AFS

February 2005



Heinith Declaration  
Attachment 6

# History of Issue: Hydrosystem Options, 2000 BiOp



- Dam breach option (A3) least risky, highest likelihood of recovery

- Current operations (A1) and maximum transport (A2) greater risk, lower likelihood of recovery

- Dam breach most likely to succeed unless:

- delayed hydro mortality of inriver migrants is negligible AND

- Transported smolts survive as well as in-river smolts after release (“D” ~ 1)

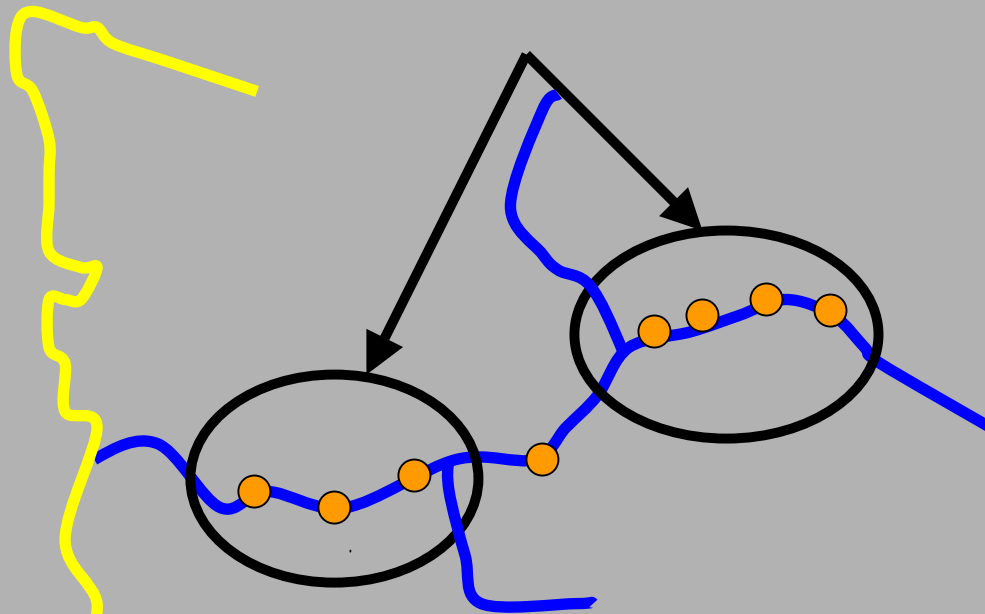
Amount of delayed mortality from hydrosystem is primary uncertainty

# Approach

---

- I. Identify mechanisms for delayed mortality  
(CSS Workshop – <http://www.fpc.org/>; Budy et al. 2002)
- II. Spatial and temporal patterns of stock performance –
  - S/R parameter update (Deriso et al. 2001)
  - PIT-tag data: survival through hydrosystem and SARs for transport vs. in-river smolts (“D”)
  - Evaluate flow/survival and climate relationship to differential and delayed mortality
  - Assess relative risk to the Snake River stream-type Chinook

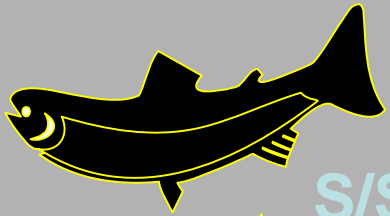
# Spatial/Temporal Analyses



Compare **UPSTREAM** stocks  
to **DOWNSTREAM** stocks:

- 1-3 dams vs. 8 dams
- Same species (similar genetically)
- Similar life history and run timing
- Share common estuary and early ocean environment

● =hydroelectric dam

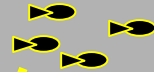


S/S

Freshwater

Smolts-per-spawner

Lower Granite



Little Goose

Monumental

Ice Harbor

Direct survival through dams

Direct survival transported fish

McNary

John Day

The Dalles

Bonneville

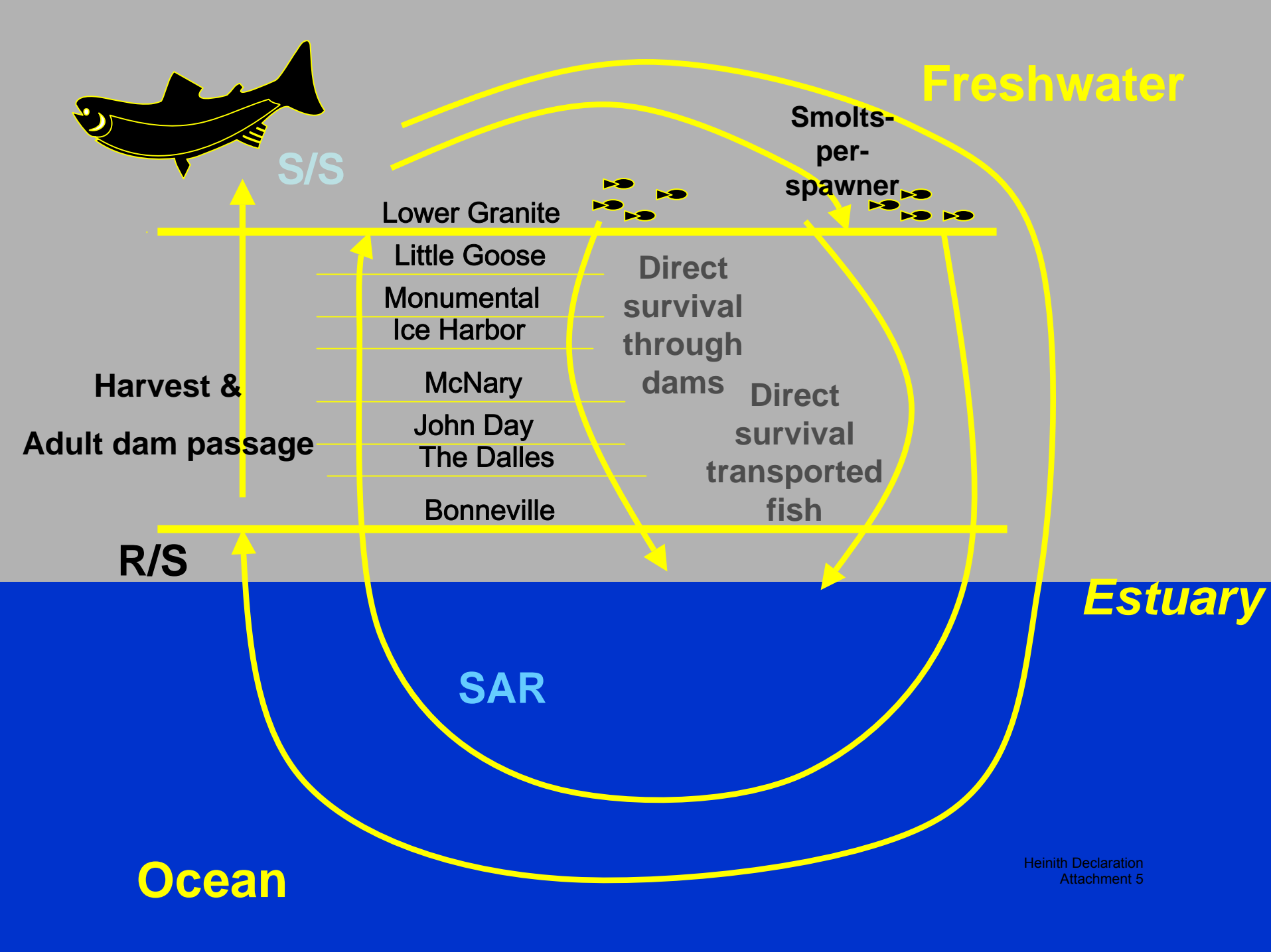
Harvest & Adult dam passage

R/S

Estuary

SAR

Ocean



# Smolt migration: Why focus on flow?

- **Mechanisms:**

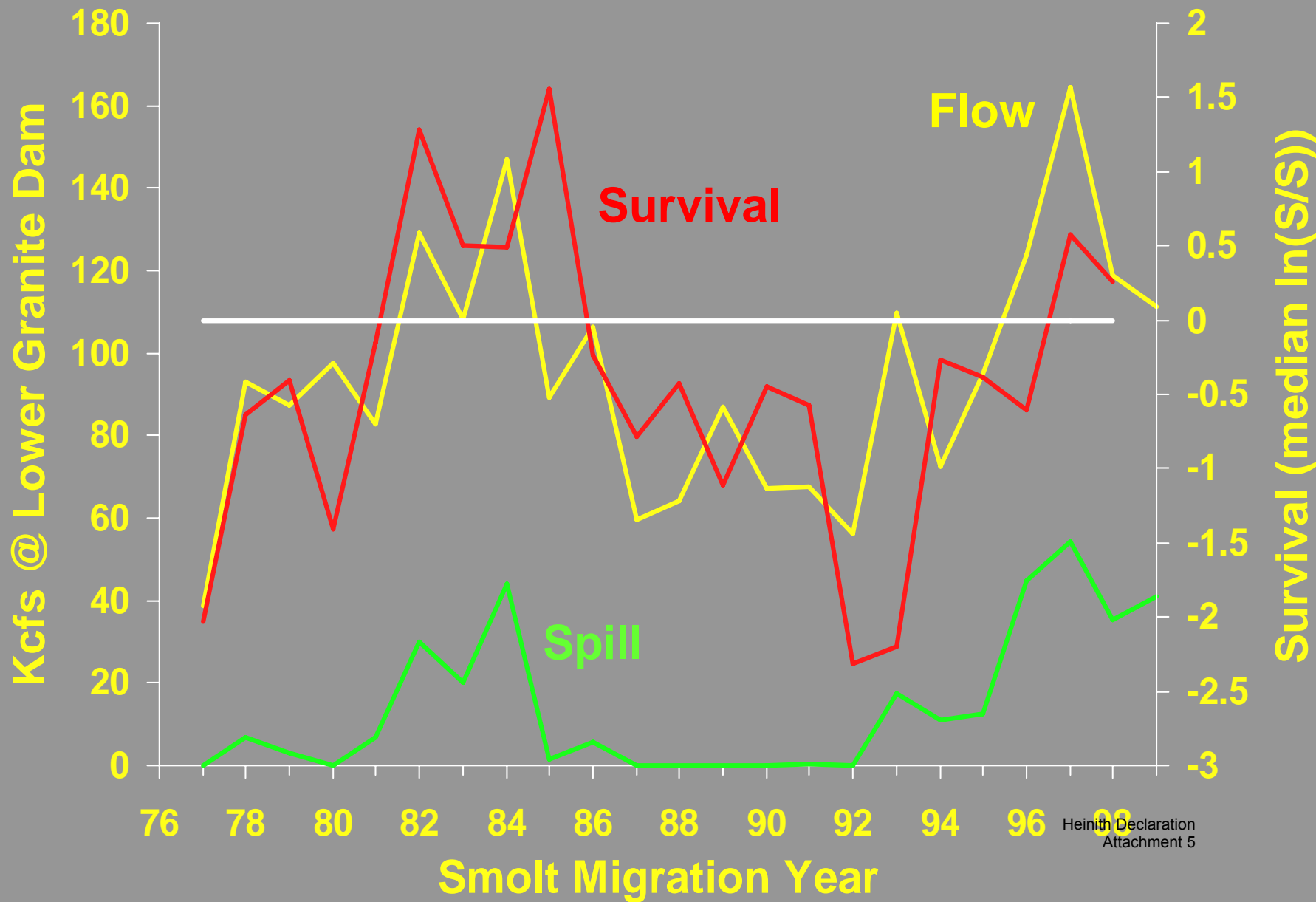
- Flow affects:**

- Migration time to estuary;
    - Temperature exposure;
    - Energy reserves and stress;
    - Timing of salt-water entry;
    - Estuary plume.

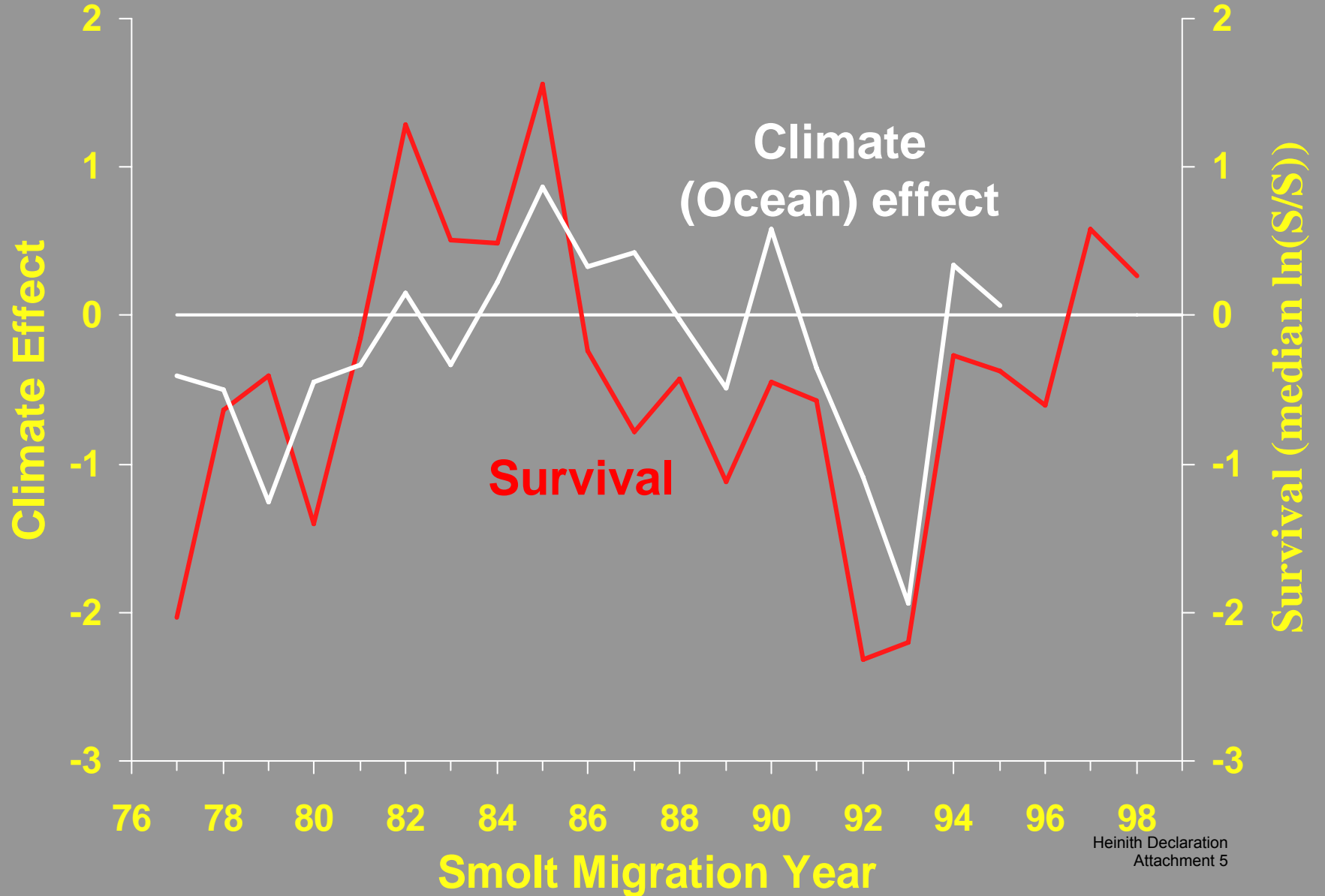
- **Measurements:**

- Direct mortality (estimated by inriver or reach survival)
  - Delayed mortality (related to fish condition, not observed directly)

# Snake River Wild Spring/Summer Chinook



# Snake River Wild Spring/Summer Chinook



# Flow Survival Analyses

## Adult Return Rates

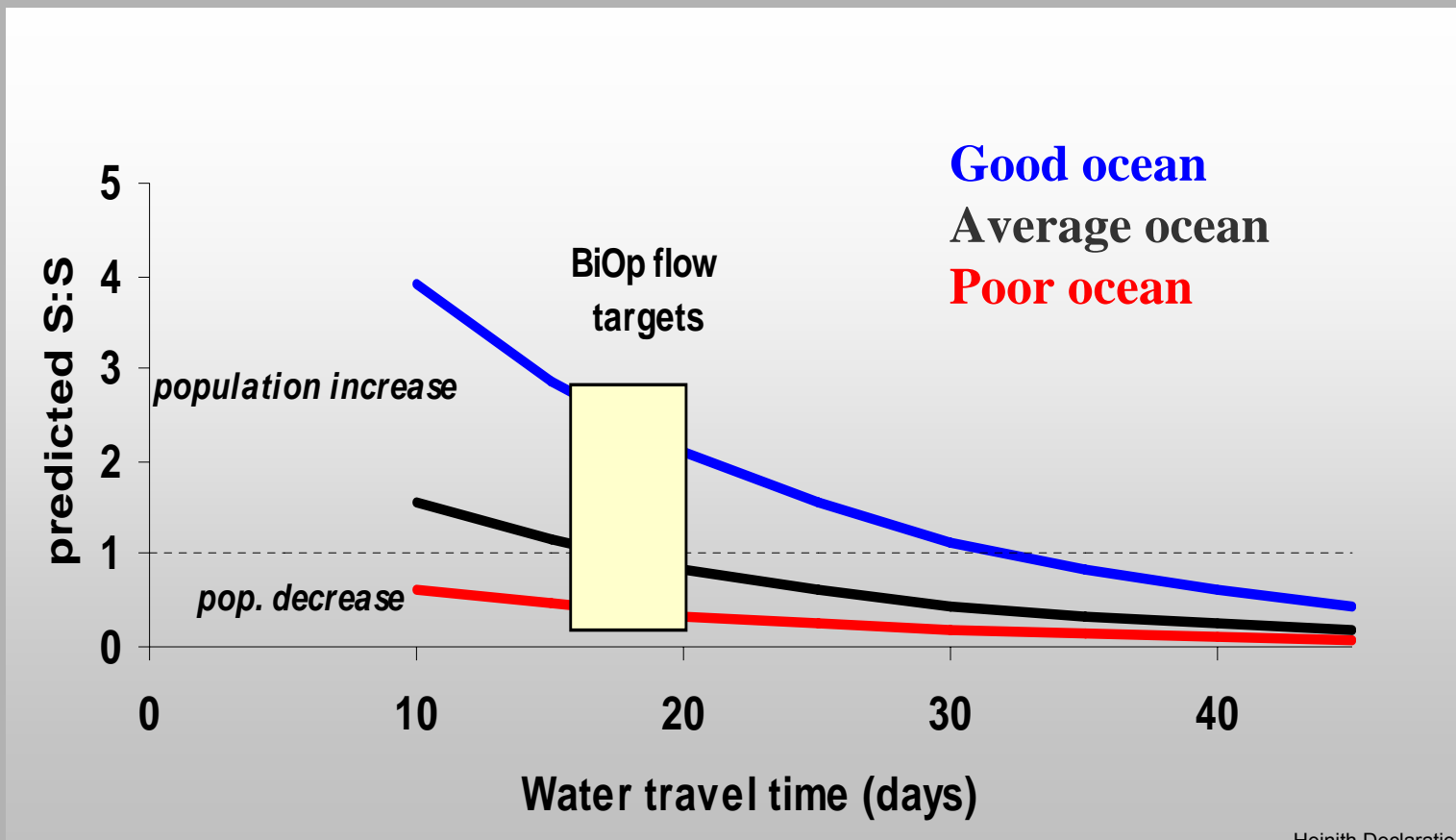
- Wild sp/su chinook SARs
- Wild steelhead SARs
- Wild sp/su chinook S/S
- Water travel time
- Spill proportion (2)
- Proportion transported
- Ocean/climate effect

Multiple regression for all variables, best models from BIC; Supported by stepwise regression

# Juvenile migration & climate (ocean) conditions were both influential in explaining patterns:

- SAR spring/ summer chinook
  - Negative correlation with proportion transported;
  - (excluding transport) WTT, climate
- SAR steelhead
  - WTT, WTT\*spill, climate
- S/S spring/ summer chinook
  - WTT, climate

# Influence of Water Travel Time and Climate Effect on Spring/Summer Chinook S/S (predicted)

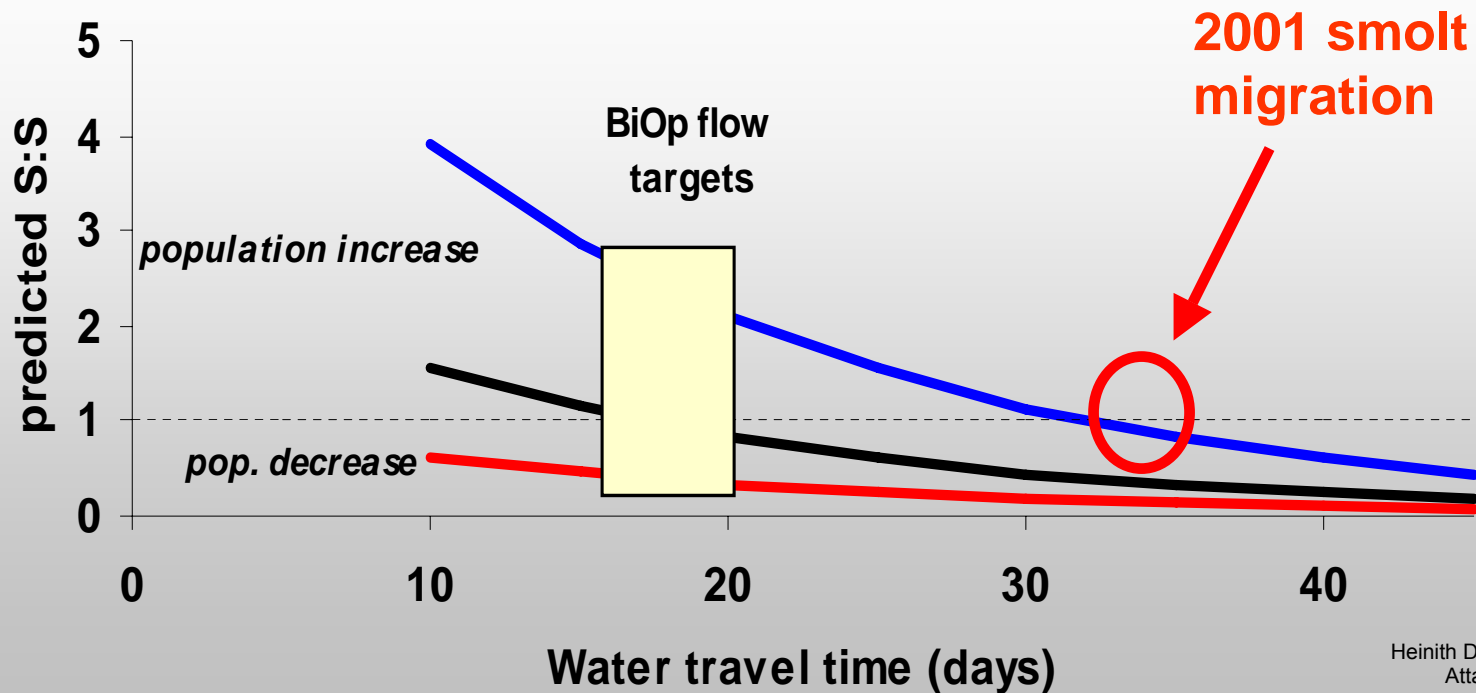


Heinith Declaration  
Attachment 5

Snake R. spring/summer chinook (7 PATH index stocks)

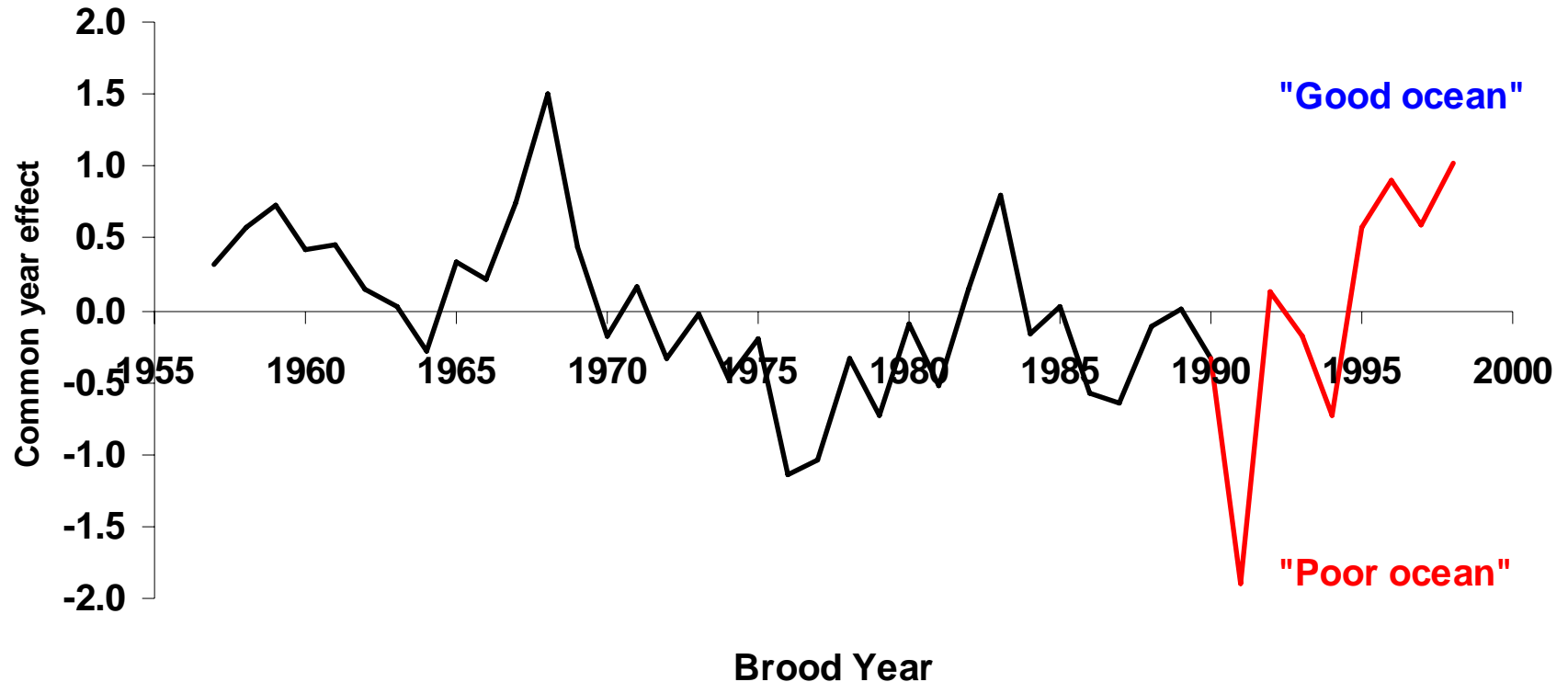
# Retrospective to Prospective:

2001 smolt migration, poor flows but “good” ocean  
Models predicted poor to mediocre returns from 2001, appear  
consistent with recent observations

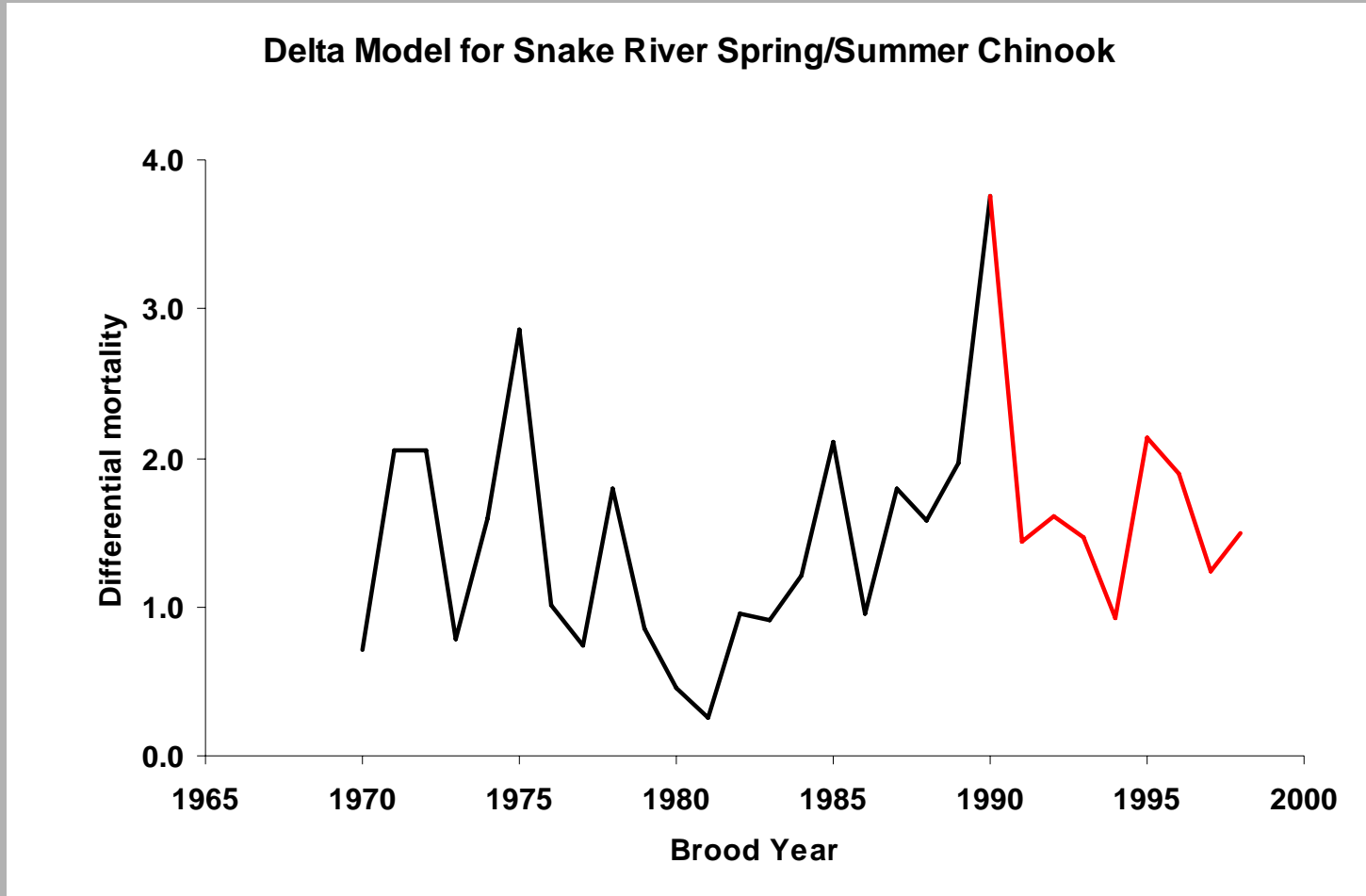


# Common year effect for Snake River and downriver (John Day) stocks

Delta Model for Snake River Spring Summer Chinook

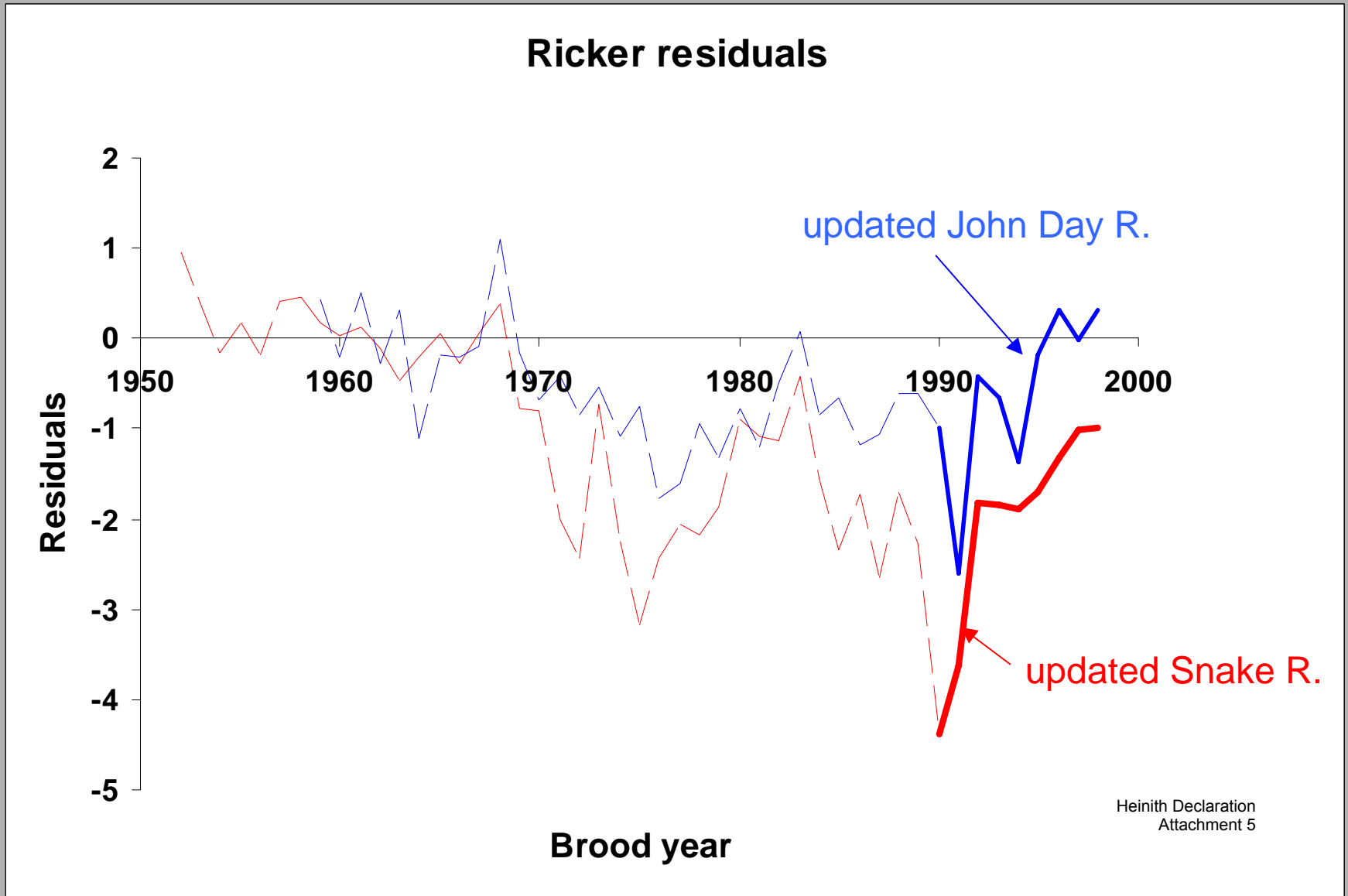


# Snake River stocks continue to show greater mortality than downriver stocks



How much is attributed to hydrosystem – direct and delayed mortality?

# Updated spawner recruit parameter estimates, 1991-1998 brood years



# Partitioning differential mortality, $\mu$ (Snake v. downriver)

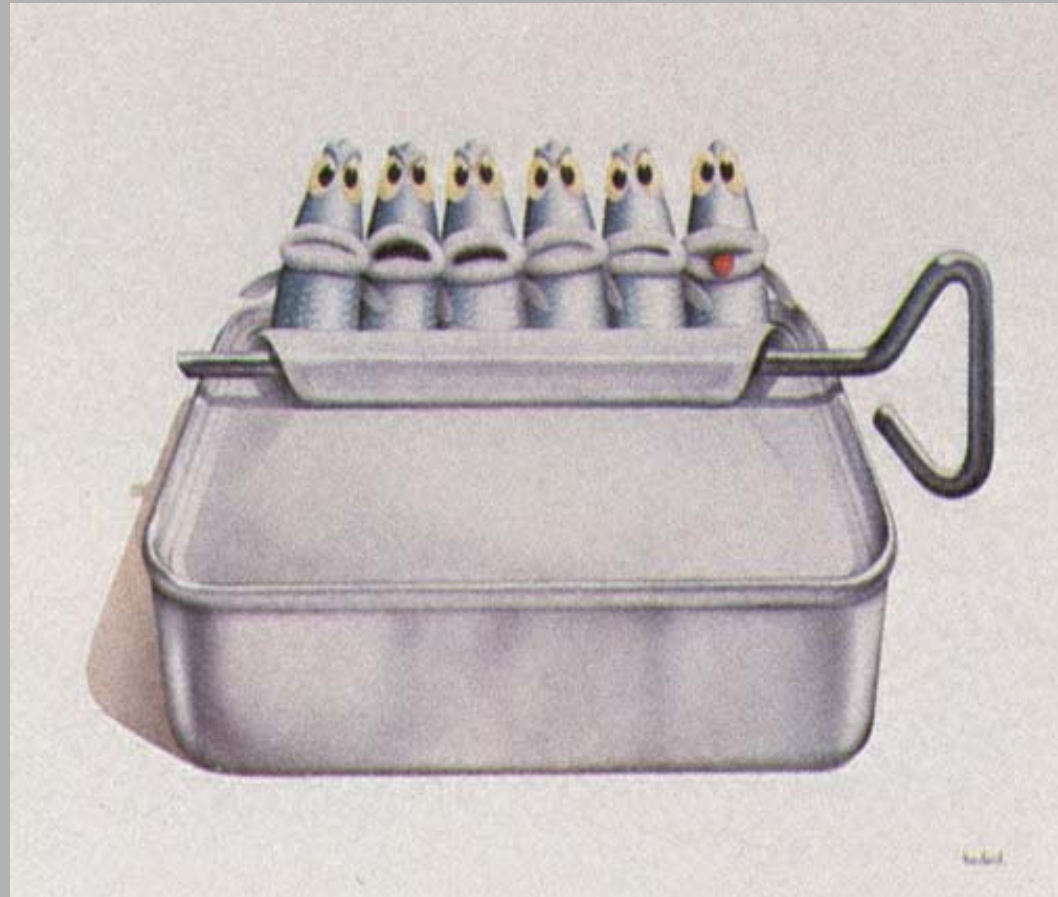
## Direct (LGR-BON):

in-river survival rate  
transport survival rate

## Delayed (BON to adult return):

differential delayed mortality of transported fish =  $D =$   
transport SAR/ in-river SAR

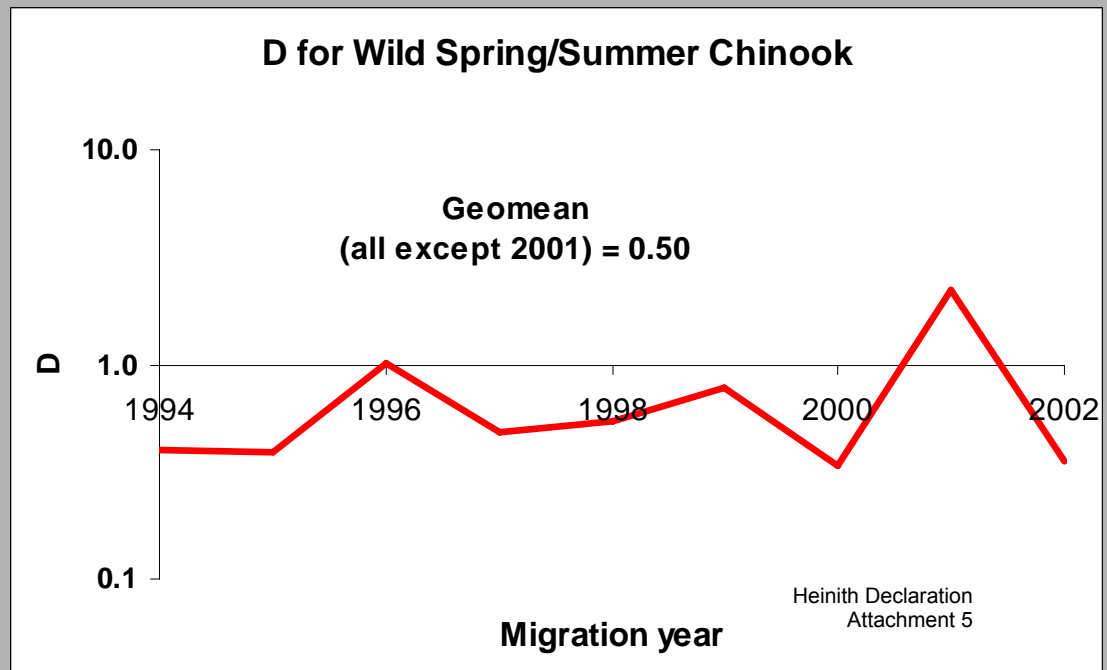
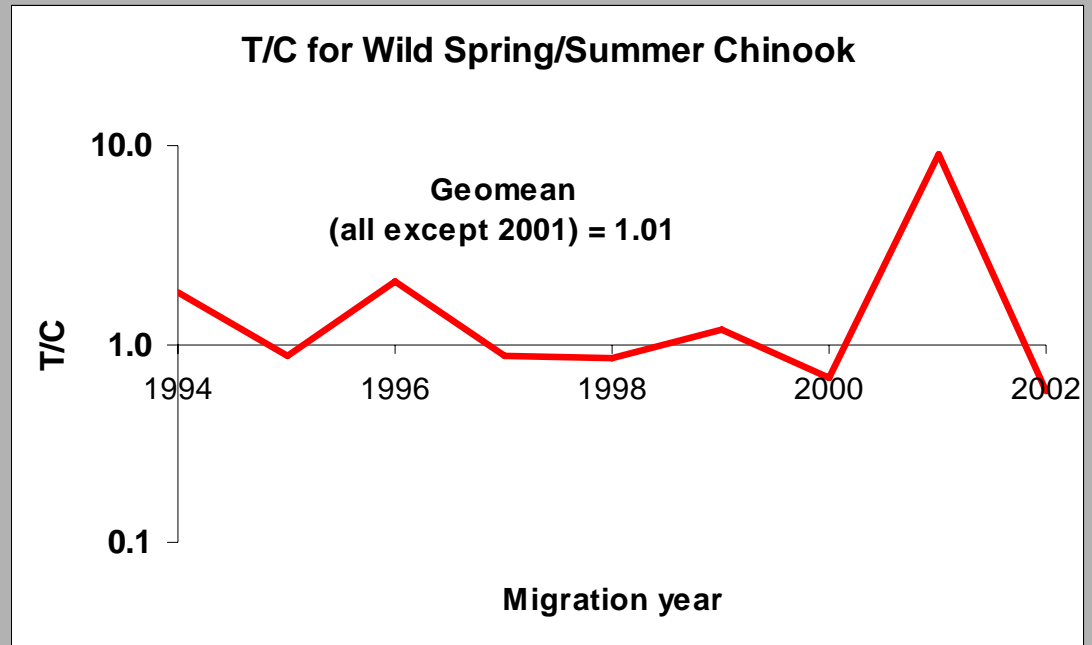
Delayed in-river mortality =  
 $\mu$  – direct & delayed components



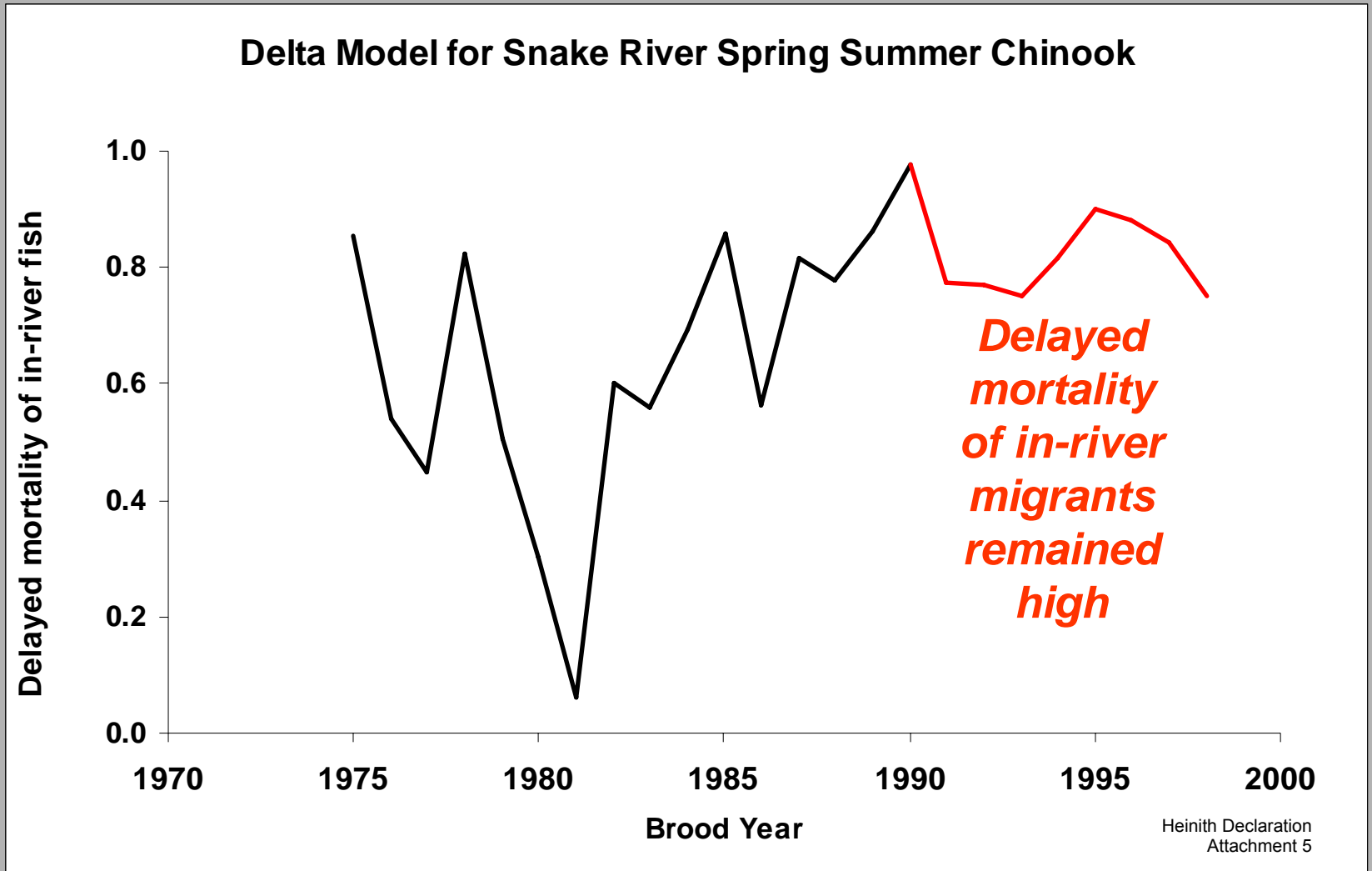
# CSS results:

*little to no benefit of transport to wild spring/summer chinook (except in low flow years)*

**T/C = 1.0**  
**D = 0.50**



# Delayed mortality of in-river migrants for Snake River stream-type chinook



# Summary

- Multiple lines of evidence show flow / survival relationship
- Recent increased recruitment and SARs apparent from improved ocean climate conditions
- Given BIOP flow targets, stocks are still at risk (under average-poor climate/ocean conditions)
- Degradation in flows will place stocks at higher risk.
- Snake River populations continue to show:
  - common survival patterns with downriver stocks
  - poorer recruitment and SARs than downriver stocks
  - delayed mortality remained high with improved ocean/climate conditions
- Poor ocean conditions will return, but when?
- Relative risk of hydrosystem options from PATH still appear relevant

# State, Federal and Tribal Fishery Agencies Joint Technical Staff

*US Fish and Wildlife Service*

*Columbia River Inter-tribal Fish Commission*

*Idaho Department of Fish and Game*

*Oregon Department of Fish and Wildlife*

February 26, 2003

Mark Walker  
Director, Public Affairs Division  
Northwest Power Council  
851 SW Sixth Avenue, Suite 1100  
Portland, OR 97204

Dear Mr. Walker,

We thank you for the opportunity to provide comment on the Independent Scientific Advisory Board's (ISAB) draft document "Review of Flow Augmentation: Update and Clarification" as it relates to the Northwest Power Planning Council's Draft Mainstem Amendments. The document provides several conclusions with which we agree:

- The ISAB's theoretical model (Appendix 4) of reach survival and the existing empirical evidence support the existence of a flow and survival relation. The alternative hypothesis of no flow survival relationship would require instantaneous mortality rates to increase as flows increased, contrary to the available empirical evidence on survival and fish travel time. In addition, for this alternate hypothesis to be true, numerous hypotheses about the interactions of fish with the biological and physical environment would also need to be true (see Attachment 1, specifically the new analysis on instantaneous mortality).
- We agree with the ISAB that for the Snake River, the empirical data show the most significant benefit to in-river survival results from flows of 100 Kcfs for spring migrants and 50 Kcfs for summer migrants. Survivals are adversely affected below these flows. These flow inflection points coincide with the Biological Opinion flow objectives.
- The ISAB appears to recommend that when flows are below the threshold of 100 and 50 kcfs for spring and summer migrants, which is lower than the Biological Opinion targets, the elimination of load following and peaking would maintain

survival at higher levels. Although untested, this presents an interesting concept that warrants further consideration.

- We agree with the ISAB conclusion that with respect to the Lower Snake proper, the greatest deviation from the Biological Opinion flow objectives resulting from the proposed amendments will occur during the summer months. Empirical data suggest the outcome will be a reduction in juvenile subyearling survival. However, we believe the proposed amendments would likely reduce peak flows in the Mid-Columbia and the lower Columbia. This would also reduce reach survival of juvenile Snake River migrants through the Lower Columbia and estuary and impact smolt to adult survivals of these salmon.

We do not agree with the ISAB's characterization of the flow augmentation paradigm, which they state, "asserts that in-river smolt survival will be proportionately enhanced by any amount of added water." Establishing reservoir draft limits and augmenting base flows with additional water are only the tools whereby the objective of providing migration flows is accomplished. The regions fishery agencies have long been working in concert with the National Marine Fisheries Service to ensure that, at a minimum, the flow levels specified in the Biological Opinion are provided during the juvenile fish migration. These levels of flow were originally selected based on existing data that suggested juvenile survival below these flows would be severely impacted. Others have recommended alternatives: the Columbia River Inter-Tribal Fish Commission has recommended a normative flow regime that more nearly resembles a natural hydrograph under various runoff conditions, and generally provides spring flows that are significantly greater than the existing targets. Data collected before and since the implementation of the Biological Opinion and presented to the ISAB both by the NMFS and the other fishery agencies and tribes in the FPC October 14 memo and the State, Federal, and Tribal Anadromous Fish Managers Comments on the Northwest Power Planning Council Draft Mainstem Amendments as they Relate to Flow/Survival Relationships for Salmon and Steelhead, substantiated the relation between flow and salmonid survival and validated the existing Biological Opinion flow targets at a minimum.

The ISAB undertook the task of accomplishing this significant review of flow augmentation at the Council's request, and admittedly there was limited progress that could be made within the short (two and a half month) time frame allotted. We recognize the time limitations forced the ISAB to narrowly focus on responses to specific questions formulated by the Council. Also, the short time frame made it difficult for the ISAB to review all materials submitted. In spite of this narrow focus the ISAB Report ventures beyond that objective. Consequently, the report raises several issues that were not adequately studied and suggests alternatives that were not fully considered. For example,

- The report concludes, "it may be possible to achieve improved survival of juvenile salmonids through the lower Snake River reaches and their dams, even at lower flows". This statement is not supported by empirical evidence. The premise in the ISAB report that survival could be maintained with lower flows if load following or peaking were eliminated and flat stable flows were provided is an interesting concept. However, load following is reflected in the data that has

- been collected to-date that shows a flow survival relation. Elimination of load following might provide benefit that would be additive to flow augmentation, but should not be substituted for flow augmentation without a long time series of empirical data justifying substitution.
- The ISAB assessment of the peaking and load following effects was based upon peaking regimes in January and February at which time there are few juvenile migrants present. The magnitude of the load following in January is significantly greater than observed during the juvenile migration, during the passage period specified in the Biological Opinion. This is because during the juvenile migration period the Snake River reservoirs under the Biological Opinion are restricted to a one foot operating range above minimum pool levels, which limits the amount of load following that can be accomplished (see Attachment 2).
  - The ISAB bases a significant amount of their review on an October 14 memo from the Fish Passage Center and data presented by the National Marine Fisheries Service describing the relation between flow and juvenile survival. Many questions raised by the ISAB in this report have already been addressed in a more comprehensive document, “State, Federal, and Tribal Anadromous Fish Managers Comments on the Northwest Power Planning Council Draft Mainstem Amendments as they Relate to Flow/Survival Relationships for Salmon and Steelhead.” This report was provided to the ISAB during their review period and questions posed by the ISAB regarding the report were addressed both verbally (December 17, 2002) and in writing (Jan. 10, 2003 memo to ISAB) (Attachment 3). This comprehensive document among other topics includes smolt to adult return (SAR) information and its relation to flow levels experienced during the juvenile migration. Had there been sufficient time allotted for this important review the ISAB could have used the SAR information, which may have enriched their view of the importance of flow to all life stages of salmon. Including adult return analysis would have been beneficial in assessing the potential effect of the draft NWPPC amendment. We strongly recommend that the ISAB complete their review of flow augmentation by including the adult return analysis.
  - The ISAB comments that the radio tagging information on subyearling migrants implies that load following for subyearling migrants is a key factor in the increase in mortality observed. The ISAB suggests an untested hypothesis regarding fish response to turbulent flow as a potential mechanism for increasing mortality. However, the ISAB did not consider a real time proven response for subyearling migrants, the potential use of spill operations to facilitate juvenile passage and reduce delay through slack water, low velocity forebays. Spill does not require additional water from storage reservoirs.
  - Although the ISAB report primarily focused on in-river migrants, the issue of arrival in the estuary too early for survival is discussed as part of their perceived paradigm of the relation between flow and survival. However, early arrival to the estuary is unlikely to apply to in-river migrants and most likely is more important to fish that are transported. We agree with the ISAB that there is a need to

determine the relation between early arrival in the estuary for transported smolts and its subsequent effect on survival to adulthood.

The NWPPC specifically requested that comments address the implications for the Council's deliberations on the mainstem amendments. While we agree with the ISAB conclusion that a significant impact of the proposed amendments will occur during the summer months and will be observed as a reduction in juvenile subyearling survival, as we stated above, we do not agree with the ISAB's conclusion that there will be no discernable effects on the survival of spring migrating salmonids. Data were provided to the ISAB depicting the different migration timing associated with stocks of spring chinook. These data suggest that early migrating stocks, the Imnaha spring/summer chinook in the lower Snake, as well as the John Day and Umatilla stocks in the lower Columbia that migrate in April prior to peak discharges are in peril of experiencing significantly lower flows during their migration period due to the implementation of the proposed amendments. The relaxation of the April 10 upper rule curve requirement of the Biological Opinion is likely to lead to deeper winter drafting of reservoirs for power needs and result in the need to refill reservoirs more intensely in early spring during the time periods when these fish migrate.

In conclusion, we believe that the ISAB report supports the biological rationale for the minimum flow objectives contained in the NMFS Biological Opinion. The ISAB report presents additional hypotheses for future study that are of some interest, although there is little data at the present time to support these hypotheses. The ISAB does suggest some operational changes in river operation that may offer benefits when Biological Opinion flow objectives cannot be met, which warrant further study and consideration.

Sincerely,



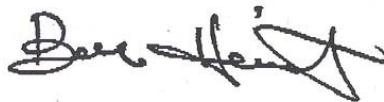
Howard A Schaller, USFWS



Steve Pettit, IDFG



Ron Boyce, ODFW



Bob Heinith, CRITFC

ATTACHMENT 1. Appendix A of US Fish and Wildlife Service comments on *Draft Mainstem Amendments to the Columbia River Basin Fish and Wildlife Program*

Appendix A - US Fish and Wildlife Service review of the Northwest Power and Conservation Council's approach to the flow-survival relationships for spring migrant juvenile salmon and steelhead contained in the *draft Mainstem Amendments to the Columbia River Basin Fish and Wildlife Program*  
February 4, 2003

We are concerned about the way the document frames and makes inferences from hypotheses about the existence of a relationship between volume of flow, acting through its effect on water particle velocity, and survival of migrating smolts. The draft mainstem amendments document, as part of the rationale for repudiating the flow targets of the Biological Opinion (BiOp), states that “[r]esearch has not validated the predicted benefits of flow augmentation from upstream storage reservoirs” (p. 31, lines 9-10). This viewpoint, together with the conclusion that available evidence for a flow-survival relationship is lacking, imply that a particular hypothesis test has been set up, and inferences made. Specifics of the test are not provided by the Council, but can be inferred. The document contains no indication that alternatives to the chosen hypothesis test were considered, that alternative methods of analyzing relevant data were considered, or that the vast amount of information about juvenile salmonid migration was factored into the conclusions.

The Council appears to have implicitly formulated a null hypothesis that there is no flow-survival relationship (or more specifically, that providing greater volumes of flow to meet targets, thus increasing water particle velocity, does not in general lead to increased survival rates). The alternative hypothesis is presumably that there is a positive relationship between flow and survival. A formal decision analysis to distinguish the relative likelihood of these hypotheses can be conducted in a number of ways. A statistically appropriate test would at the least explicitly state both the choice for acceptable level of probability of Type I error (incorrectly rejecting the null hypothesis) and the resulting power of the test ( $= 1 - \text{Type II error probability}$ , where a Type II error is failing to reject the null hypothesis when it is in fact false). The statistical power of the test (the probability of correctly rejecting the null hypothesis, given that the alternative hypothesis is true) will also depend on the natural variability and error in measuring data on survival at different flow levels, as well as the effect size. The effect size in this case is the degree to which survival depends on flow (e.g. the slope of a line relating survival and flow), and should be a biologically significant amount. The Council's position that no flow-survival relationship has been demonstrated is not accompanied by analyses of statistical power estimating the ability to find such a relationship in existing data, if it does in fact exist. Power would likely be low with short data sets, given error and uncertainty in survival estimates and natural variability.

The Council's conclusions are influenced by their decision about where the burden of proof lies, i.e. that unless meeting flow targets can be proven conclusively to increase survival rates, they should be abandoned in favor of presumably more certain upstream biological and economic benefits. Presumably, the Council would be more willing to accept a Type II error than a Type I error. However, there are reasons why a more precautionary approach to hypothesis testing is warranted in endangered species contexts. Steidl and Thomas (2001) cite investigators who have suggested that Type II errors be considered paramount when monitoring endangered species; or at least that Type I and

Type II errors be balanced based on their relative costs. Shrader-Frechette and McCoy (1992) give reasons why in applied cases, Type I error is often more acceptable than Type II error, whether the null hypothesis is “positive” (no harm) or “negative” (no benefit). Type II error leads to possible harm or loss of benefit, respectively. In endangered species recovery activities, if a Type II error is committed, a population could be on its way to extinction before the decline is detected and preventative action is taken. Conversely, if the population is monitored after initiating recovery actions (such as implementing hard flow targets), and the population is actually increasing, a Type II error would lead to the mistaken inference that the actions are not having the desired effect, perhaps jeopardizing continuance of those actions.

Proper consideration of the possible detrimental effects of failing to meet flow targets requires acknowledging the limitations inherent in the available empirical data on flow and survival. It should be kept in mind, for instance, that it’s difficult to accurately characterize exact hydrological conditions experienced by individual release groups in the survival studies: “Identifying and quantifying relationships between environmental variables and travel times or survival of PIT-tagged migrant juvenile salmonid release groups in the Snake River present difficult challenges. Among these is defining the environmental conditions to which a release group is exposed.” (NMFS 2000). The most relevant question we can ask in light of these limitations of data is not whether we can tease out effects on highly variable survival estimates from small variations in flow within a season. Many factors affecting survival probability will always remain outside of management influence. A more relevant question is, over a longer time series, given a representative range of uncontrolled variation in factors affecting survival, are greater flows *on average* associated with higher survival rates?

A plot of survival rate under different flows and different uncontrolled factors may help illustrate the difficulties in detecting a true relationship between flow and survival, given that uncontrolled factors also are certain to affect survival rate. Uncontrolled (and unmeasured) factors might be intrinsic, such as smolt physiological condition, or they could be largely external (e.g. predator density-dependent functional response). If we consider a component of survival (or mortality) that is influenced by uncontrolled factors, and one that is influenced by flow, the flow-survival relationship could be obscured by either random or directional variation in uncontrolled survival factors. Variation within a season will tend to obscure an intra-annual flow-survival relationship, and variation between years will tend to obscure an inter-annual flow-survival relationship. In Figure 1, a hypothetical composite factor, which can take values from 0 to 1, is shown on the x-axis, with resulting survival rate shown for low, medium, and high flows. The x-factor survival component varies as a negative exponential function of x-factor value, while flow-induced survival varies as a positive exponential function of flow. We can see from the figure that even though there is positive flow-survival relationship (i.e. at a given uncontrolled factor level, higher flows always result in higher survival), it could be lost in the data if the uncontrolled factors vary within a season or between years. For example, a year with higher flow may have also have a higher x-factor, resulting in lower overall survival than a year with lower flow but lower x-factor.

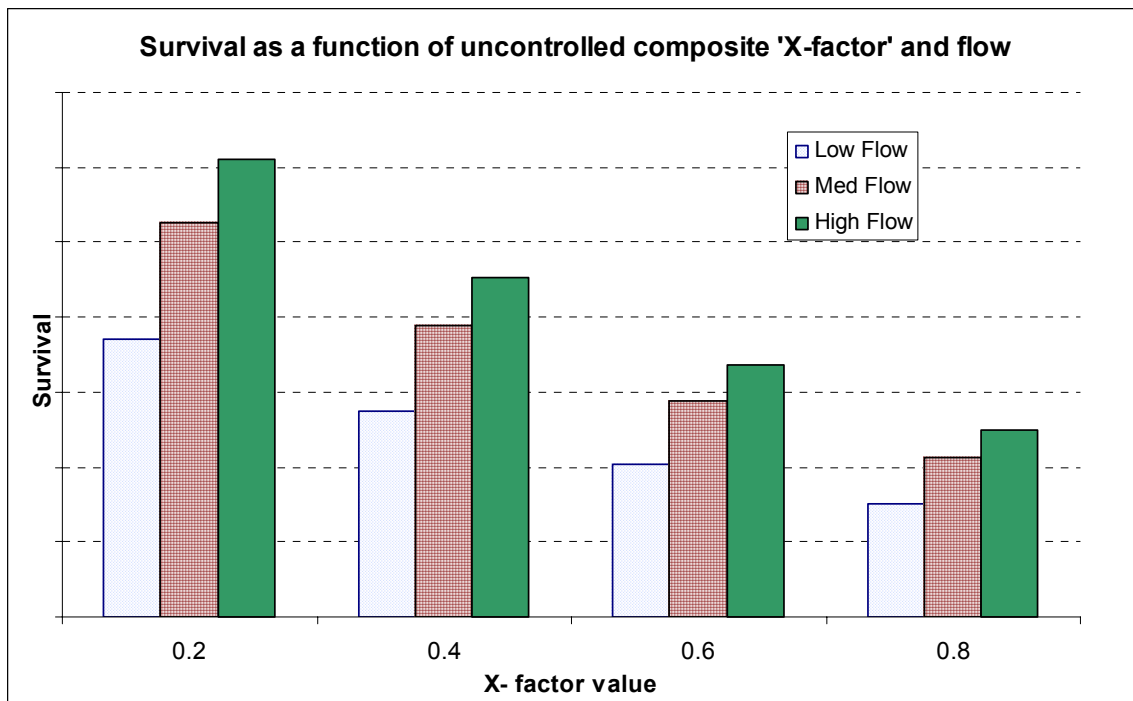


Figure 1. Hypothetical response of survival to composite uncontrolled factors and flow.

Given these caveats, we can look at how estimates of survival rates, from the 1970s through the most recent years, vary with water particle travel time (WTT). WTT is used as a surrogate for flow, since at constant reservoir volumes, there is a strong inverse correlation between flow volume and WTT, and because WTT estimates over reaches which include the Snake and Columbia rivers integrate the effect of flows in the relevant reservoirs. We plotted empirical survival rate-per-kilometer (s/km) estimates from NMFS studies against water travel time. The s/km and WTT values are derived from the longest reach estimate over which NMFS made a survival estimate in that year, and the length in km of that reach. Survival estimates in figures are standardized to the approximate length of hydrosystem (500 km). Flow values corresponding to selected points are shown in parentheses (Snake flow, Columbia flow) to place the variation in flow between years in context. Survival-per-km is a better index than per-project for comparing survival rates among different years and different reach lengths. In 2001, for example, per-project survivals for short reaches would have grossly overestimated survival through the entire hydrosystem (FPC 2002). An alternative method of comparing survival among years, using the data sets with consistent reaches over years demonstrated a relationship between flow and reach survival (FPC 2002).

Figure 2 shows data for yearling chinook, from the full time series. With data from the 1970s included, there is a significant survival /WTT relationship.

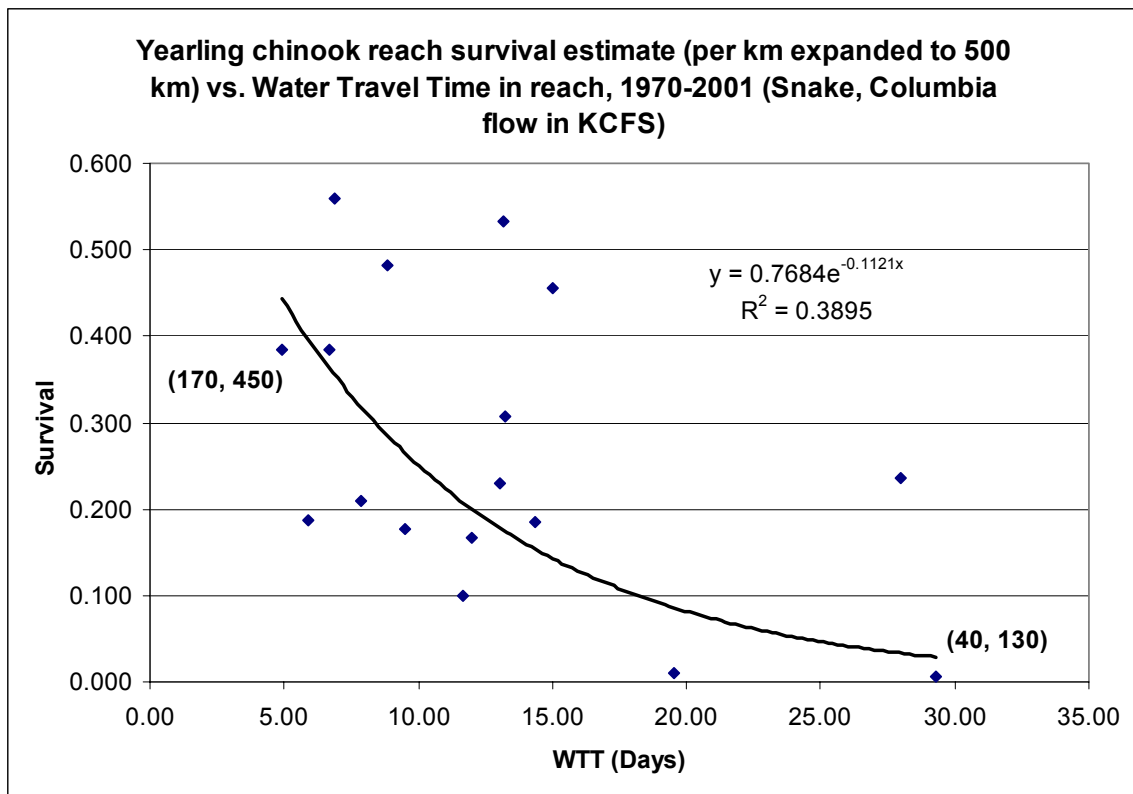


Figure 2.

The inclusion of data from 1970-80 is controversial, as some believe unique conditions in some of those years resulted in some low flow/low survival years that would not occur again. For yearling chinook, with the recent, PIT-tag data only, no survival/WTT relationship is apparent (Figure 3).

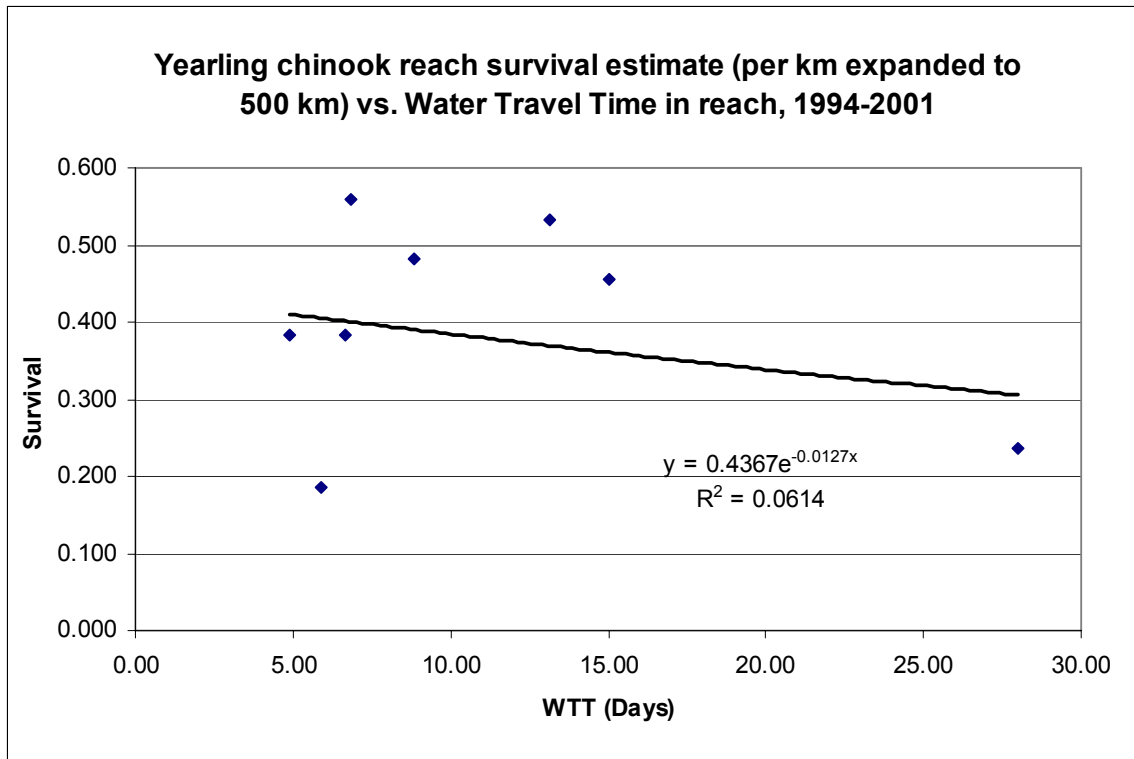


Figure 3.

Figure 4 shows the results for migrating steelhead with the full time series. A strong survival-WTT relationship is indicated.

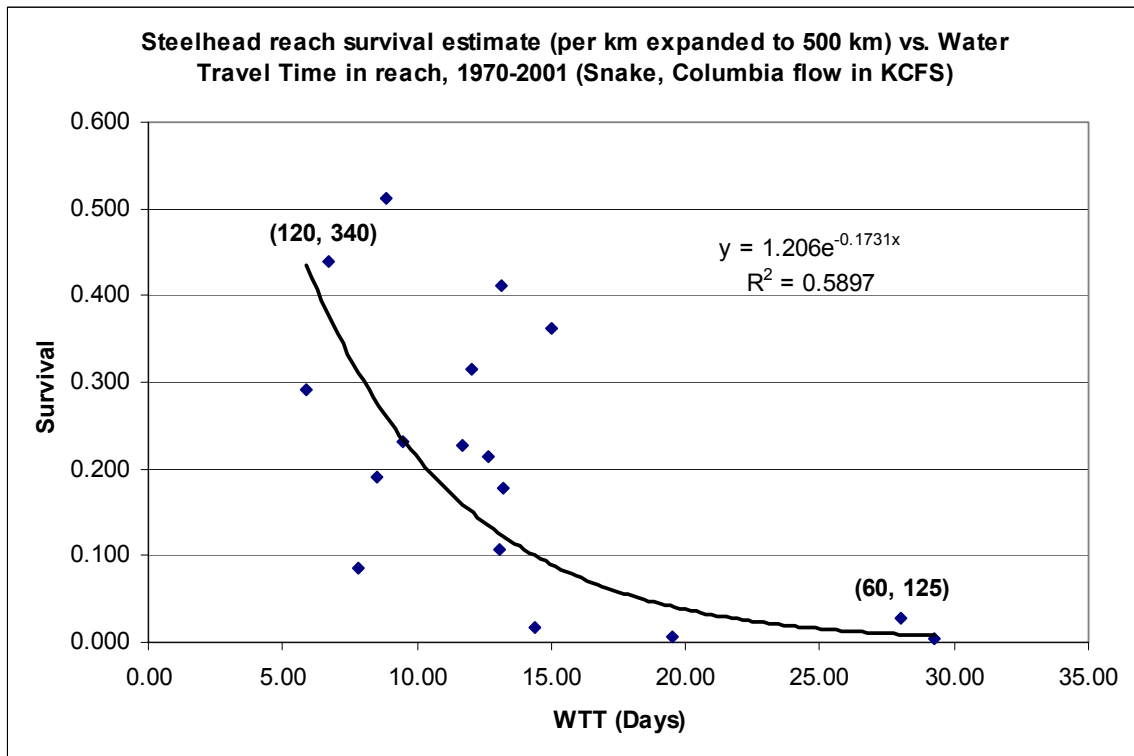


Figure 4.

When we exclude the older data, and use only the PIT-tag data, the survival-WTT relationship for steelhead seems even stronger (Figure 5).

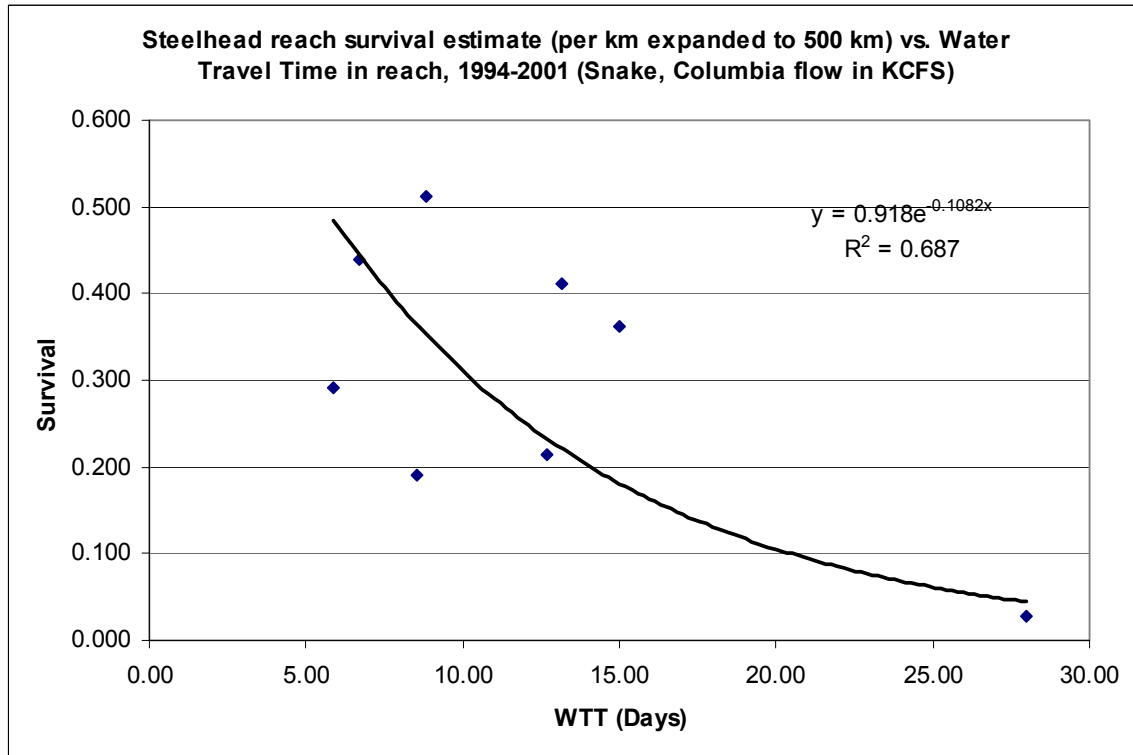


Figure 5.

A formal power analysis can be done for the data presented. Because no relationship was found for chinook using PIT-tag data only (Fig. 3), we perform an analysis of power to detect an exponential survival-WTT relationship on this data set. We assume a one-tailed hypothesis test on the slope of natural log of survival vs. WTT; i.e. the null hypothesis is that  $b \geq 0$ ; and the alternative hypothesis is  $b < 0$  (representing a positive relationship between flow and survival). The observed standard deviations of the X and Y values are used, with different levels of "true" underlying values of  $b$ . Power for the regression is estimated as in Zar (1984, section 19.4) using the correlation coefficient  $r$  (which is directly proportional to  $b$  if the ratio of standard deviations of X and Y is held constant). An alpha value (Type I error rate) of .05 is used. The results are shown in Figure 6 for the 8 years of PIT-tag data.

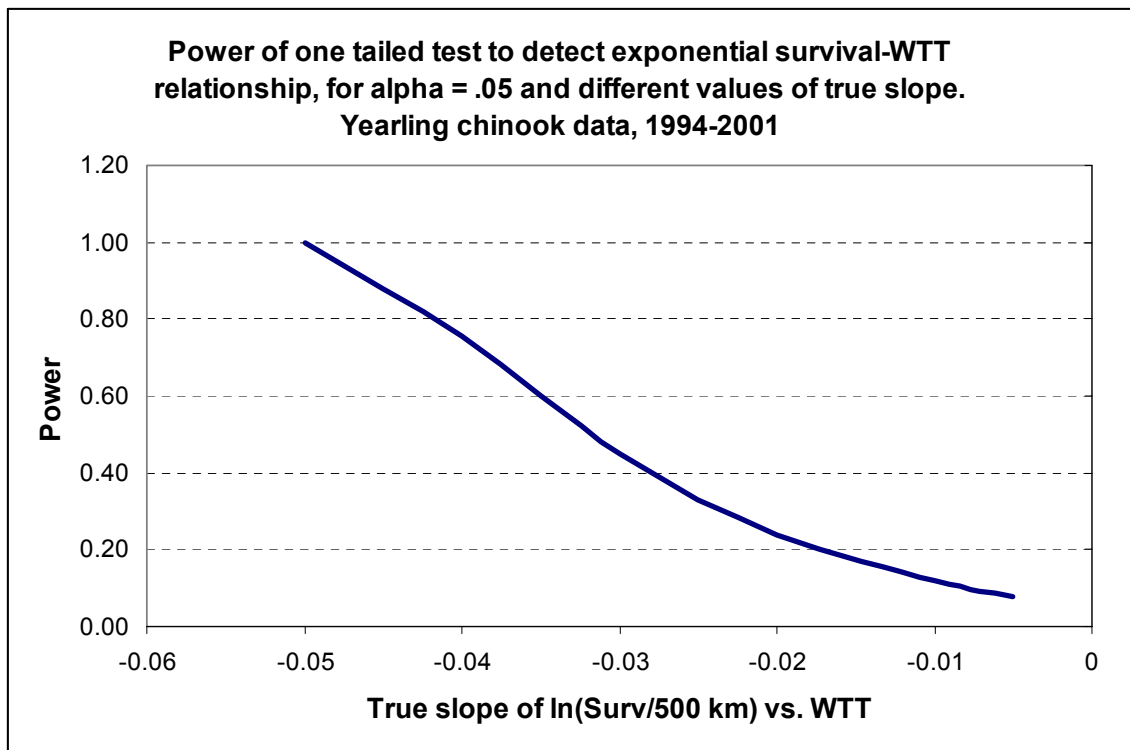


Figure 6.

A commonly accepted target value of statistical power to reject the null hypothesis at alpha = .05 is 80%. Figure 6 shows that this much power would not be expected unless the absolute value of the slope were greater than .04. In other words, there is a substantial chance that a true relationship of as much as -.04 is going undetected in the data. A *b* value of -.04 represents an additional 4% mortality for every additional day of water travel time.

The appropriateness of using data from the 1970s to help inform management of the hydrosystem today is in dispute. However, it is telling that, despite the inherent natural variability, anthropogenic sources of variability, and error in estimation of survival rates, leading to low statistical power to detect flow-survival relationships, three of the four relationships show a significant survival-WTT relationship. We also note that the figures presented fit a simple exponential curve to the data. Using a more realistic and flexible two-parameter curve, such as was used in FLUSH (one of the juvenile passage models used in PATH: Marmorek and Peters 1998), would doubtless result in higher  $R^2$  for the cases where a significant relationship was found.

Another caution applies to the analyses above, and to any inferences made from the reported NMFS annual survival rates. There is a misconception among some in the region that annual reach survival estimates from PIT-tags are “primary data”, not sensitive to assumptions or method of calculation. The Comparative Survival Study (CSS) has calculated reach survival estimates for yearling chinook and steelhead for the years 1994-2002 with a validated survival estimation program using raw PIT-tag data. CSS found that annual PIT-tag survival estimates are sensitive to the way that tag release

groups at Lower Granite Dam are blocked within the season (i.e. daily blocks, weekly blocks, or longer periods). Calculating the season aggregate or using 3-7 time blocks (cohorts) sometimes gives very different values than using daily LGR cohorts, as NMFS does. Uncertainty about the best estimate of annual reach survival may hamper the ability to detect flow-survival relationships, and it should be acknowledged as a possible confounding factor when evaluating evidence for flow-survival relationships in PIT-tag data.

It's useful also to look at evidence for relationships between flow (WTT) and migration rate or travel time of spring migrants. Speeding up the journey through the hydrosystem is a candidate mechanism for increased flow leading to increased survival. Both historical and recent data provide strong, uncontroversial evidence of a flow-fish travel time relationship for yearling chinook and steelhead. For example, both passage models in PATH had strong positive fish travel time-WTT relationships, despite the fact that the survival-fish travel time relationships in the models differed substantially (Marmorek and Peters 1998). NMFS (2000) found "A strong and consistent relationship exists between flow and travel time for spring migrants. Increasing flow decreases travel time." Smith et al. (2002) found that for both chinook and steelhead, travel time strongly correlated with flow volume. These findings that spring migrating smolts appear to rely on swiftly moving water to get downstream is consistent with evolutionary life-history strategies of both species in their natural environment.

Given that WTT (and hence flow) is closely linked to fish travel time, a hypothesis about existence or strength of flow-survival relationship necessarily implies a hypothesis about whether or how much mortality rate (or survival rate) changes with time in the system. In PATH, this was a key point of controversy: disagreement between the two passage models revolved around the rate of mortality. In CRiSP the daily rate of mortality was essentially constant over time while in FLUSH the rate of mortality increased the longer fish are in the river (Marmorek and Peters 1998, Section 4.2, WOE Submission 14). Whether mortality rate increases with time, or stays constant with time, there will be a flow-survival relationship since fish travel time is directly proportional to water travel time. This is because under either assumption, total mortality increases with time, and since over a fixed distance, faster water velocity results in fewer days spent in the hydrosystem, there will be less mortality when flows are higher (all else being equal). In contrast, the hypothesis that there is no flow-survival relationship necessarily implies that, on average, daily mortality rate increases with flow, since in years with higher flows fish are traveling faster but experiencing the same total mortality (all else being equal) through the system as at lower flows.

A graph of the form of the relationship between daily mortality rate and WTT (flow) for the three hypotheses is shown in Figure 7. The FLUSH hypothesis, of course, results in a fairly strong survival-WTT relationship, when the increasing daily mortality rate combines with the fish travel time-WTT relationship. The CRiSP constant mortality hypothesis also results in a survival-WTT relationship because of the fish travel time-WTT relationship, though not as strong as in FLUSH. The hypothesis which reflects the assumption of no-flow survival relationship (No Q-S) requires that daily mortality rate increases with flow.

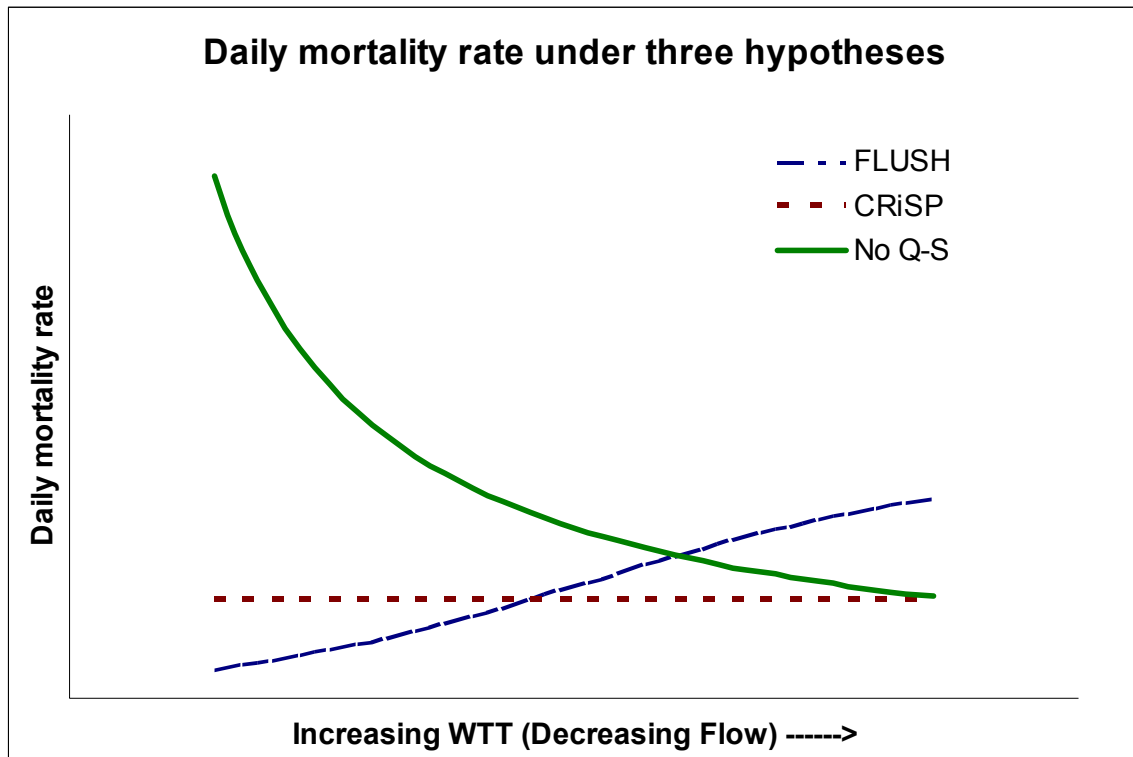


Figure 7.

The “no flow-survival” hypothesis implies specific hypotheses about the interaction of the fish and the biological and physical environment. These hypotheses must be true for survival to be independent of flow, given that fish move faster as flow increases. The overall set of hypotheses has been termed the “gauntlet” hypothesis. For the gauntlet hypothesis to be true, mortality agents the fish face in the hydrosystem must not be, on average, appreciably affected by the amount of flow. This requires that:

- Predator *distribution* is not modified so as to alter consumption rates
- Predator *behavior* is not modified so as to alter consumption rates
- Predator consumption rates are not related to prey migration speed (i.e. encounter time not related to consumption rate)
- Exposure of smolts to increased temperatures under low flows (due to migration extending longer into season) does not affect consumption rates
- Exposure to increased temperatures does not increase smolt mortality from sources other than predation
- Survival per day must be higher in low flow years than in high flow years

Using the available survival and fish travel time data, we can evaluate evidence for the no flow-survival hypothesis, versus for those which imply a positive relationship between flow and survival. To do this, we need to use data from a consistent reach; otherwise variations in the rate of survival (or mortality) per day between years could be attributable to differences in the reaches traversed, rather than any relationship between flow and mortality per day. We use published estimates of annual survival rates and

median travel times for primary release groups from the PIT-tag studies, for both yearling chinook and steelhead. The reach over which survival was estimated has included more projects as PIT-tag detectors have been installed at lower river dams. However, the longest reach (Lower Granite Dam to Bonneville Dam) has been available for only the last few years. From 1995 to 2001, for both chinook and steelhead, survival estimates were made for the reach from LGR Dam tailrace to McNary Dam and this was the reach used (estimates were made from LGR to Lower Monumental Dam in 1994 as in other years; however this reach was judged too short to give relevant information). In years when travel times were estimated from LGR to MCN dam, annual median travel time is estimated by weighting each release group's median by the group's proportion of the total number of PIT-tagged fish released at LGR dam. In the other years (1995 for both chinook and steelhead and 1996 for steelhead), weighted median travel times from Port of Wilma to MCN and from Port of Wilma to LGR were estimated, and the latter subtracted from the former to come up with median LGR to MCN travel time. Survival rate per day was then calculated by taking the  $t^{\text{th}}$  root of LGR to MCN survival rate, where  $t$  is LGR to MCN median fish travel time. Daily mortality rate is  $1 - \text{daily survival rate}$ .

Table 1 shows the data sources for survival rate and travel time estimates. The results of the mortality rate calculations plotted against spring migration water travel time estimates are shown in Figures 8 and 9.

Table 1. Sources of data used in mortality per day analysis: reference (table numbers).

| Year | Chinook survival rate | Chinook travel time | Steelhead survival rate | Steelhead travel time |
|------|-----------------------|---------------------|-------------------------|-----------------------|
| 1995 | 1 (2)                 | 2 (D1, D9)          | 1 (2)                   | 2 (D2, D10)           |
| 1996 | 1 (2)                 | 3 (19, D3)          | 1 (2)                   | 3 (C1, C5)            |
| 1997 | 1 (2)                 | 4 (11)              | 1 (2)                   | 4 (9)                 |
| 1998 | 1 (2)                 | 5 (25)              | 1 (2)                   | 5 (23)                |
| 1999 | 1 (2)                 | 6 (26)              | 1 (2)                   | 6 (28)                |
| 2000 | 7 (1)                 | 7 (27)              | 7 (10)                  | 7 (31)                |
| 2001 | 8 (1)                 | 8 (27)              | 8 (10)                  | 8 (31)                |

- 1 Williams et al. (2001)
- 2 Muir et al. (1996)
- 3 Smith et al. (1998)
- 4 Hockersmith et al. (1998)
- 5 Smith et al. (2000a)
- 6 Smith et al. (2000b)
- 7 Zabel et al. (2001)
- 8 Zabel et al. (2002)

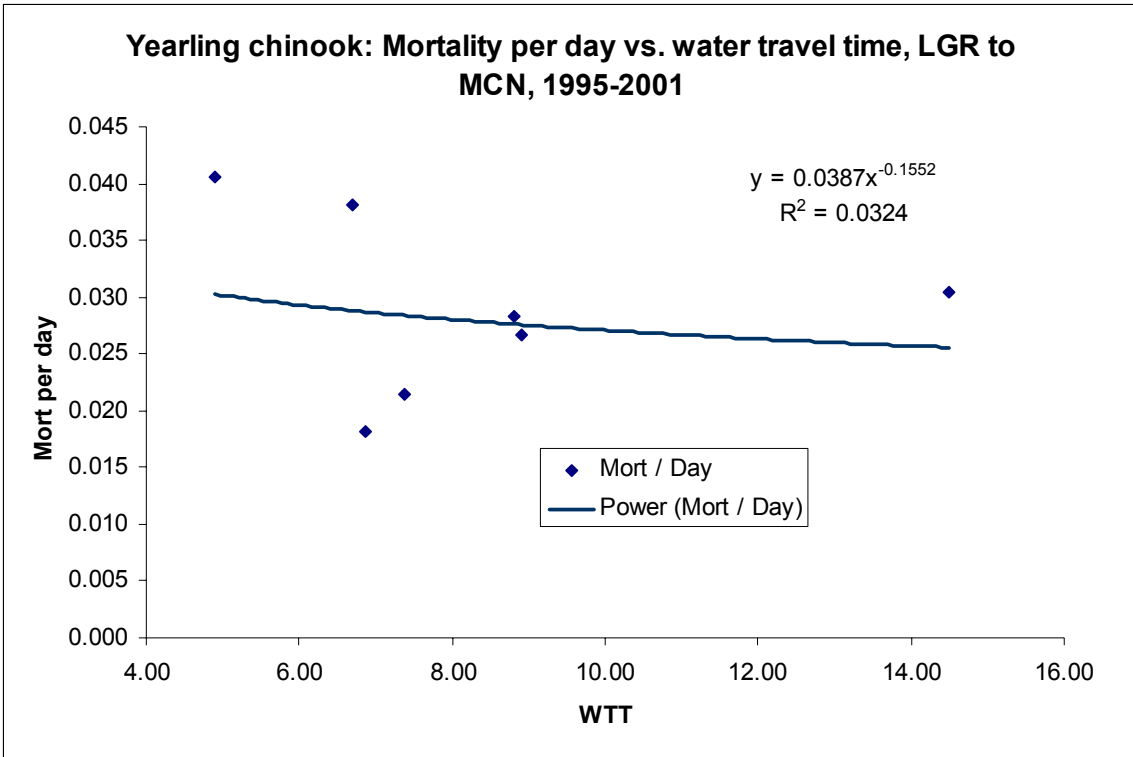


Figure 8.

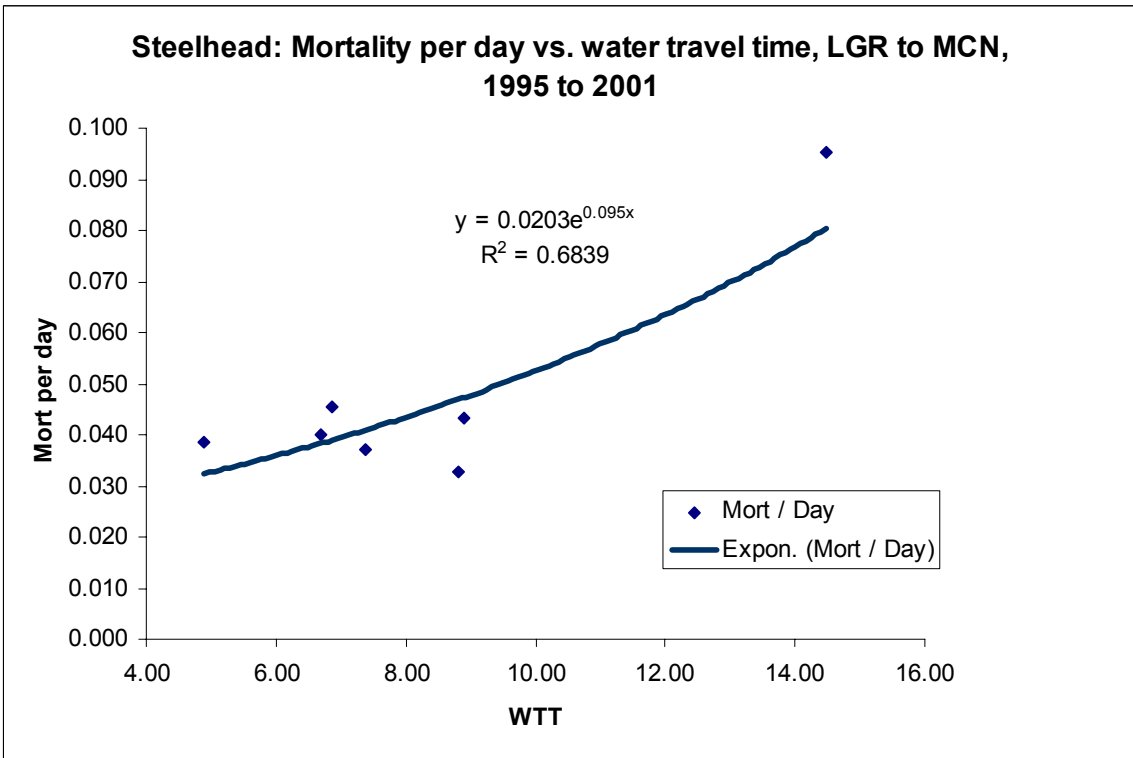


Figure 9.

The trend line fitted for chinook in Figure 8 is a power curve. If the no flow-survival hypothesis were correct, we would expect mortality per day as a function of water travel time to tend to follow a power curve with a negative exponent. The low  $R^2$  suggest that the data do not follow this kind of curve, and the no-flow survival relationship hypothesis is not supported. With steelhead (Fig. 9), fitting a power curve gives a positive exponent. An exponentially increasing trend (shown) fit the data even better. The steelhead data also do not support the no flow-survival hypothesis, and in fact show evidence of mortality rate increasing, rather than decreasing, with time.

A weight of evidence process that compared the evidence for the different hypotheses could be undertaken. This would include any empirical information from the river system under discussion, as well as evidence from the general literature about the mechanisms affecting chinook, steelhead, and related species in other systems. The last bullet point above was examined here using annual survival rates and weighted annual median travel times from the annual reports of NMFS survival studies and CSS PIT tag studies.

Finally, apart from the question of whether there is an observable, or expected, relationship between flow and survival of juvenile migrants within the hydrosystem, there are other reasons to be cautious about abandoning flow targets. These include the appropriate placement of the burden of proof (discussed earlier), effects to survival outside of the hydrosystem (discussed elsewhere), the precautionary principle, and the wisdom of a formal decision analysis removed from the traditional null/alternative hypothesis testing format. A rigorous weight of evidence approach would include findings and considerations from previous work, seen in the context of the species' entire life cycle and the greater management framework. Sample considerations can be found in the NMFS white paper on flow and survival (NMFS 2000):

- “Thus, higher flows, while decreasing travel time, may also improve conditions in the estuary and provide survival benefits to juvenile salmonids migrating through the estuary or the Columbia River plume. By reducing the length of time smolts are exposed to stressors in the reservoirs, higher flows also likely improve smolt condition upon arrival in the estuary.”
- “Since a migration rate/flow relationship has been established repeatedly for spring migrants, the focus of flow augmentation in the spring should be to decrease travel times and hence shift arrival timing in the estuary closer to historical timing, with the assumption that arrival timing has been under evolutionary control.”
- “Certainly, increased flows, particularly when base flows are low, will not harm spring migrants. Given the critical levels of many spring migrating stocks, continuing the flow augmentation program is consistent with a ‘spread the risk’ strategy.”

## References

- FPC (Fish Passage Center). 2002 Draft comments on Zabel et al. (2001), "Draft Survival estimates for the passage of spring-migrating juvenile Salmonids through Snake and Columbia River dams and reservoirs, 2001". Northwest Fisheries Science Center, National Marine Fisheries Service.
- Hockersmith, E. E., S. G. Smith, W. D. Muir, B. P. Sandford, J. G. Williams, and J. R. Skalski. 1999. Survival estimates for the passage of juvenile salmonids through Snake River dams and reservoirs, 1997. Report to Bonneville Power Administration, Contract DE-AI79-93BP10891, Seattle, Washington.
- Marmorek, D. R., and C. N. Peters, editors. 1998. Plan for Analyzing and Testing Hypotheses (PATH): Weight of Evidence Report. Compiled and edited by ESSA Technologies Ltd., Vancouver, British Columbia.
- Muir, W. D., S. G. Smith, E. E. Hockersmith, S. Achord, R. F. Absolon, P. A. Ocker, B. M. Eppard, T. E. Ruehle, J. G. Williams, R. N. Iwamoto, and J. R. Skalski. 1996. survival estimates for the passage of yearling chinook salmon and steelhead through Snake River dams and reservoirs, 1995. Report to Bonneville Power Administration, Contract DEAI79-93BP10891, and U.S. Army Corps of Engineers, Project E86940119, Seattle, Washington.
- NMFS. 2000. White Paper: Salmonid travel time and survival related to flow in the Columbia River Basin. Available at: <http://www.nwfsc.noaa.gov/pubs/white/whiteflow.pdf>.
- Shrader-Frechette, K.S., and E.D. McCoy. 1992. Statistics, costs and rationality in ecological inference. *Trends in Ecology and Evolution* 7: 96-99.
- Smith, S. G., W. D. Muir, S. Achord, E. E. Hockersmith, B. P. Sandford, J. G. Williams, and J. R. Skalski. 2000a. Survival estimates for the passage of juvenile salmonids through Snake, and Columbia River dams, and reservoirs. 1998. Report to Bonneville Power Administration, Contract DE-AI79-93BP10891, Seattle, Washington.
- Smith, S. G., W. D. Muir, G. Axel, R. W. Zabel, J. G. Williams, and J. R. Skalski. 2000b. Survival estimates for the passage of juvenile salmonids through Snake, and Columbia River dams, and reservoirs. 1999. Report to Bonneville Power Administration, Contract DE-AI79-93BP10891, Seattle, Washington.
- Smith, S. G., W. D. Muir, E. E. Hockersmith, S. Achord, M. B. Eppard, T. E. Ruehle, J. G. Williams, and J. R. Skalski. 1998. Survival estimates for the passage of juvenile salmonids through Snake River dams and reservoirs, 1996. Report to Bonneville Power Administration, Contract DE-AI79-93BP10891, Seattle, Washington.

- Smith, S.G., W.D. Muir, J.G. Williams, and J.R. Skalski. 2002. Factors associated with travel time and survival of migrant yearling chinook salmon and steelhead in the lower Snake River. *North Am. J. Fish. Mgmt.* 22: 385-405.
- Steidl, R.J. and L. Thomas. 2001. Power analysis and experimental design. Pgs. XX-XX *In* Design and analysis of ecological experiments, 2<sup>nd</sup> edition. S. Scheiner and J. Gurevitch, editors. Chapman & Hall.
- Williams, J.G., S.G. Smith, and W.D. Muir. 2001. Survival estimates for downstream migrant yearling juvenile salmonids through the Snake and Columbia River hydropower system, 1966-1980 and 1993-1999. *North American Journal of Fisheries Management* 21: 310-317.
- Zabel, R.W., Smith, S.G., Muir, W.D., Marsh, D.M., Williams, J.G., and J.R. Skalski. 2001. Survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs, 2000. Report to Bonneville Power Administration, Contract No. 1993BP10891, Project No. 199302900, 62 electronic pages (BPA Report DOE/BP-10891-10).
- Zabel, R.W., Smith, S.G., Muir, W.D., Marsh, D.M., Williams, J.G., and J.R. Skalski. 2002. Survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs, 2001. Report to Bonneville Power Administration, Contract No. 00004922, Project No. 199302900, 143 electronic pages (BPA Report DOE/BP-00004922-1).
- Zar, J.H. 1984. *Biostatistical analysis*. 2<sup>nd</sup> edition. Prentice-Hall, Englewood Cliffs, NJ

**Additional analysis for response to ISAB report 2003-1, Review of Flow  
Augmentation:  
Update and Clarification**

We extended the analysis performed in Appendix A of these comments (“US Fish and Wildlife Service review of the Northwest Power and Conservation Council’s approach to the flow-survival relationships for spring migrant juvenile salmon and steelhead contained in the draft Mainstem Amendments to the Columbia River Basin Fish and Wildlife Program”, February 4, 2003) to perform the tests for a flow-survival relationship suggested in Appendix 4 of the ISAB report. The data used and sources are the same as in our Appendix A, pages 10-13. Here we assume an exponential decay of survival rate with travel time (Eq. 3 of ISAB Appendix 4), which allows estimation of an instantaneous mortality rate ( $\mu$ ) for each study year. Regressing annual estimates of  $\mu$  against annual water travel time estimates is a practical test of the hypothesis that flow and instantaneous mortality are linearly related, as suggested by the ISAB in Eq. 8 of Appendix 4. Water travel time is used instead of flow for reasons provided in our Appendix A (e.g. it integrates the effect of the different flows in the Snake and Columbia rivers, which is necessary because the test reach extends from Lower Granite dam to McNary dam).

The results are displayed in Figures 1 and 2. Figure 1 shows no relationship between  $\mu$  and WTT ( $p = 0.72$ ) for yearling chinook; Figure 2 shows an apparent positive relationship between  $\mu$  and WTT ( $p = 0.01$ ) for steelhead. As expected, these results closely mimic the results for daily mortality rate in Figures 8 and 9 of Appendix A, and suggest the same conclusions: the available evidence provides no reason to reject the null hypothesis of constant mortality rate for chinook, but does provide reason to reject the null hypothesis for steelhead in favor of a mortality rate that increases with water travel time (i.e. increases as flow decreases). In other words, the analysis for chinook supports the ISAB’s contention that the available data are suggestive of the null model, with no relationship between flow and instantaneous mortality rate. The steelhead analysis does not support this contention. In both cases, a positive flow-survival relationship is supported, as fish migration speed through the hydrosystem is strongly and positively related to flow. The alternative hypothesis of no flow survival relationship would require instantaneous mortality rates to increase as flows increased, contrary to this empirical evidence on survival and fish travel time.

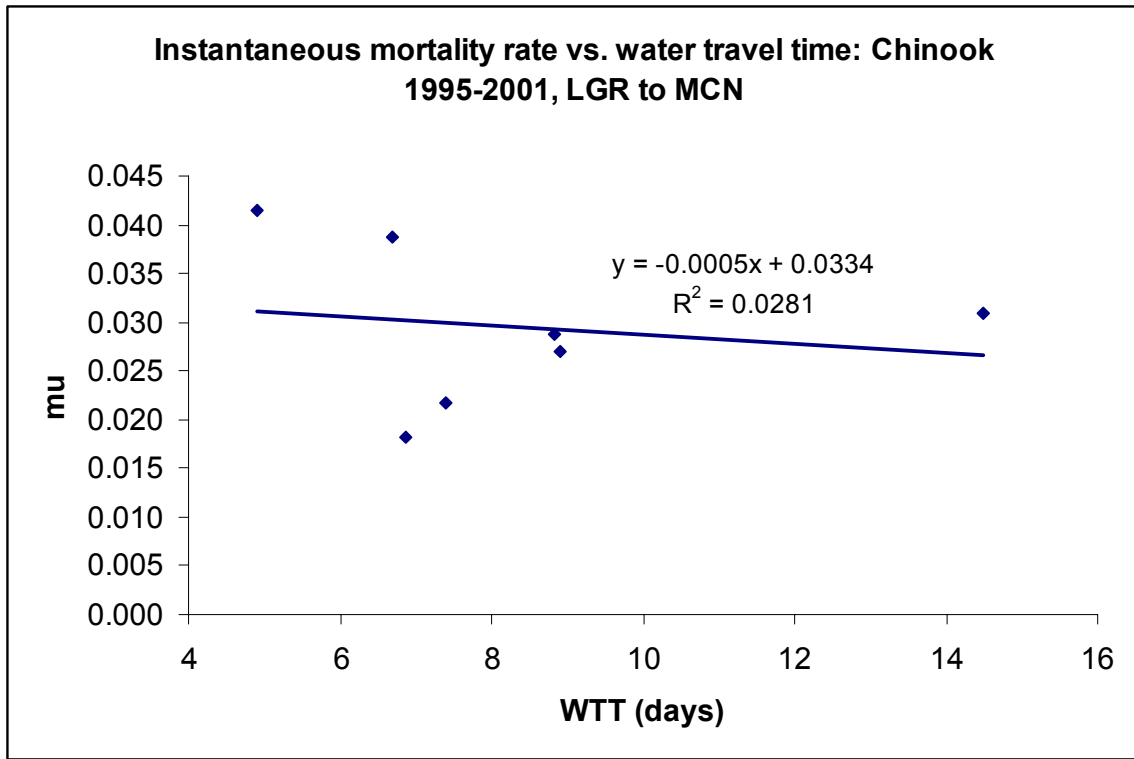


Figure 1.

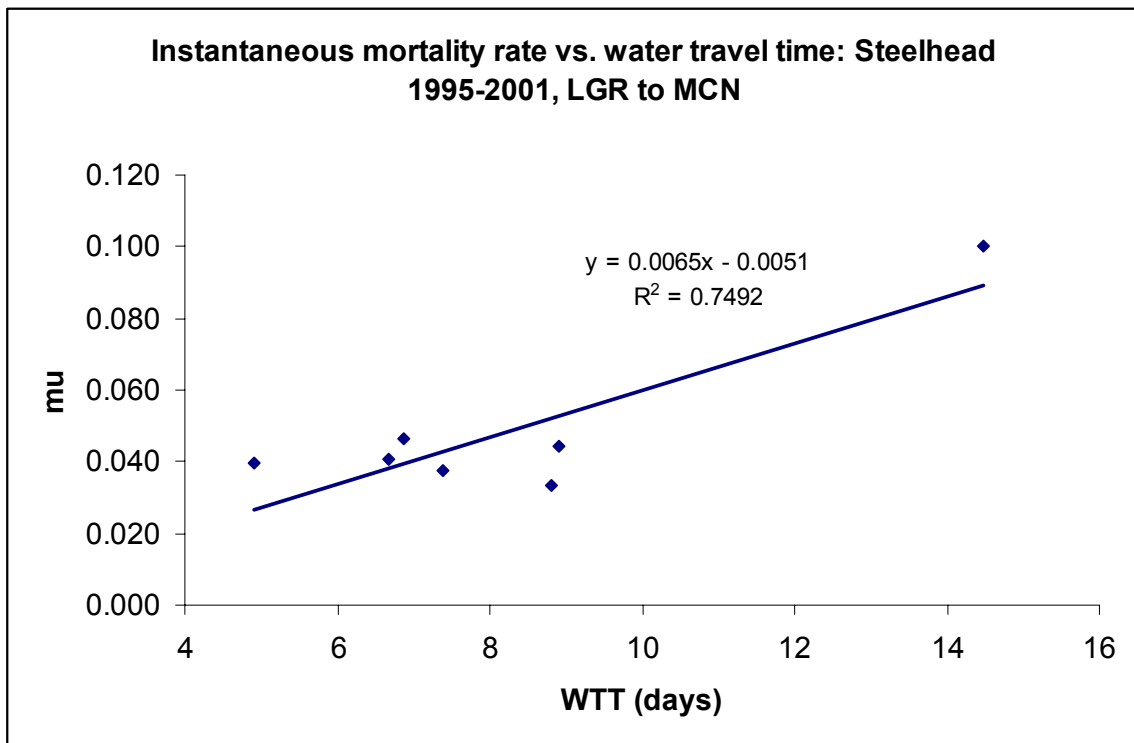


Figure 2.

ATTACHMENT 2. January 13, 2003 letter to Dr. Richard Whitney



## FISH PASSAGE CENTER

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January 13, 2003

Dr. Richard Whitney  
Independent Scientific Advisory Board  
Northwest Power Planning Council  
851 SW 6<sup>th</sup> Avenue, Suite 1100  
Portland, OR 97204-1348

Dear Dick,

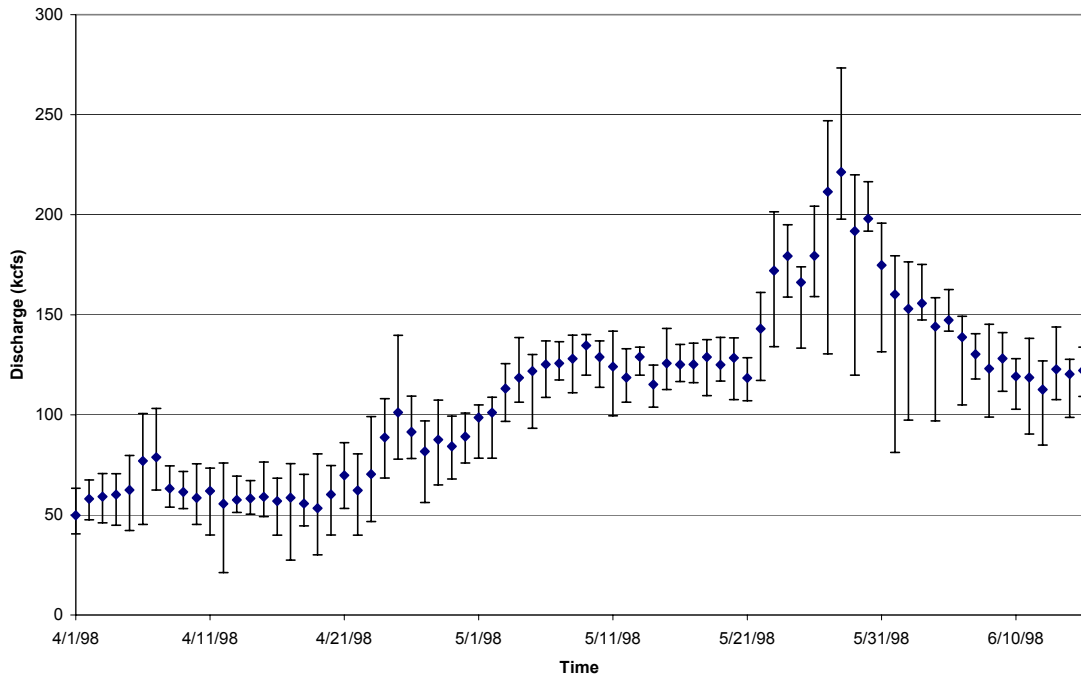
This letter is in response to your data request to the Fish Passage Center. On December 17<sup>th</sup>, 2002 the Fish Passage Center staff, together with other fishery agency technical staff, met with the ISAB relative to some recently conducted analyses of flow and fish survival. Subsequent to the meeting you contacted the Fish Passage Center and requested that we explore the relation between flow and juvenile survival using minimum flows during the migration period rather than the average daily flows that we used to calculate water transit time in our analyses.

### Input Data:

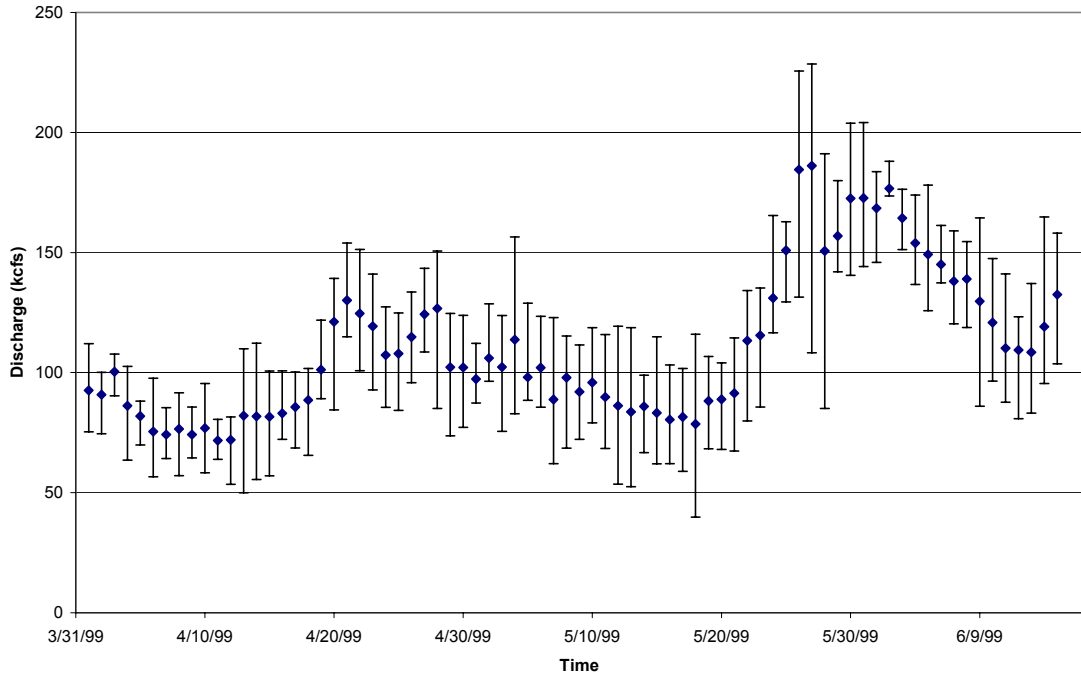
The following graphs depict the range of flows observed for each daily average flow observed during the migration seasons used in our analyses (1998-2002) at Lower Monumental Dam. We chose Lower Monumental as the reference point since it is the mid point of the migration corridor. The minimum for each day is the lowest hourly average within the 24-hour period. Similarly the maximum is the highest hourly value for that same 24-hour period.

You will note from the graphs that the minimum flow varies in the same pattern as the average flow. This is true for the relation between the average flow and the maximum flow. The correlation between the minimum daily flow and the average flow has an  $r^2 = 0.95$  and for the maximum daily flow and the average daily flow the  $r^2 = 0.98$ . We would anticipate that given the high correlations among the maximum, minimum and the average, we would get the same relations regardless of which measurement we choose.

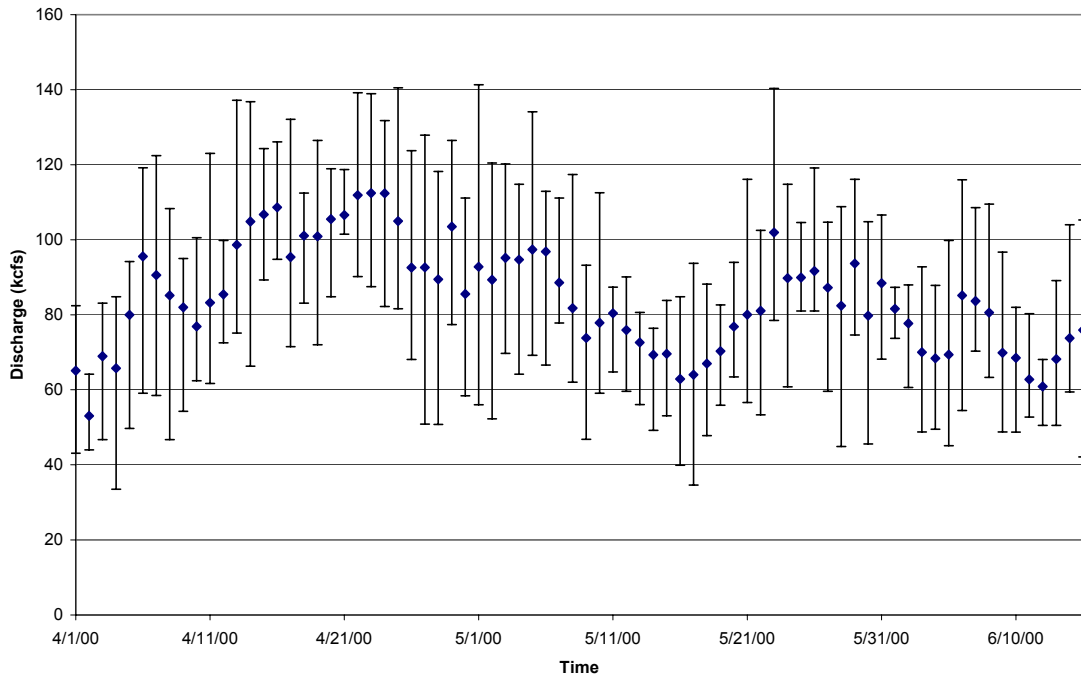
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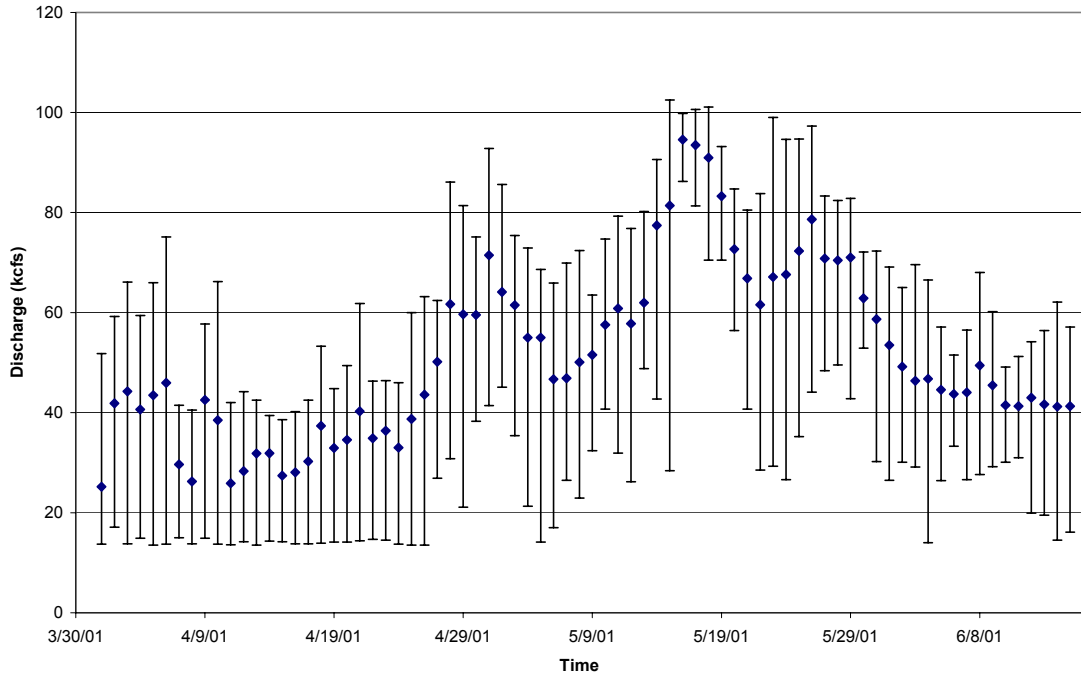
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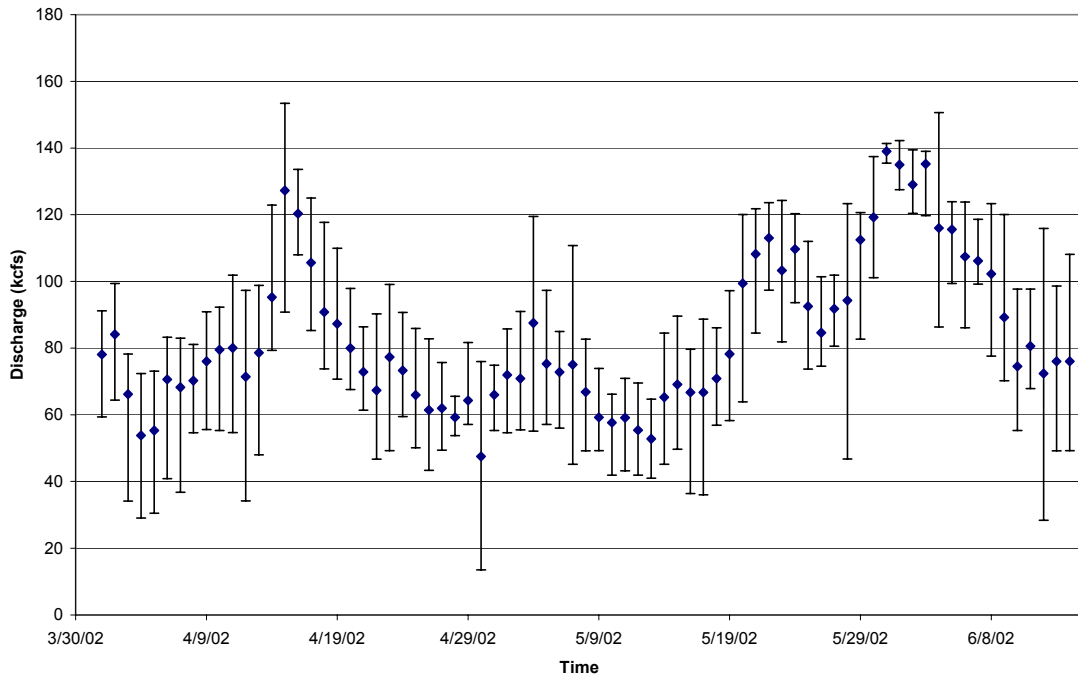
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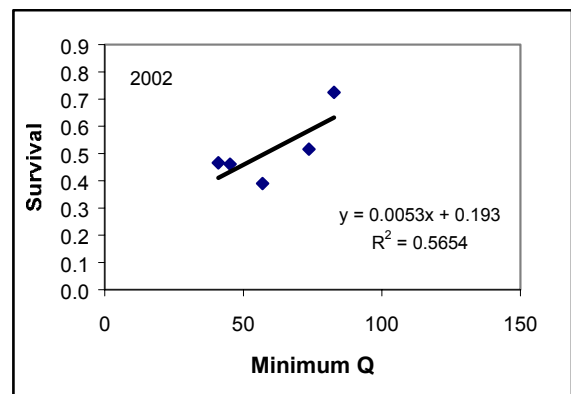
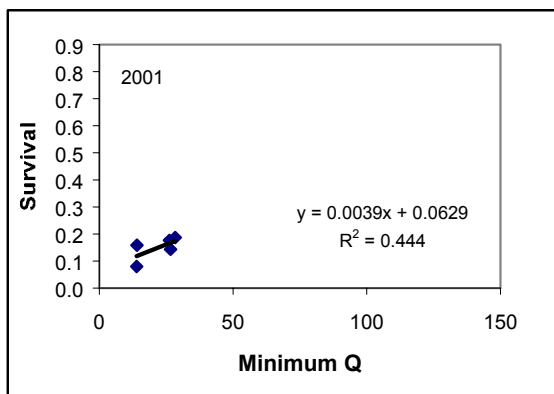
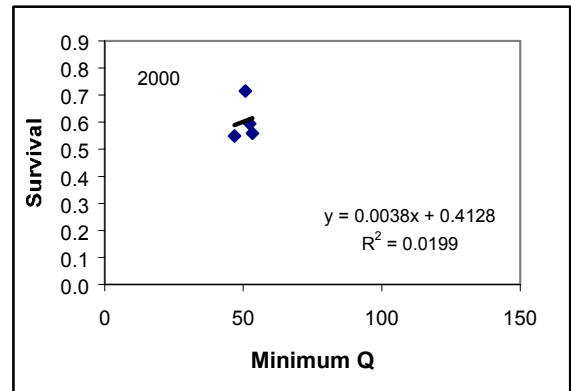
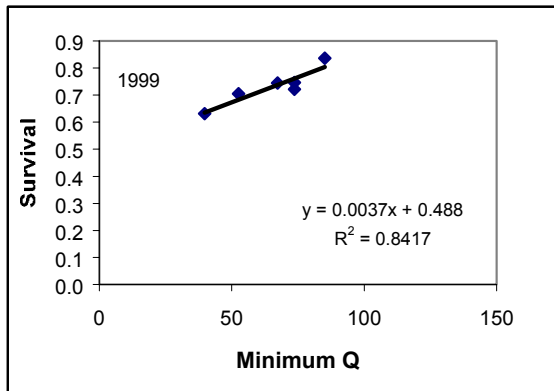
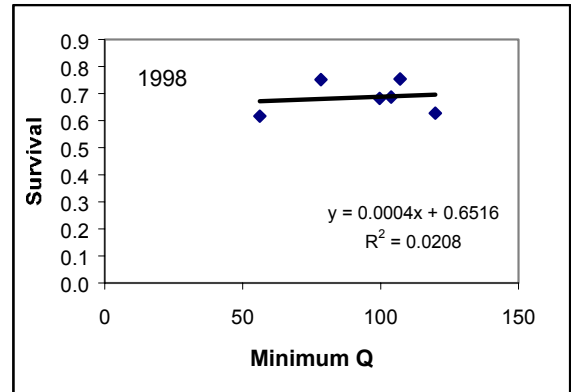
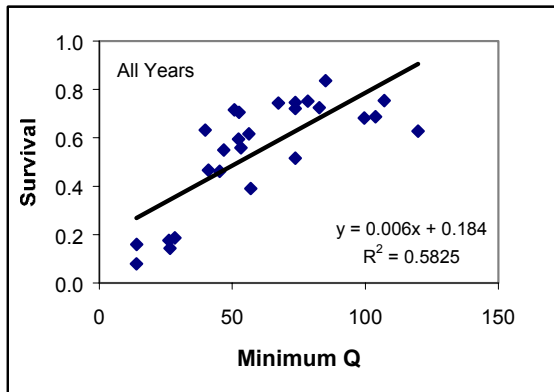
#### Analysis:

We initially conducted the analysis using our steelhead groups, since in our original study steelhead exhibited the most significant relation to water transit time. We looked at the relation between flow and juvenile survival using:

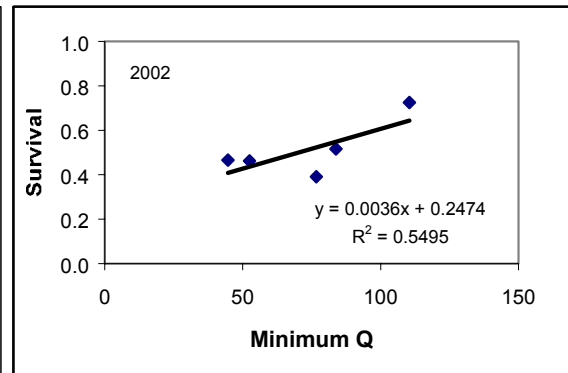
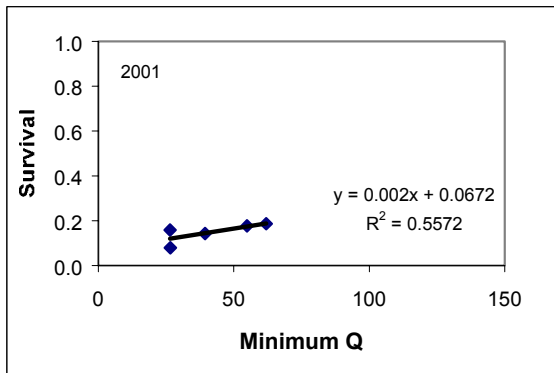
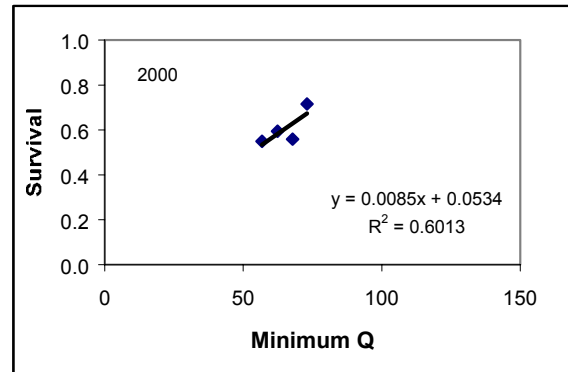
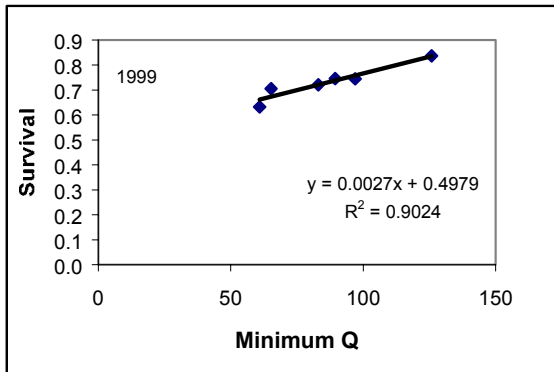
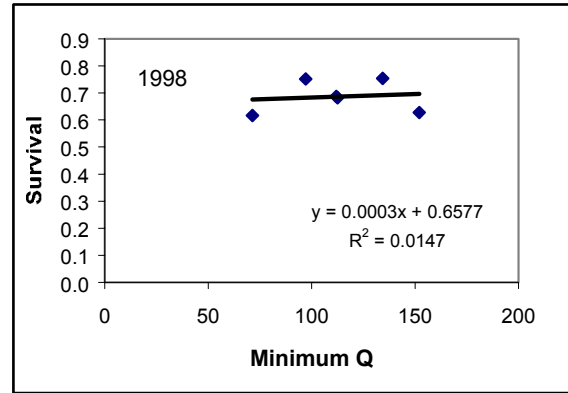
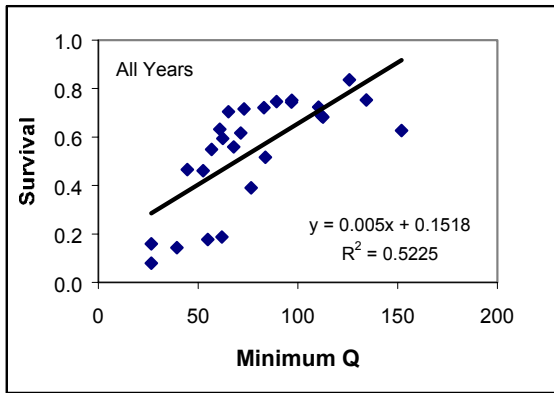
- 1) the minimum hourly flow observed during the time period;
- 2) a weekly average of the minimum hourly flows observed in a day;
- 3) the average of the daily flows for the period;
- 4) the maximum hourly flow observed during the time period;
- 5) a weekly average of the maximum hourly flows observed in a day.

The following pages summarize for steelhead the relation observed using each characterization of flow for all survivals observed for all years combined and for each year separately.

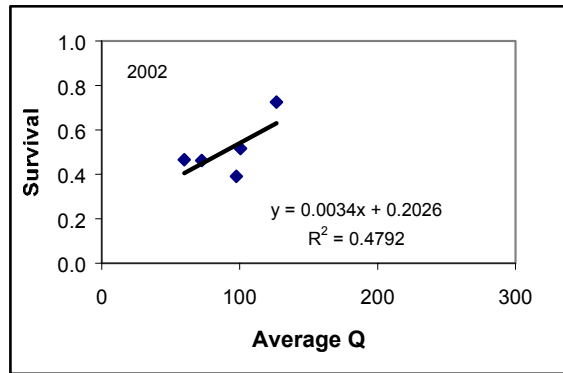
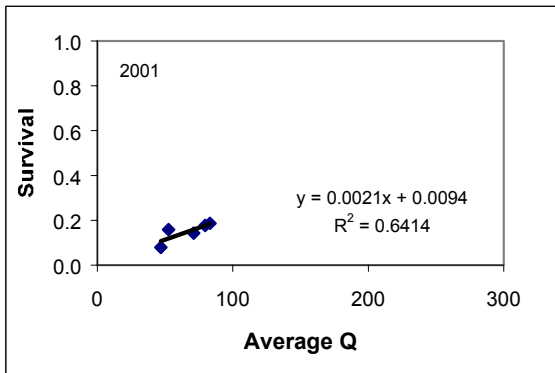
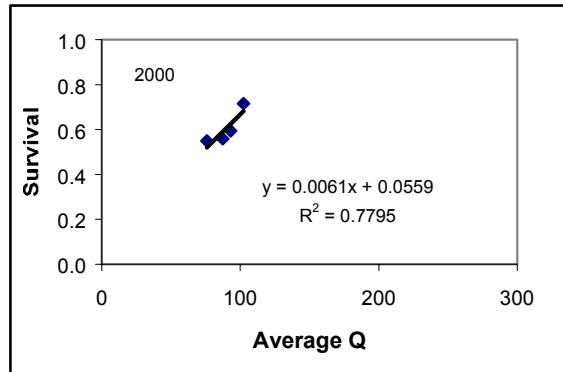
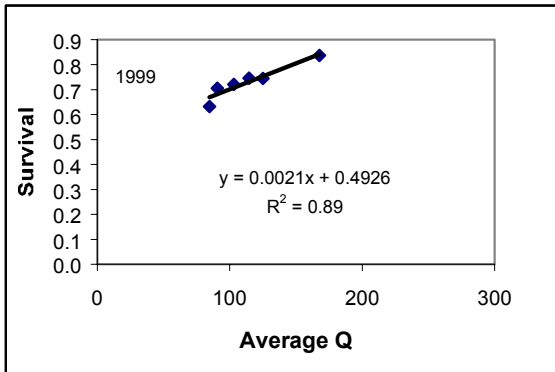
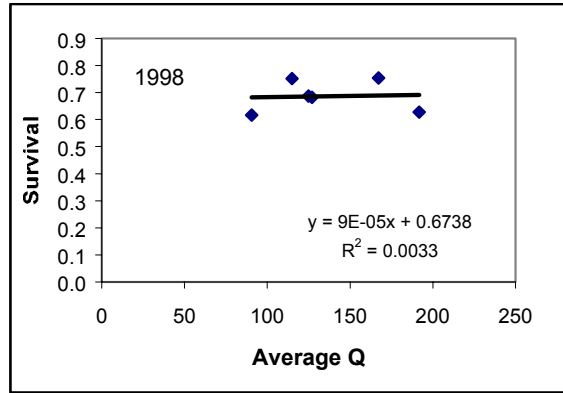
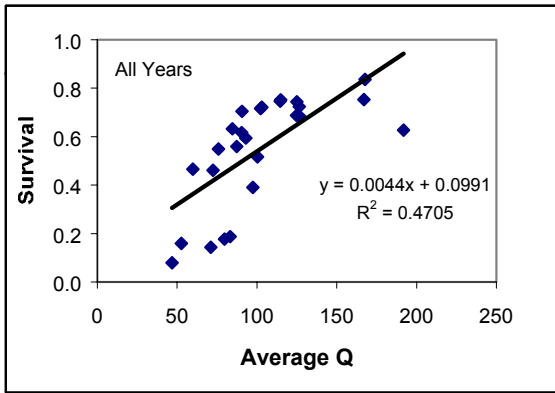
**Steelhead Survival LGR to MCN versus Minimum Q at Lower Monumental Dam**



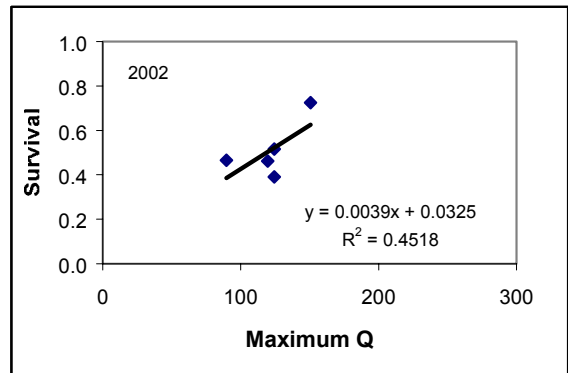
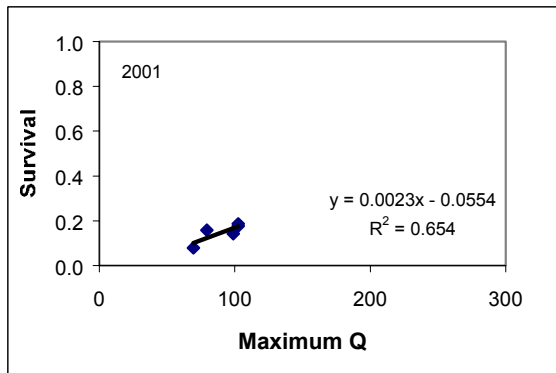
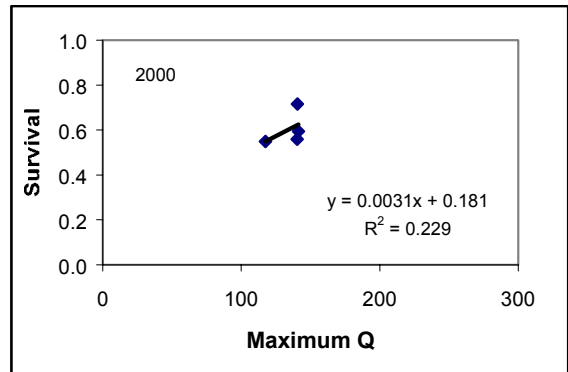
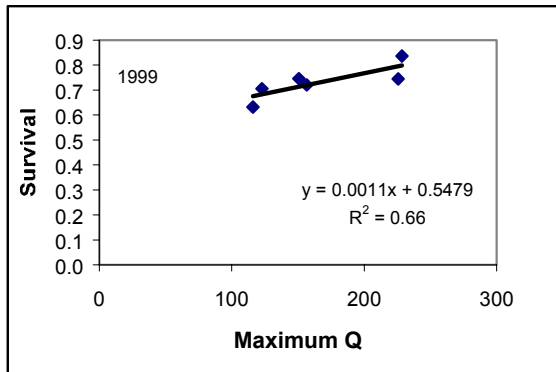
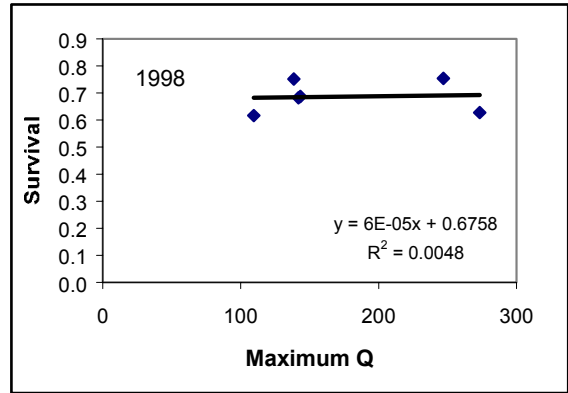
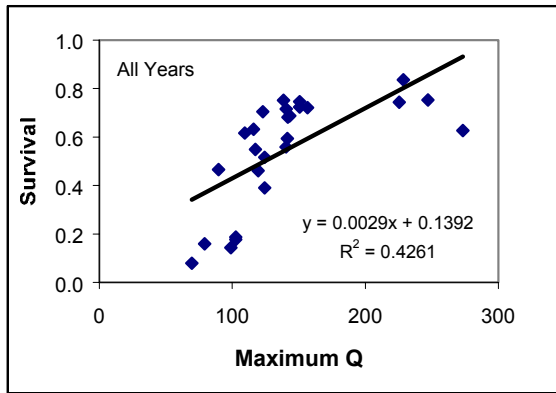
**Steelhead Survival LGR to MCN versus Weekly Avg MinQ at Lower Monumental Dam**



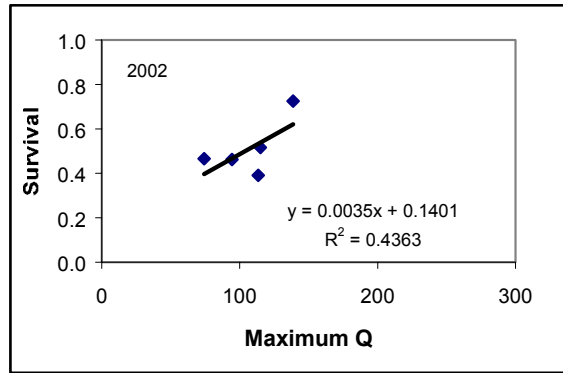
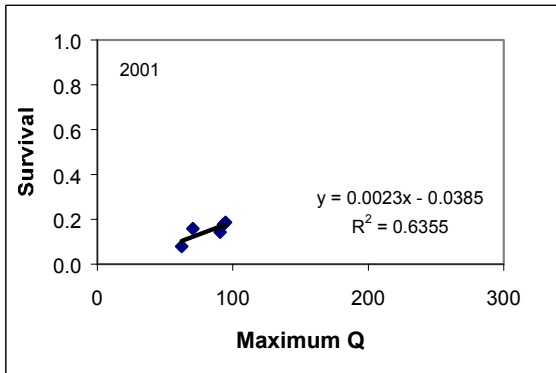
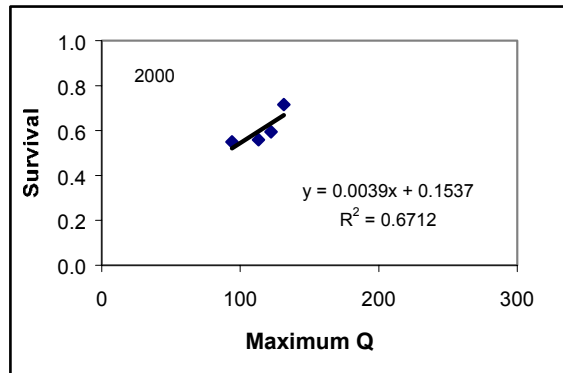
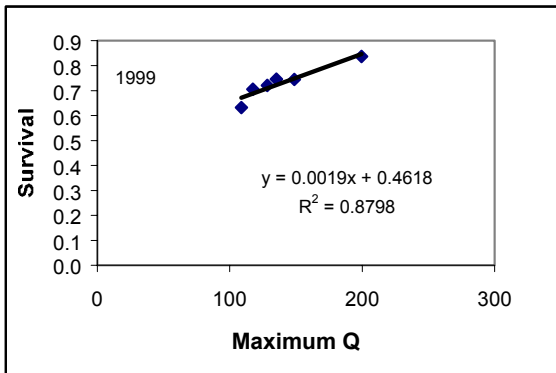
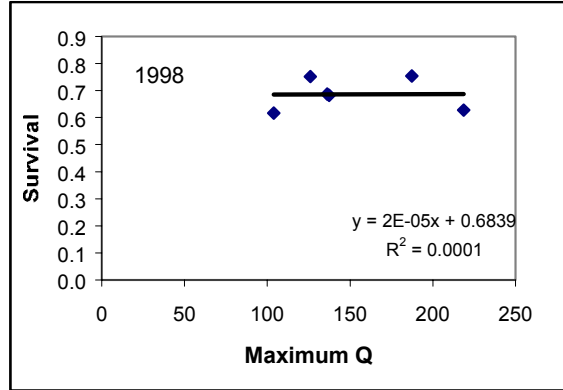
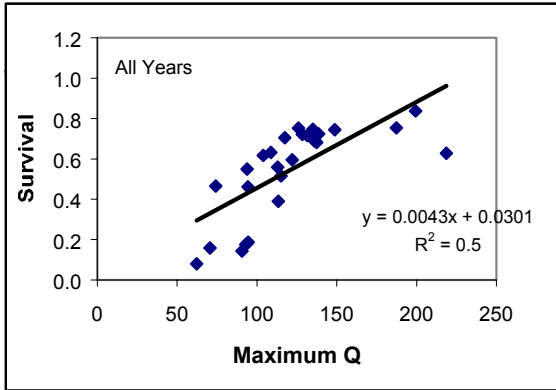
**Steelhead Survival LGR to MCN versus Weekly Avg Q at Lower Monumental Dam**



**Steelhead Survival LGR to MCN versus Maximum Q at Lower Monumental Dam**



**Steelhead Survival LGR to MCN versus Weekly Avg MaxQ at Lower Monumental Dam**



Conclusions:

We performed the requested analysis on the steelhead survival for the Lower Granite to McNary Dam river reach. These data showed the highest relation to water transit time in our original analysis. The flows were indexed to Lower Monumental Dam as representative of flow in the reach. We also looked at some yearling chinook data, which showed similar results.

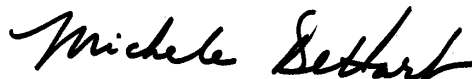
The Biological Opinion calls for the Snake River reservoirs to operate under a restricted elevation range during the juvenile fish migration, which can only vary up to one foot above the minimum operating range (MOP). The result of this action restricts the daily fluctuations that occur in river flow, which is evidenced by the high correlation of maximum and minimum flow with average flow. When the Biological Opinion measures were developed for flow targets an average sliding scale of 85-100 Kcfs was chosen for Lower Granite Dam. This was based on past information that incorporated daily load following and fluctuations in flow.

We see no evidence in this information to suggest that anything other than the average flow in the present hydrosystem configuration determines survival for Snake River migrants. The results obtained for the minimum flow reflect the results obtained for average flow. However, it could not be expected that the same results would be obtained if the hydrosystem were operated consistently at a lower flow. As we said in our original analyses a full range of flows is necessary to show the relation between water transit time (or flow) and survival and this is best demonstrated when all years of data are combined. Within year flow and survival relations are difficult to show due to the overlap in time of smolt release groups.

We recognize that flow fluctuations and minimum flows play an important role in the survival of emerging Hanford Reach fall chinook. Similar operating range restrictions are not required for the Mid Columbia projects and, consequently, wide fluctuations in daily flow occur that have been documented as a factor in stranding emergent fall chinook. However, Snake River migrants are not prone to the same stranding issues because of several differences that exist including the general age and size of the juvenile migrants, the geology of the area (more steep sided reservoirs) and the restrictions on hydrosystem operating ranges.

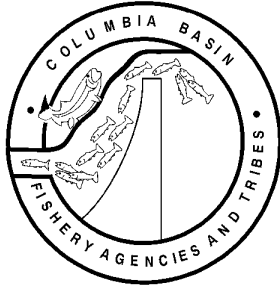
We hope these analyses are of help to you in your review of the NWPPC proposed amendments.

Sincerely,



Michele DeHart  
Fish Passage Center Manager

Attachment 3. Written response to the questions posed by ISAB prior to December 17<sup>th</sup> 2002 meeting with ISAB, which were responded to orally at the meeting.



# FISH PASSAGE CENTER

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January 10, 2003

Independent Scientific Advisory Board  
Northwest Power Planning Council  
851 SW 6<sup>th</sup> Avenue, Suite 1100  
Portland, OR 97204-1348

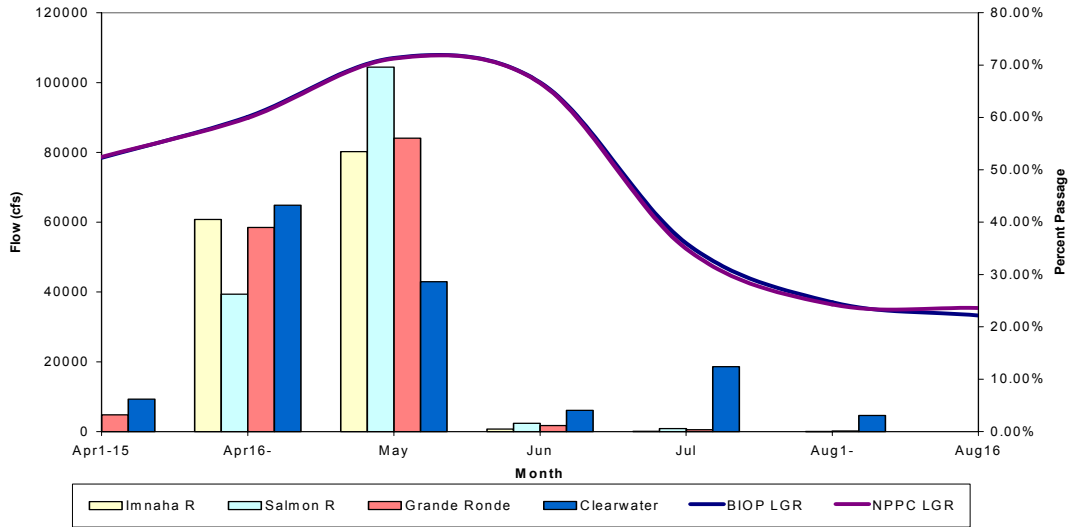
Dear ISAB Members,

On December 17, 2002 a group of fishery agency and Fish Passage Center staff met with the Independent Scientific Advisory Board (ISAB) to discuss the comments developed by the State, Federal, and Tribal Anadromous Fish Managers on the Northwest Power Planning Council's (NWPPC) Draft Mainstem Amendments as they Relate to Flow/Survival Relationships for Salmon. A series of questions were developed by the ISAB prior to the meeting and the attendees responded to those questions during the meeting. As a follow up to the meeting we are providing a written response to the questions (Attachment A).

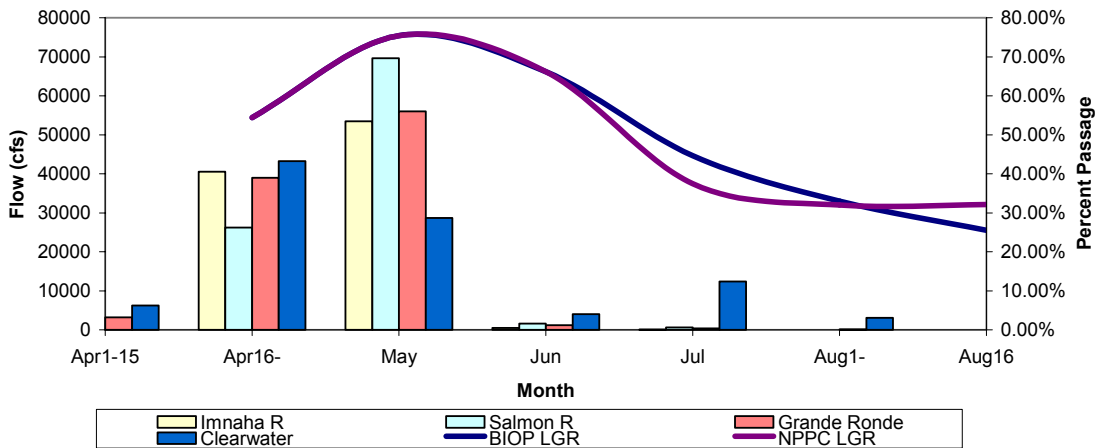
Additionally, at the meeting we expressed concern regarding the range of timing exhibited by the different stocks of salmon. We told the ISAB that we would provide them with that information for consideration during their present review. The following graphs depict the timing of specific stocks together with the flows that occur under low and average flow levels for the 50 year historic record, both under the implementation of the Biological Opinion and under the proposed NPPC amendments.

The first two graphs look at arrival time at Lower Granite Dam of yearling and subyearling chinook stocks migrating over the entire spring and summer periods for available PIT tag information. The third graph focuses on the summer period and the migration timing of subyearling chinook. As seen from the graphs, shifting water out of July could have serious impacts to a large proportion of the chinook migrants.

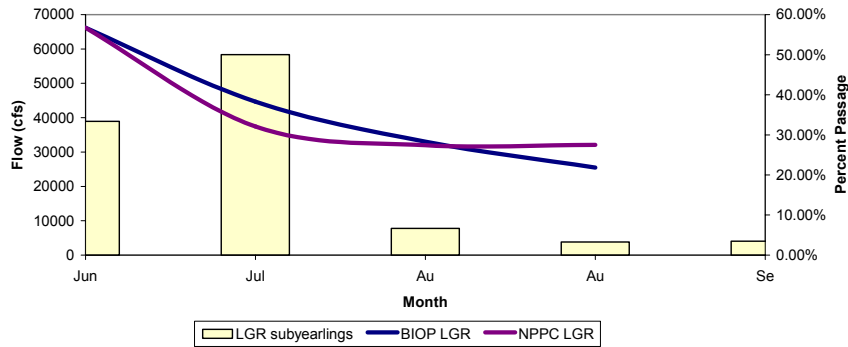
**Impact of Flow Proposals at Lower Granite Dam during Average Water Year Compared to Chinook Migration Timing**



**Impact of Flow Proposals at Lower Granite Dam during Low Water Year Compared to Chinook Migration Timing**

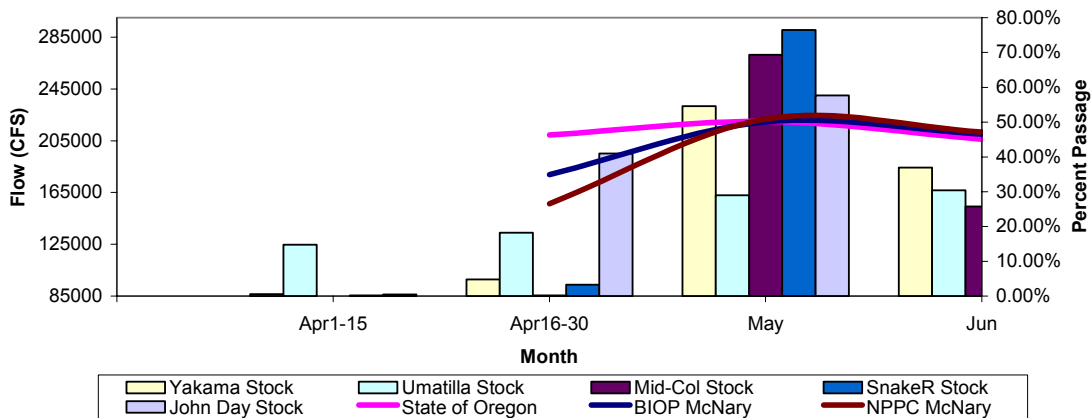


**Impact of Flow Proposals at Lower Granite Dam during Low Water Year Compared to 1998-2002 Average Subyearling Chinook Migration Timing**

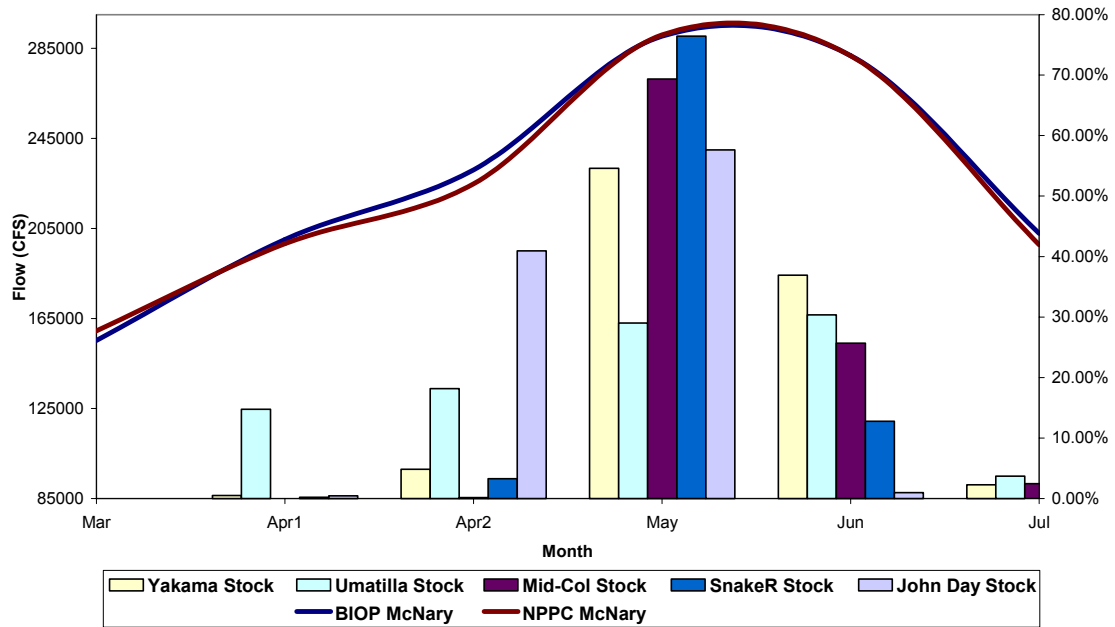


The next two graphs show the migration timing of chinook stocks in the Lower Columbia River. Here we can see that while the second half of April is not normally characterized as a significant passage period for spring migrating juveniles as a whole, it does represent a period of time when significant proportions of specific stocks are migrating. Stocks migrating from the John Day, Umatilla and Yakama river basins dominate the second half of April.

**McNary Dam Low Water Year 80% Exceedence Expected Discharges for Proposed Operations Compared with 5 yr Average Spring Chinook Migration Timings for Various Stocks at John Day Dam**



**McNary Dam 50 yr Average Water Year Expected Discharges for Proposed Operations  
Compared with 5 yr Average Spring Chinook Migration Timings for Various Stocks at John  
Day Dam**



We hope this information is helpful to you in your present review. Please feel free to contact us if you need any additional information.

Sincerely,

Michele DeHart  
Fish Passage Center Manager

## ATTACHMENT A

Documentation of December 17<sup>th</sup>, 2002 responses to the ISAB questions on the Benefits of Flow Augmentation document.

**I. What do you mean by “...the discrete relation between flow and water transit time (WTT) (also known as water particle travel time)” see (Figures 1 and 2 showing relation between WTT and average flow in the Snake River and McNary Dam reservoir). How is WTT computed for the rest of the analyses in your report?**

The word “discrete” relation was poor wording – it should read “direct” relation (or possibly it would be better to say “inverse” relation). The reason flow and water transit time are related is that water transit time is computed as a function of flow. For a single reservoir and its respective dam, water transit time is computed as Volume/Flow where river discharge (flow) and volume at the associated reservoir elevations for the time period of interest is used. This approach allows a specific water transit time to be generated for each individual segment of the overall reach for which travel time and survival estimates are being generated. This is an improvement over the methods used in the past where flow was simply indexed over a calculated number of days at a particular dam such as Lower Monumental Dam or Ice Harbor Dam (e.g., dates of middle 50% passage at the dam and dates from release to median passage at the dam are two common methods of averaging flows).

**II. Karl Dreher in his presentation to the Council on 12/11/02 seems to claim that there is no relationship between flow and water particle travel time, i.e., velocity. This seems to be in direct conflict with Figures 1 and 2. Please explain the difference interpretations. How were the figures developed? Formula? Assumptions? What is the evidence for a relationship?**

We were not present at the Karl Dreher presentation and, therefore, cannot respond to what was said during his presentation. However, the relation between flow and water transit time is a physical relation. Water transit times through the reservoirs were calculated using the storage replacement method, of which flow is inversely related. This method was suggested as the preferred option by Hydrological Engineering Center at the COE. Furthermore, the COE Hydrological Engineering Center ran their HEC-2 model over the Lower Snake River over the same range of conditions as used in the FPC analysis (the data used to compute water transit times) and it is consistent with the results obtained using the storage replacement method. Marshall C. Richmond, Chief Engineer at the Pacific Northwest National Laboratory in Richland, Washington provided estimates of water transit times through the Hanford Reach at various discharges using their 1D unsteady flow model (MASS1) (Richmond, Perkins, Chien, 2002).

**III. What is “Average Q”, e.g. at McNary Dam.**

Average Q at any project is the average over the period of interest of the COE’s daily average discharge values for that project.

**IV. What do you mean by “Whenever a component survival estimate was greater than 1, then the standard error divided by 1 was used as the threshold criteria.”**

When a component survival estimate (e.g., LMN to MCN) is estimated to be greater than 1, then we simply used the value of the standard error divided by 1 in the decision of whether the CV was greater than 0.25. This was to avoid shrinkage in the CV as the point estimate increased 100% survival. The goal was to not compute an overall reach survival estimate from the product of a the various segments of the overall reach if any individual segment’s survival point estimate was so imprecise as to have a confidence interval of approximately +/- 50% of the point estimate.

**V. In Figures 3, 4, and 5, e.g., “Wild yearling chinook travel time versus water transit time. Hatchery Yearling Chinook Median Travel Time versus Water Transit Time Lower Granite Dam to McNary Dam 1995 to 2002” why is the one year (upper center) so far from the others? High travel time but mid water transit time?**

The data point with an estimated high travel time and mid-range water transit time is from the April 1-7 release block in 2002. Water temperature on April 1 was approx 8°C (46°F), the lowest of the years considered. Smolt travel time from LGR to LGS was 19 days (approx 60% of total reach travel time) for these early fish, while water transit time was only 4 days. Cold water and low smoltification apparently contributed to the long travel time estimate, which for the reach was about 50% longer than the next weekly block.

**VI. In Figures 3, 4, and 5, e.g., “Wild yearling chinook travel time versus water transit time. Hatchery Yearling Chinook Median Travel Time versus Water Transit Time Lower Granite Dam to McNary Dam 1995 to 2002” why is the one year (upper center) so far from the others? High travel time but mid water transit time?**

The three data points with extremely long travel times are not from three years, but instead are simply the three temporal periods of 2001. The travel time/water transit time plots for the Mid-Columbia River reach include up to three temporal (two-week) periods per year.

**VII. When is multicollinearity a problem? My rule was always to see if there were wild changes in the coefficients with minor changes in the data set. See the quote “The correlation between WTT and SPILLPROP for steelhead was  $r = -0.87$ , a level still low enough so that multicollinearity is not a problem.”**

Multicollinearity was considered to be a problem in the strictest interpretation of when it creates singularity in the inverse of the variance-covariance matrix. The rule of thumb from Myers’ regression text was used. Since multicollinearity is less than the extreme case still has an unfavorable effect of inflating the variances of the parameters being estimated, we cannot rule out a particular parameter may not be important just because its slope parameter was not significant when in the presence of its moderately collinear pair

in the model. But when both moderately collinear pairs of factors are able to remain in the model jointly, then it good evidence that each factor is important to the relation being modeled.

**VIII. In regression modeling with highly correlated variables, I (McDonald) have used “ridge regression” to help stabilize the coefficients, i.e., usually one coefficient is large and negative and the other is large and positive, but residuals continue to look good, and they jump around if small changes are made in the data. Have you considered using ridge regression to include both temp and flow in the models when temp and flow are highly correlated? If no, why not?**

We did not attempt to run ridge regression. The technique in Myers’ regression textbook was reviewed. However, the dangers of arrive at an improper shrinkage factor  $k$ , which is key to properly adjusting the variance-covariance matrix before inverting it, lead us away from pursuing that approach further.

**IX. Have you conducted any new analysis of Billy Connor’s data? Starting on page 23 it seems like you are mostly quoting and repeating his results. Are there any differences in your interpretation of the data and Connor’s?**

The document was developed collectively by a group of State, Federal and Tribal staff and FPC staff. Billy Connor took part and was responsible for developing this section.

**X. Do you have any concerns with the methods used by Connor to estimate “...mean flows and water temperatures recalculated to represent those that would have occurred if flow were not augmented (from Table 3).” What are the assumptions and methods?**

This is the methods section from Connor et al. (in press b). The flow exposure index was recalculated after subtracting the daily volume of water released for summer flow augmentation (Appendix 1). The water temperature exposure index was recalculated using temperatures that were simulated for the tailrace of Lower Granite Dam under the flow conditions had the summer flow augmentation not been implemented (Appendix 2). Water temperatures were simulated using a one-dimensional heat budget model developed for the Snake River by the U.S. Environmental Protection Agency (Yearsley et al. 2001). Past model validation showed that daily mean water temperatures simulated for July and August were within an average of 1.1oC of those observed (Yearsley et al. 2001).

**XI. This is the first time that we have seen three variables in the regression models to predict survival. What is different or what data have been added to previous analyses? See, e.g., “Table 7. Multiple regression models for predicting survival of combined hatchery and wild yearling chinook salmon in the Snake River from the tailrace of Lower Granite Dam to the tailrace of McNary Dam.” Please review the criteria used for selection of the models. In particular was AIC used? Maybe I missed it.**

Using more than simply a flow-related variable to determine a relation with smolt survival is not a new idea. NMFS in publish papers has utilized several predictor

variables in the regression models. In studies of smolt travel time in the past we have utilized several predictor variables in regression models. In the present application to smolt reach survival, the predictor variables were water transit time, proportion of spill, and water temperature. Because each of these predictor variables are linked to conditions that can influence survival, the model that contained the most predictor variables that each had slope parameter significantly different than zero was chosen as the best model with explanatory capability. Even when spill proportion did not remain in a model in the presence of water transit time, we acknowledged that its influence was still present because the spillway route is a dam's highest survival route based on past NMFS studies.

**XII. Explain the interpretation of “Figure 21. Survival of PIT tagged yearling chinook from McNary Dam tailrace to Bonneville Dam tailrace based on time of passage at McNary Dam, 2001.” What is this figure telling us?**

Figure 21 simply shows the estimated survival of yearling chinook temporally blocked based on dates of passage at McNary Dam to the tailrace of Bonneville Dam. Superimposed on the resulting survival estimates over the season is the annotation as to whether or not spill was occurring at downstream dams in the reach of interest, and if so, at how many dams. The point of the plot is to show that there was a trend in increasing survival in the lower Columbia River in 2001 that was coincident with the increase in spill provided at dams within the reach. Flows were only moderately changing in 2001 and water temperatures followed the normal course of increasing over time, which links well with increasing predation activity over time. Under these conditions, one would expect reach survival to decrease over the season had spill never been used in the lower Columbia River. The fact that this trend was not observed lends more support to the benefit of the limited spill periods over which the additional spillway route of passage was available at the dams to improving smolt survival over what would have otherwise occurred without any spill provided.

(Then answers to questions 13-15 were previously provided to the ISAB and are attached here.)

**XIII. Are there confounding factors that would explain the negative relationship noted in the quote “We found a moderate to strong relationship between chinook SARs and transportation proportion ( $r^2 = 0.64$ ,  $p < 0.001$ ); however this relationship was negative suggesting years in which the proportion transported increased the SARs decreased (Figure 27).” Are the years with low SAR just the years with bad ocean conditions and high proportion of transported fish?**

**XIV. How do we interpret the information in Figure 28 dealing with  $\mu$ , i.e., “...direct and delayed hydrosystem survival of Snake River spring/summer chinook relative to downriver spring/summer chinook, estimated in PATH by the parameter  $\mu$  (Deriso et al. 2001)”?**

**XV. What is the parameter “delta” derived in the Plan for Analyzing and Testing Hypotheses (PATH), as a measure of climate/ocean mortality influences? How is it measured? See Table 22 and Figure 29. Help interpret Figure 29.**

## **Additional Questions e-mailed on December 12<sup>th</sup>, 2002.**

**1. A major criticism of flow augmentation coming from the upper basin folks is that the interannual patterns of flow, travel time, and survival that the FPC generally has used are not relevant to the within-year amounts of additional water that are provided by flow augmentation policies. Over the broad span of flows among years, there is a clear trend (amplified by recent extreme high and low flow years). On this most folks seem to agree. However, they say that a relatively small amount of added water volume within a year may not mean much for fish. In fact, they say it means most for fish depending on when and how (what temperatures, etc.) that water is added, not the volume. The ISAB said as much in its last report on the subject. That seems to be one reason they suggest shifting the timing of the water that is used for FA. Would the FPC provide their evidence that within-year flow augmentation is important for survival, and specifically when and under what conditions they believe it is most valuable (e.g., late summer flows of cold water from Dworshak for cooling the Lower Snake).**

The difficulty in determining the effect of “flow augmentation” is that flow augmentation implicitly means that flow is being added to a level of flow provided for other uses. The present hydrosystem operations as anticipated by the Biological Opinion are the result of consideration and melding of power, flood control, recreation, resident fish and fish passage needs. It is difficult therefore to quantify actual “flow ” for fish passage. Flows provided for fish migration also generates power and other benefits. The separation of flows provided for fish benefits versus power or other benefits is an accounting issue that has never been clearly resolved. For example, the accounting of flow for fish or power was raised during the winter months of 2001, when power demand required higher flows during the winter months, which also benefited the natural spawning area below Bonneville Dam. Similar accounting issues have been raised regarding spill. The Biological Opinion identifies specific levels of spill for fish passage; often spill levels are higher because of flood control or flow in excess of power generation needs. The accounting for this excess spill separately from the BIOP spill levels is a prevailing question. We do not know how to accurately and separately account for the amount of flow that results from each of the purposes of system operations. Our analysis addresses the benefit of flow for fish passage regardless of whether the flow is the result of flood control releases or hydropower generation.

The effect of flow increases and decreases on fish travel time can be estimated using the flow/water transit time and travel time relationships developed for specific River reaches. These relationships have been developed over several decades over a wide variation of conditions. The recent data and the historical data have remained consistent over the years. This is because the mechanisms of travel time are less complicated and involve fewer variables. Flow is the direct and determining factor over fish travel time. On the other hand, juvenile survival estimates are an index describing the juvenile migration. Determination of incremental flow and survival is difficult because of the actual complex mechanisms that determine survival. A within year flow survival relationship does not emerge in the present data, not because flow is not important but, because of several factors including the limitations of data collection and analysis. First, juvenile survival is the result of many direct and indirect environmental and biotic variables. By necessity these variables such as flow are described as averages over a period of time. This

dampens the effect of that variable. Second, within year flow survival relationships are not apparent from available data because the individual survival release groups overlap and the environmental variables such as flow is averaged over many days and many overlapping release groups. Third, annual estimates of survival address the problem of overlap to some degree, however the annual flow average (even over large groups) had not changed substantially until 2001, when the Biological Opinion measures were not implemented. Our present data shows a significant flow survival relationship as a result of the large change that occurred in the flow variable when the Biological Opinion measures were not implemented.

The FPC identified these issues in memorandums to the Fishery Managers in 1992 and again in 1995 that the problem of excessive overlapping of PIT tagged release groups as they migrate through the study reach will not allow discrete partitioning of the incremental effects of environmental or biotic variables that affect survival. NMFS recognized this phenomenon after implementing the methodology for several years. Smith and Muir (1996) state, "Identifying and quantifying relationships between environmental variables and survival and travel time of release groups of PIT tagged migrant juvenile salmonids have presented difficult challenges. Chief among these is that fish from a single release group do not migrate as a group but spread out over time. If conditions change over a short period of time relative to the time it takes for the bulk of the release group to migrate through a particular river section then different fish from the group experience different levels of various environmental factors. In this situation estimated survival probabilities (defined for the entire release group) are usually valid estimates of average survival for the group. However, it is difficult to accurately quantify the environmental conditions to which the entire release group was exposed and to relate that to the survival estimates. More over, if a series of releases is made and migrations are protracted the various release groups may have considerable overlap in passage distributions, further clouding the relationship between survival probabilities and environmental variables by decreasing the contrast in the levels of exposures among the various groups."

The above problems created by overlapping environmental and biotic conditions within a single year are reduced when comparisons are made across years. Nevertheless, the environmental and biotic conditions observed across years must span a fairly wide range of values to offset the natural variability inherent in them. Therefore the regression analyses demonstrate statistical significant differences in survival due to these environmental and biotic conditions. The year 2001 is so an important in these regression analyses because it defines the true range of conditions that are possible in the present hydrosystem. When 2001 survival data is considered, the FPC analyses demonstrate that statistically significant relations between reach survival of yearling chinook and steelhead smolts and the flow-related variable of water transit time are obtainable. But even these relations do not allow the determination of incremental effects of flow augmentation alone. In our answer to your Question 9, we discuss how spill also influences the smolt survival in the reach by providing the route of highest survival at each dam to the proportion of smolts that utilize that route. Therefore, in every reach survival estimate there are contributions of both spill passage at the dams and flow-related variables in the reservoirs to the overall smolt survival estimates. We have been successful in demonstrating that analyses of survival data must include a series of years

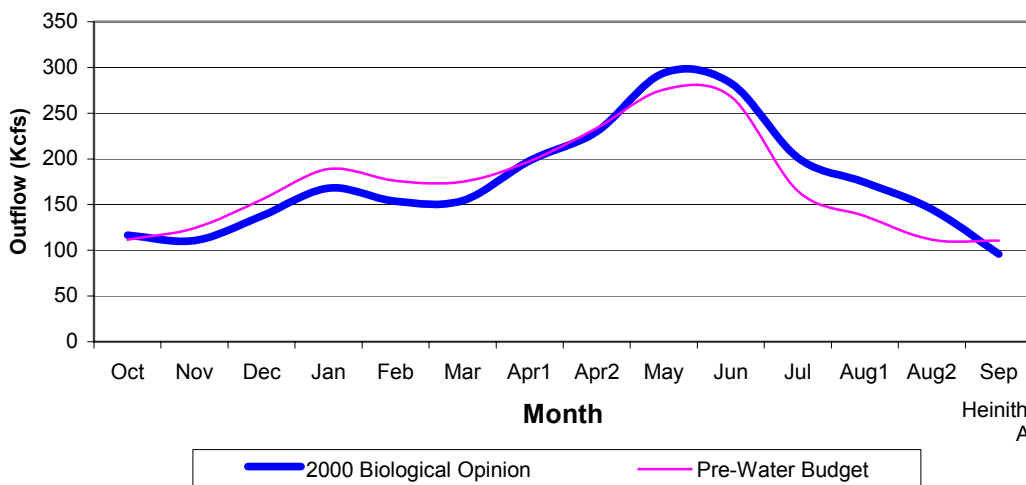
in order to get a wide enough range of environmental and biotic conditions to show statistically significant relations between smolt survival and a joint set of predictor variables which include a flow-related variable.

The fact that among year flow, water transit time, fish transit time relations can be established provides significant reasons to achieve, at a minimum, Biological Opinion flow objectives in any given year. The proposed NWPPC Program measures would move water from the fish migration period, back to the winter period, affecting flow during the fish migration period. This would be contrary to the intent of the Biological Opinion. Seasonal flow targets were derived in order to meet minimal hydrosystem survival rates in conjunction with harvest, hatchery and habitat measures, which are required to achieve overall population survival and recovery. Flows should be met throughout the migration period because of differences in passage timing for individual populations. Within populations there are different out migration timing for various life-history strategies (e.g. differing overwintering locations within a tributary). The importance of providing protection measures across populations and life-history types has been thoroughly documented, such as ISG Return to the River(1996, 2000) and NMFS Viable Salmonid Populations (McElhany et al. 2000). In addition, in river survival estimates represent only one component of the life cycle, which flows can effect. Other effects of flow include the additional direct mortality that occurs down stream of reach studies and the indirect or delayed mortality that occurs as a result of fish condition, arrival timing and estuary and plume conditions.

**2. With the Canadian Treaty dams providing most of the reshaping of the annual hydrograph for the Columbia River from its historical pattern, how much influence on the lower Columbia discharge (and therefore changed fish survival) can we realistically expect from augmented flows from Hungry Horse, Libby, Dworshak, and the Hells Canyon project? Aren't the changed flows and survivals fairly trivial? (Unless carefully timed, as above).**

The operation of the Canadian Projects was factored into the development of the actions necessary to implement the Biological Opinion flow measures. The changes in flow that result from operating the US Reservoirs to the April 10<sup>th</sup> upper rule curve, and the augmentation volumes from these reservoirs are not trivial in achieving the Biological Opinion flows and affecting survival. A comparison could be made to the operation of the power system prior to the implementation of the Water Budget and the subsequent implementation of the Biological Opinion. Both scenarios occurred with the Canadian Treaty dams in place, yet significantly more water was moved into the fish migration period.

**Columbia at McNary: Average of 50 years (1929-1978)**



**Answers to Questions 13-15 from the ISAB on Fish and  
Wildlife Managers-NWPPC Response Flow and Spill  
Update Summary of Data Analysis and Review  
Regarding Mainstem Fish Passage Relating to Flow**

**Answers Prepared by:**

**Charlie Petrosky  
Idaho Fish and Game**

**and**

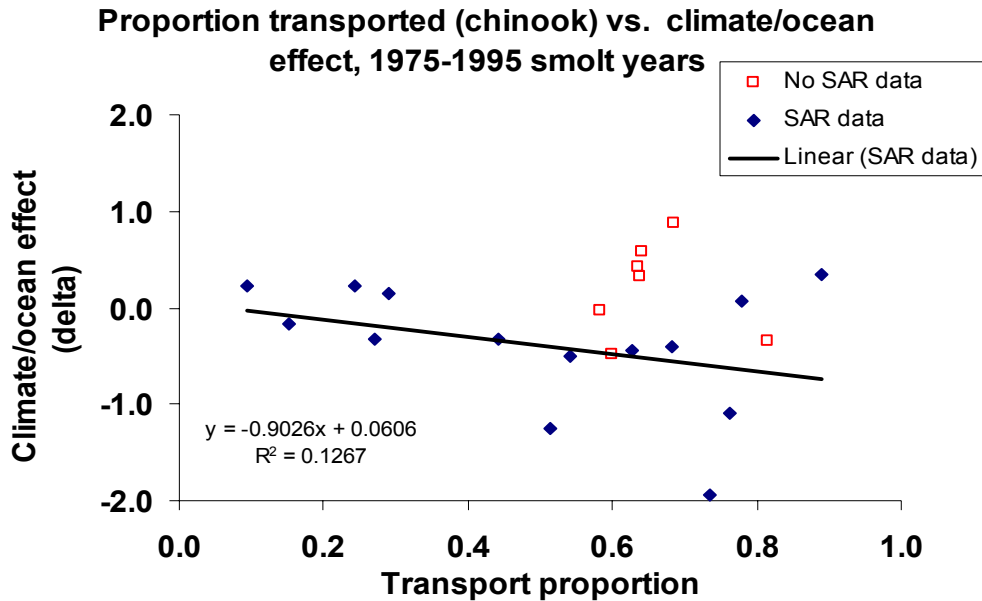
**Howard Schaller  
US Fish and Wildlife Service**

**December 17, 20002**

## ISAB Question XIII

Graphed the two variables in question relating to potentially confounding factors

### Transport Proportion Vs Delta



Any relationship between proportion transported and delta appears to be weak

It is apparent from the data that the years with high transport proportions are not always the years with bad ocean conditions

**ISAB Question XIV**

In the Model from figure 28:

$\mu$  represents the relative difference in mortality between upriver and downriver stocks;

In Deriso et al. (2001)  $\mu$  is subtracted from  $\ln(R/S)$  in linear Ricker function

$$\ln(R/S) = (a + \delta_t - X_n - \mu_t) - b \cdot S$$

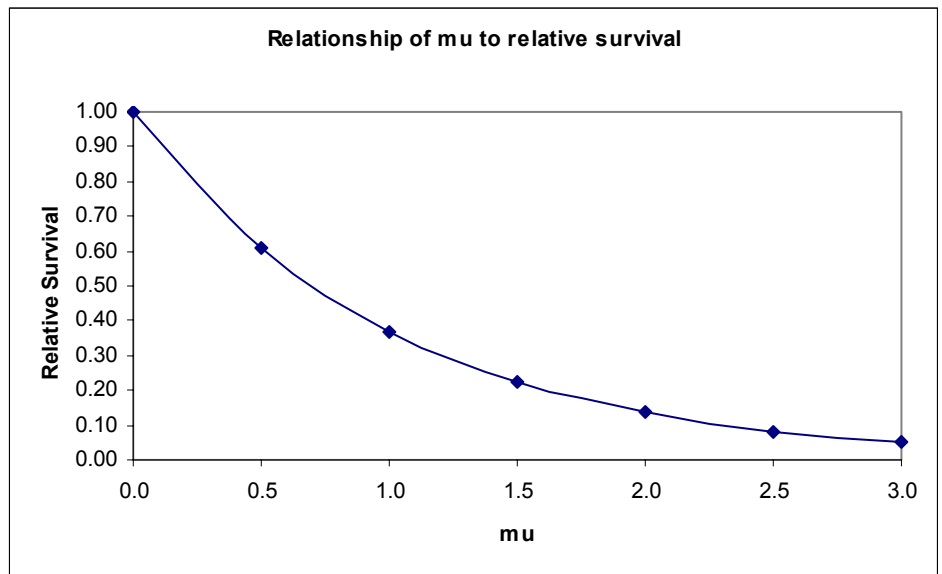
where;

- $a$  =intrinsic rate of population growth 'Ricker a'
- $\delta_t$  = common year effect (climatic/ocean effect)
- $X_n$  =direct hydrosystem mortality for lower river stocks
- $\mu_t$  =differential mortality (relative difference in mortality between upriver and downriver stocks)
- $t$  =year

e.g., for  $\mu = 1$  (Snake River stocks had a relative mortality increase of 1.0); translates to a relative survival of 0.366;  $\exp(-\mu)$

1975-1995 range of observed  $\mu$  was 0.19 to 2.77;  
Snake River stocks survived 6% to 83% as well as the downriver stocks

| $\mu$ | relative survival |
|-------|-------------------|
| 0.0   | 1.00              |
| 0.5   | 0.61              |
| 1.0   | 0.37              |
| 1.5   | 0.22              |
| 2.0   | 0.14              |
| 2.5   | 0.08              |
| 3.0   | 0.05              |



**Figure 28 indicates that relative hydrosystem mortality increased with increased water travel times**

**ISAB Question XV part 1**

In the Model from figures 29-31 where;

$\delta$  is defined as common year effect (climatic/ocean effect)  
from Deriso et al. (2001) see derivation from description of  $\mu$

$\ln(\text{SAR}) = \text{WTT} + \delta$  or  $\ln(\text{S/S}) = \text{WTT} + \delta$

effect of  $\delta$  is additive to  $\ln(\text{SAR})$  and productivity ( $\ln(\text{R/S})$  or  $\ln(\text{S/S})$ )

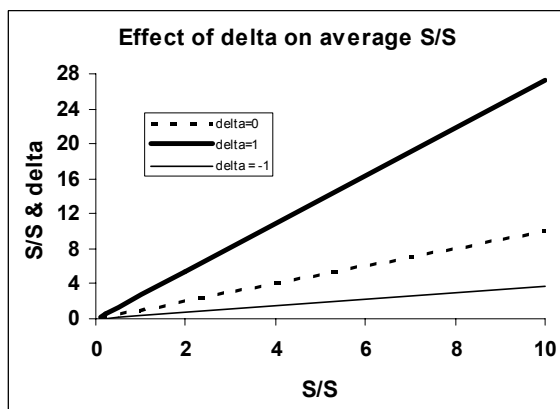
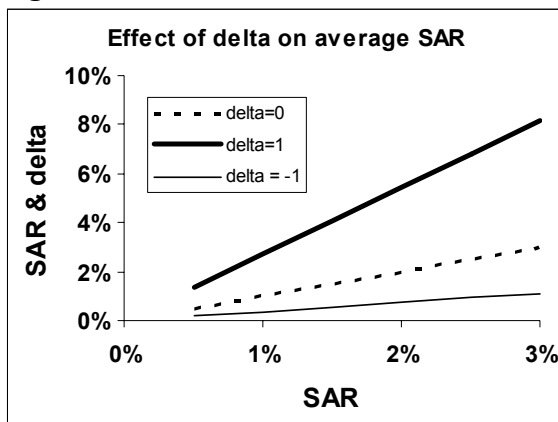
| $\ln(\text{SAR})$<br>delta=0 | $\ln(\text{SAR})$<br>delta=1 | $\ln(\text{SAR})$<br>delta =<br>-1 | $\ln(\text{S/S})$<br>delta=0 | $\ln(\text{S/S})$<br>delta=1 | $\ln(\text{S/S})$<br>delta =<br>-1 |
|------------------------------|------------------------------|------------------------------------|------------------------------|------------------------------|------------------------------------|
| -5.30                        | -4.30                        | -6.30                              | -2.30                        | -1.30                        | -3.30                              |
| -4.61                        | -3.61                        | -5.61                              | -1.61                        | -0.61                        | -2.61                              |
| -4.20                        | -3.20                        | -5.20                              | -0.69                        | 0.31                         | -1.69                              |
| -3.91                        | -2.91                        | -4.91                              | 0.00                         | 1.00                         | -1.00                              |
| -3.69                        | -2.69                        | -4.69                              | 0.69                         | 1.69                         | -0.31                              |
| -3.51                        | -2.51                        | -4.51                              | 2.30                         | 3.30                         | 1.30                               |

effect of  $\exp(\delta)$  is multiplicative to SAR and R/S or S/S

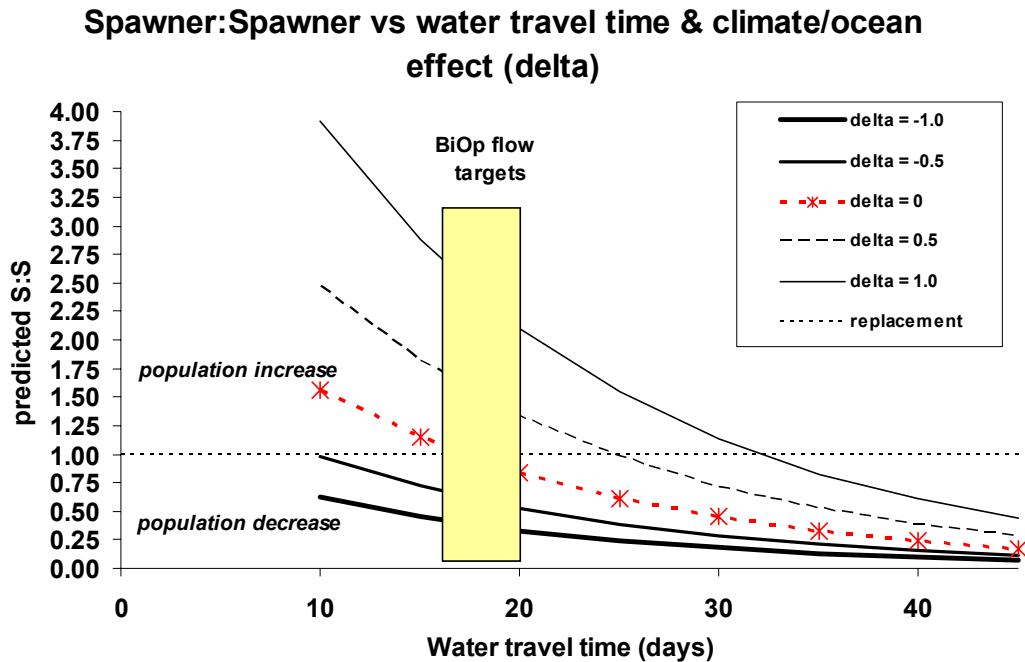
| SAR<br>delta=0 | SAR<br>delta=1 | SAR<br>delta =<br>-1 | S/S<br>delta=0 | S/S<br>delta=1 | S/S<br>delta =<br>-1 |
|----------------|----------------|----------------------|----------------|----------------|----------------------|
| 0.50%          | 1.36%          | 0.18%                | 0.10           | 0.27           | 0.04                 |
| 1.00%          | 2.72%          | 0.37%                | 0.20           | 0.54           | 0.07                 |
| 1.50%          | 4.08%          | 0.55%                | 0.50           | 1.36           | 0.18                 |
| 2.00%          | 5.44%          | 0.74%                | 1.00           | 2.72           | 0.37                 |
| 2.50%          | 6.80%          | 0.92%                | 2.00           | 5.44           | 0.74                 |
| 3.00%          | 8.15%          | 1.10%                | 10.00          | 27.18          | 3.68                 |

e.g., if SAR = 1%, effect of  $\delta = 1$  is a 2.72 fold increase in SAR

e.g., if SAR = 1%, effect of  $\delta = -1$  is a 1/2.72 fold change in SAR



## ISAB Question XV part 2



**A water velocity and survival (population productivity) relationship is apparent when assessing adult spring/summer chinook information**

**Focusing on the yellow bar, which represents the water travel time (velocity) generated by BIOP flow targets (yellow bar), we can observe the population performance relative to replacement ( the dashed horizontal line)**

**For the BIOP Flow target velocities the populations approach or exceed replacement under average to good climate/ocean conditions**

**However, below Biop Flow targets the populations approach or exceed replacement only under good climate/ocean conditions**

**Risk of further population decline is greater below the BIOP flow targets**