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

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February 26, 2003

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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

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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 – 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.

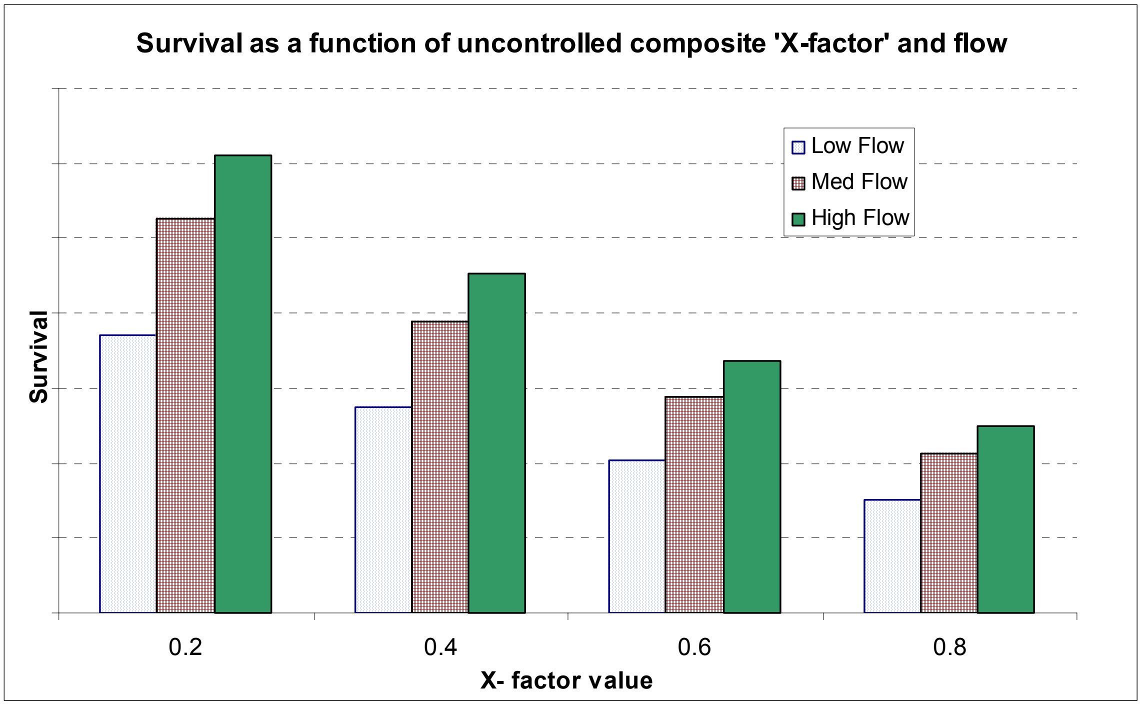

Figure 1. Hypothetical response of survival to composite uncontrolled factors and flow.

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.

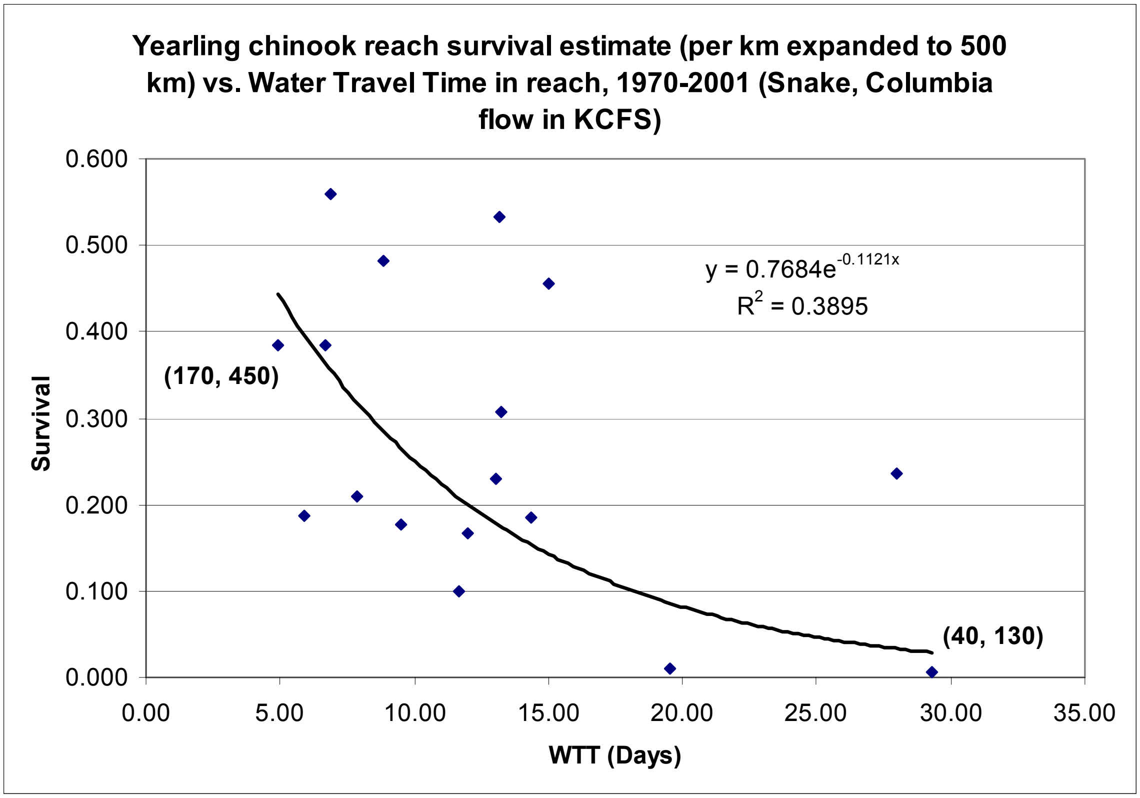

Figure 2.

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).

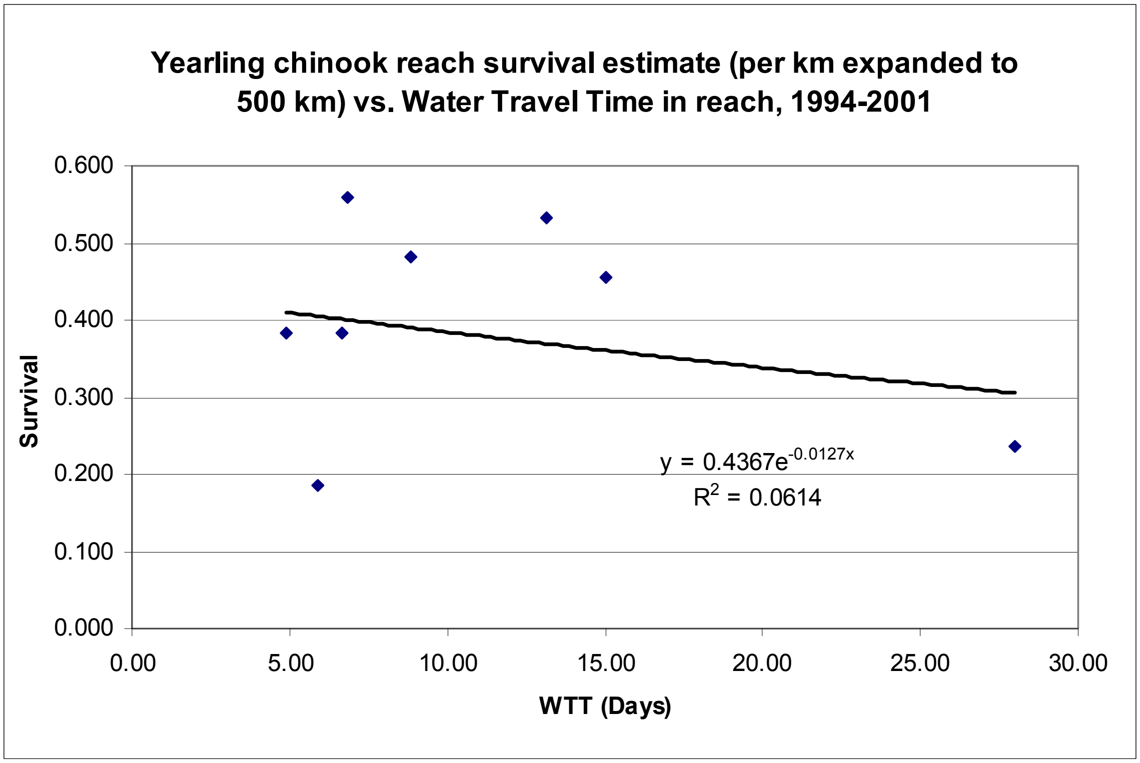

Figure 3.

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

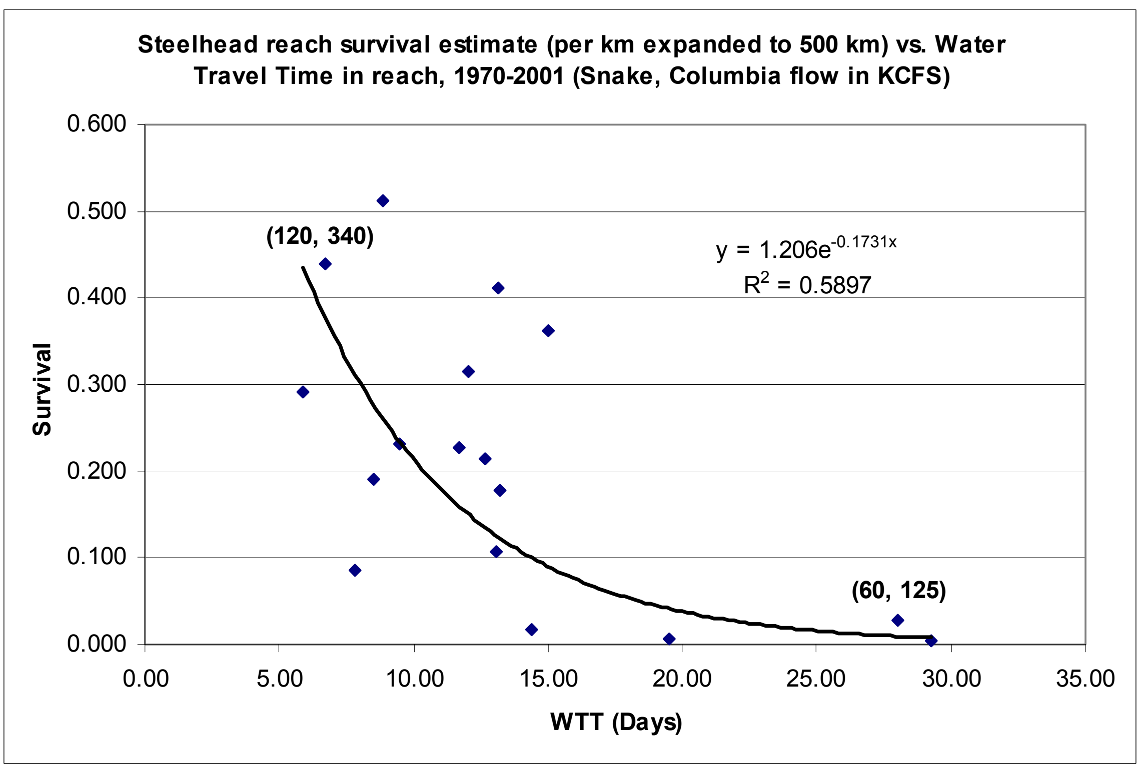

Figure 4.

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

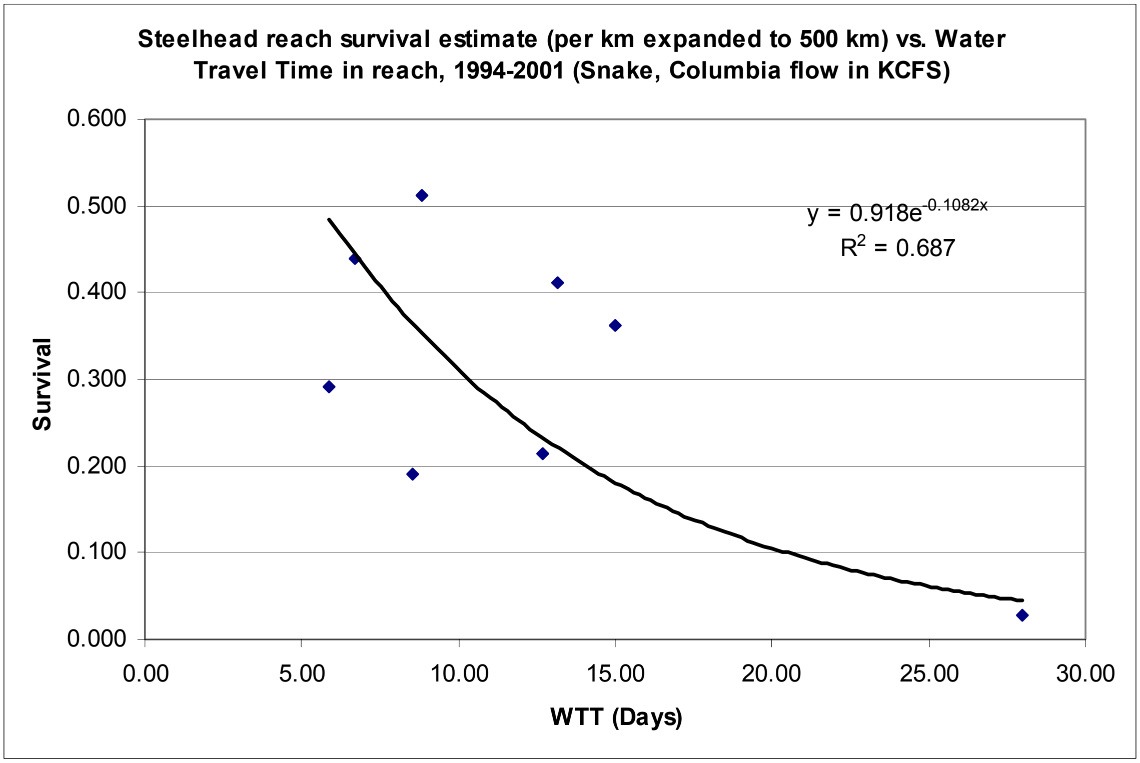

Figure 5.

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.

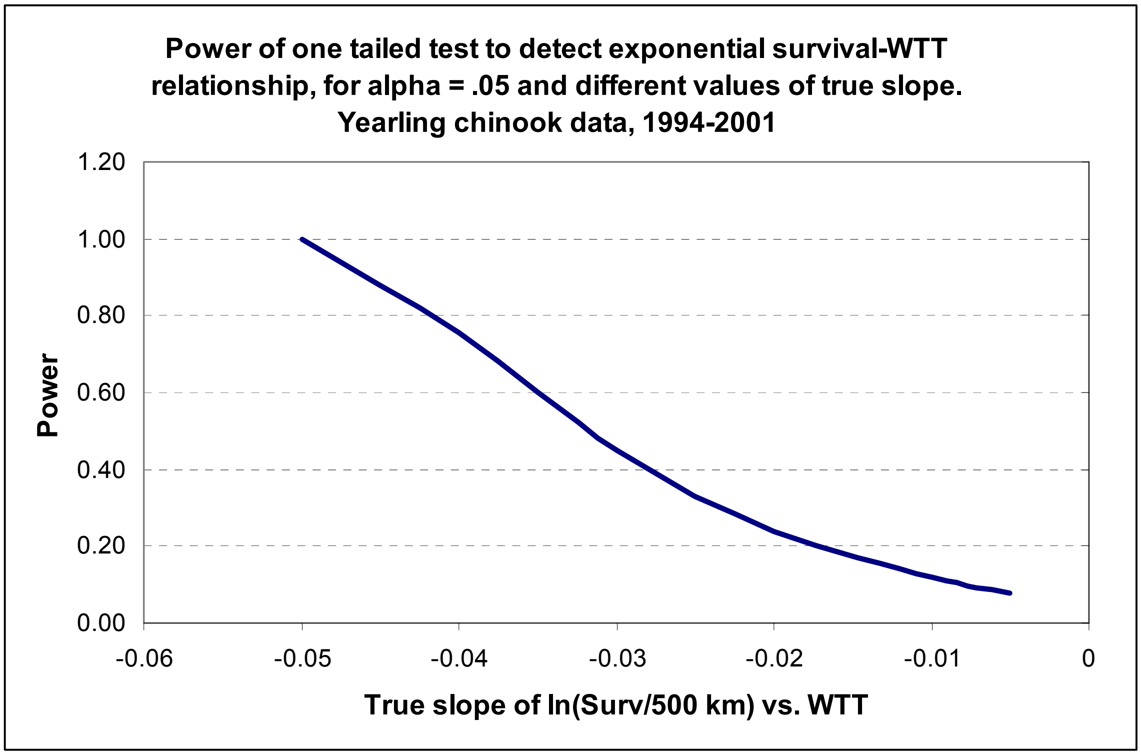

Figure 6.

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.

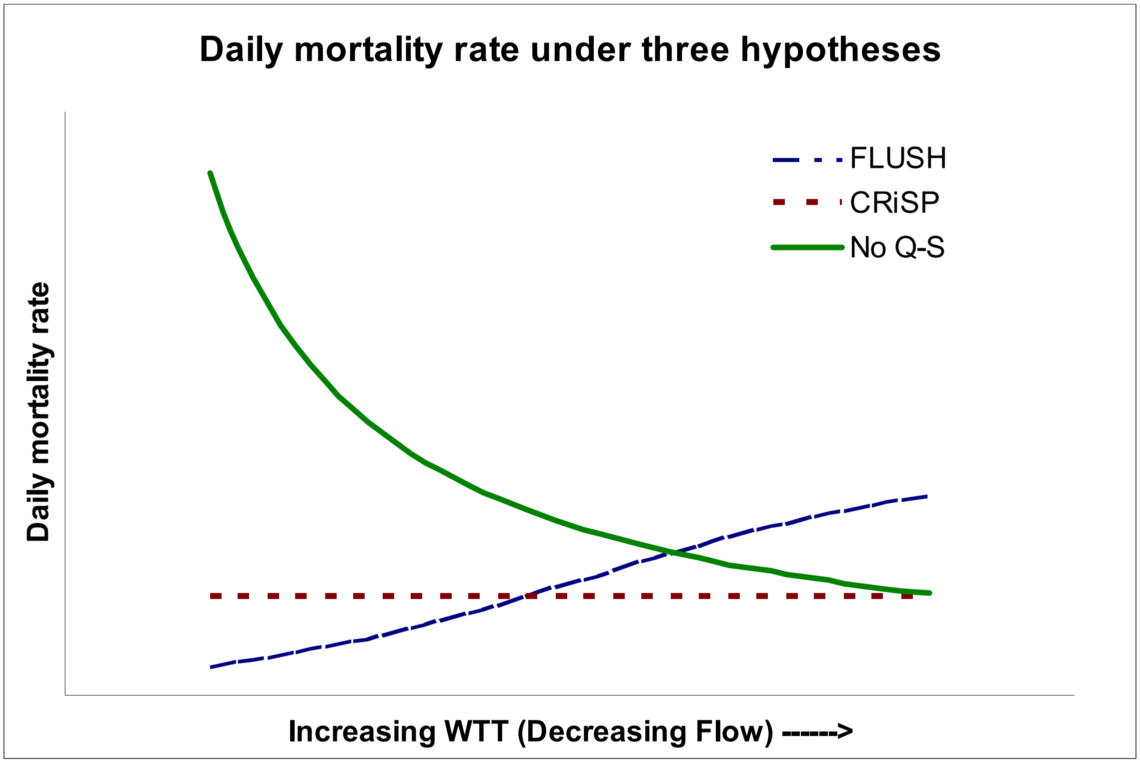

Figure 7.

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^{th} root of LGR to MCN survival rate, where t is LGR to MCN median fish travel time. Daily mortality rate is 1 – 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)

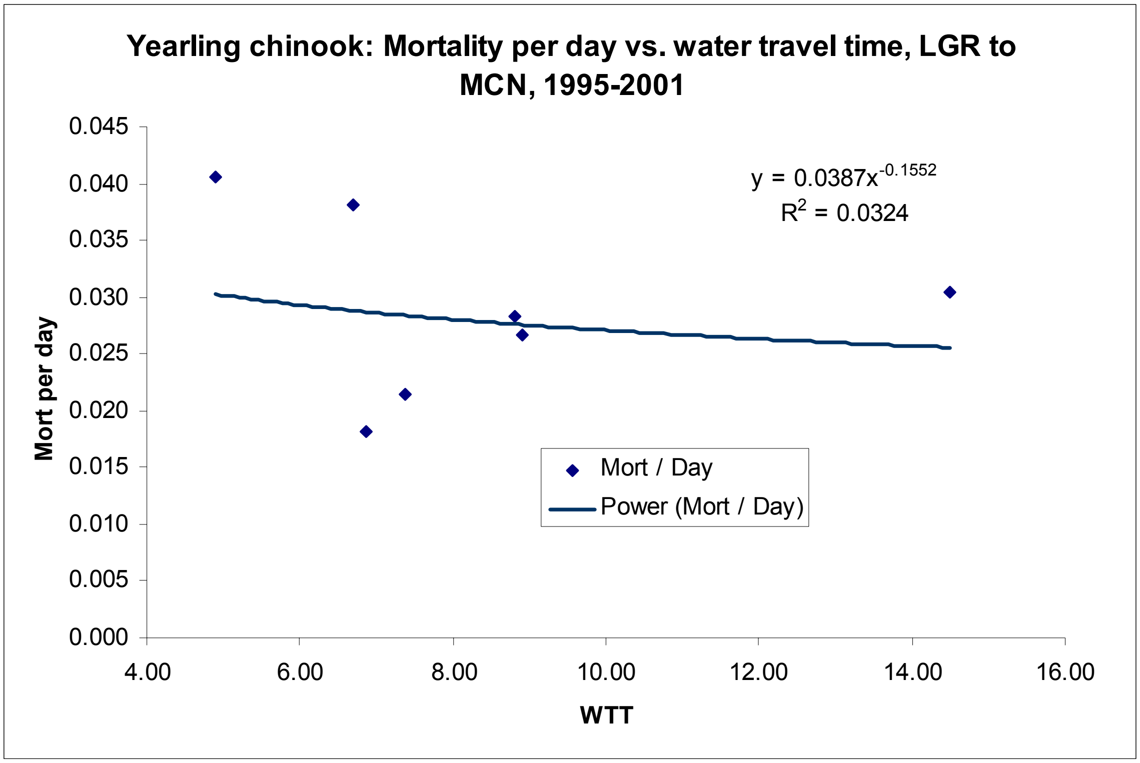

Figure 8.

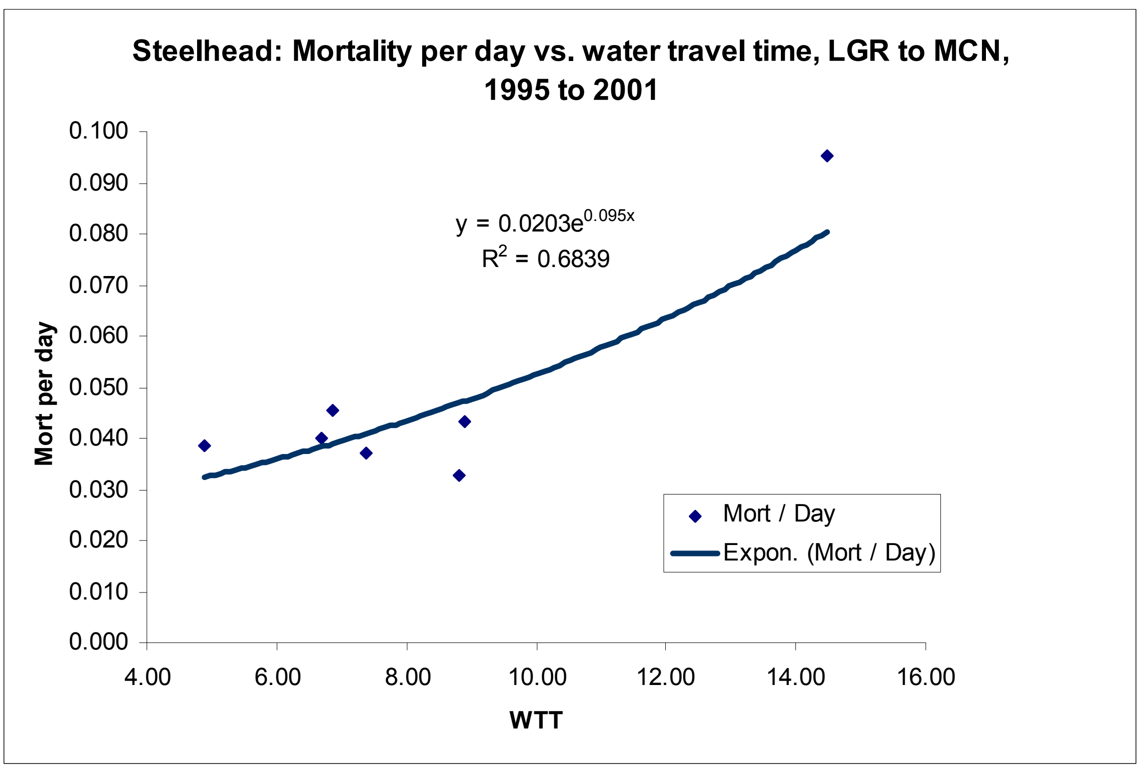

Figure 9.

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."

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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 (μ) for each study year. Regressing annual estimates of μ 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 μ and WTT ($p = 0.72$) for yearling chinook; Figure 2 shows an apparent positive relationship between μ 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.

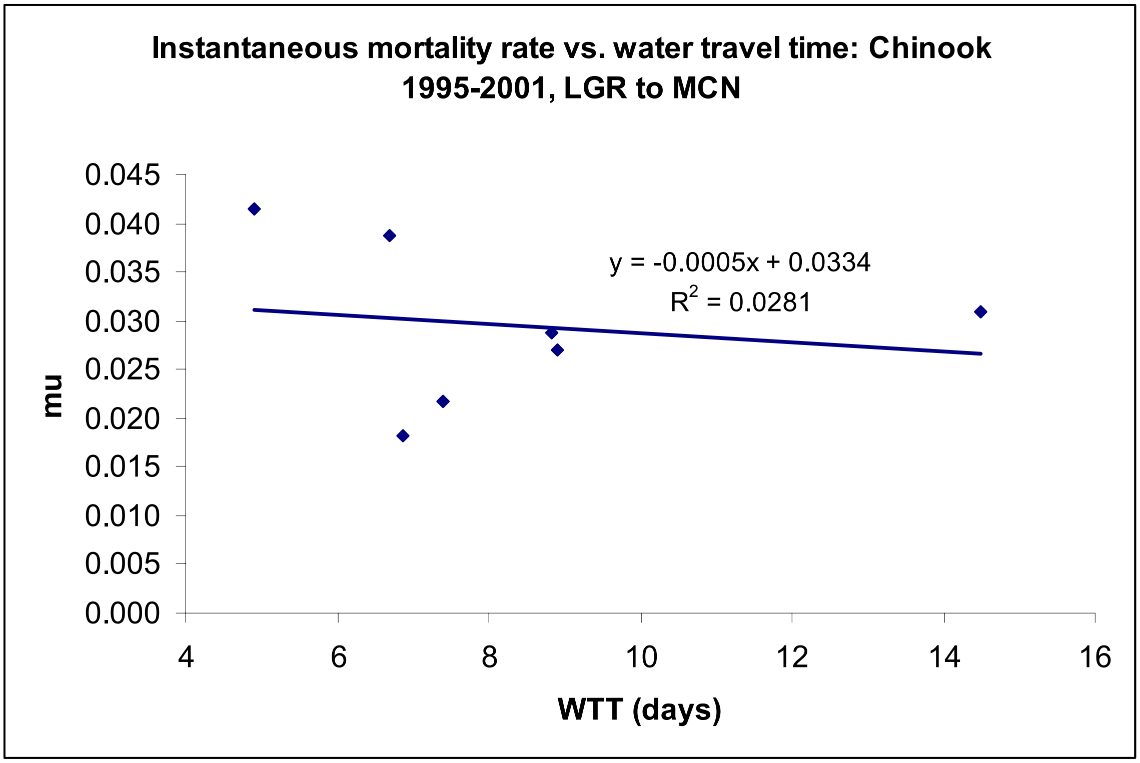

Figure 1.

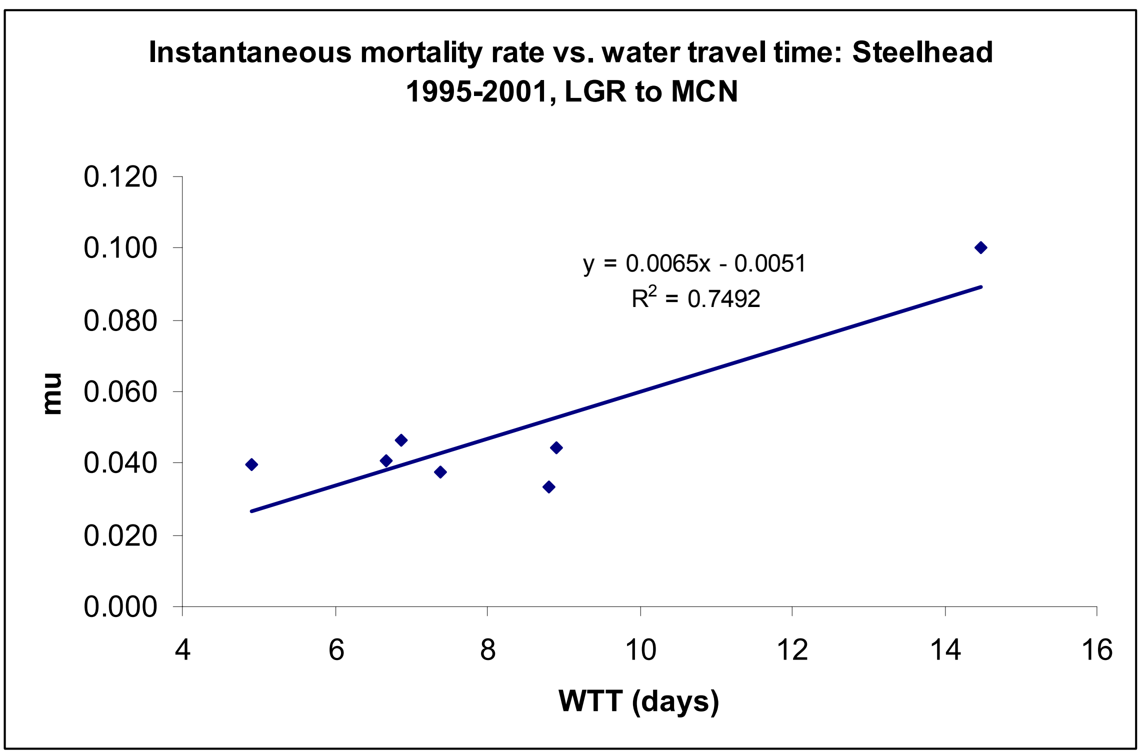

Figure 2.

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

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January 13, 2003

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

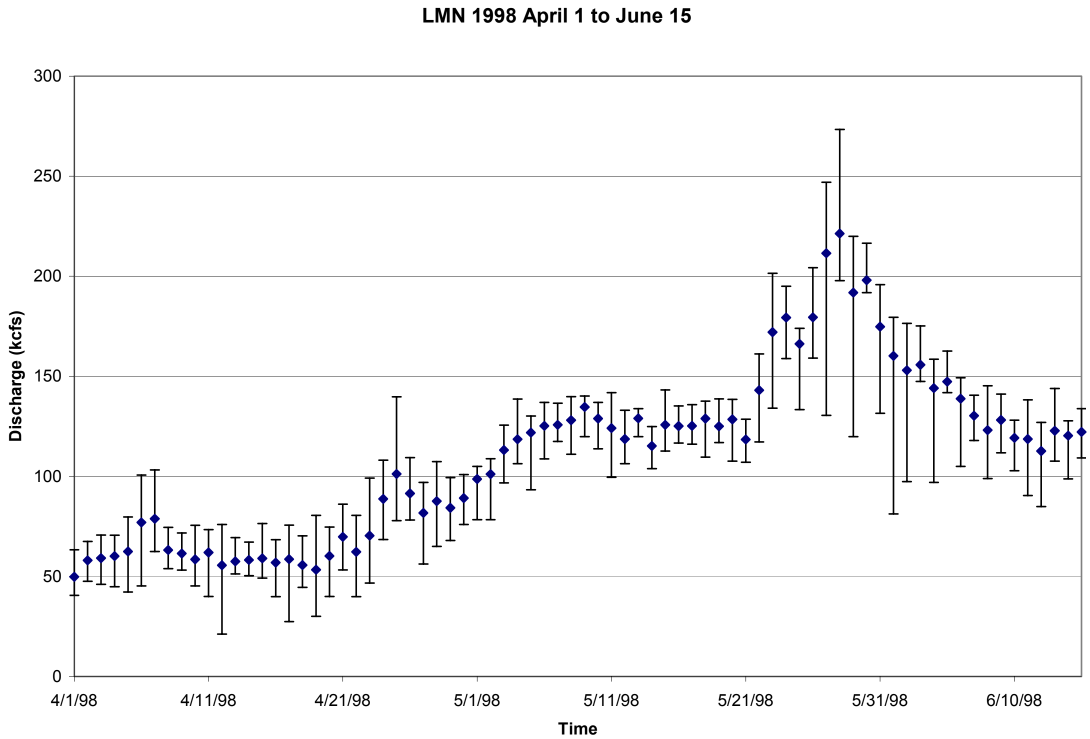
Dear Dick,

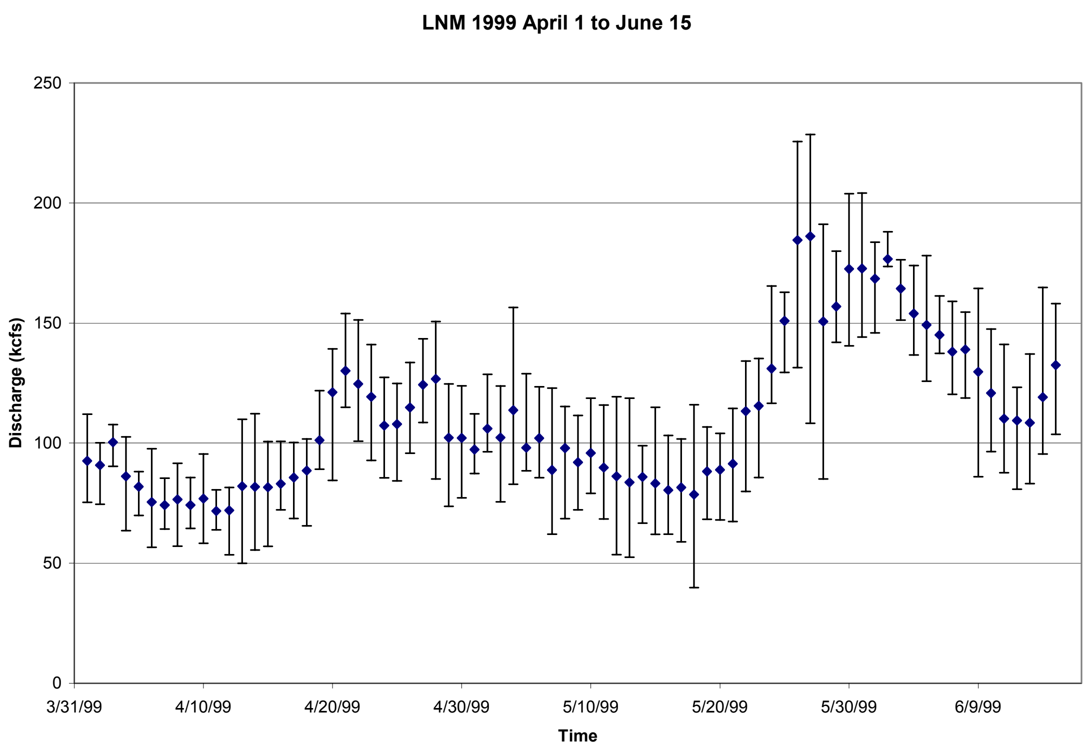
This letter is in response to your data request to the Fish Passage Center. On December 17th, 2002 the Fish Passage Center staff, together with other fishery agency technical staff, met with the ISAB relative to some recently conducted analyses of flow and fish survival. Subsequent to the meeting you 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.

<u>Input Data:</u>

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.


LMN 1998 April 1 to June 15
Discharge (kcfs)
300
250
200
150
100
50
0
4/1/98
4/11/98
4/21/98
5/1/98
5/11/98
5/21/98
5/31/98
6/10/98
Time


LNM 1999 April 1 to June 15
Discharge (kcfs)
250
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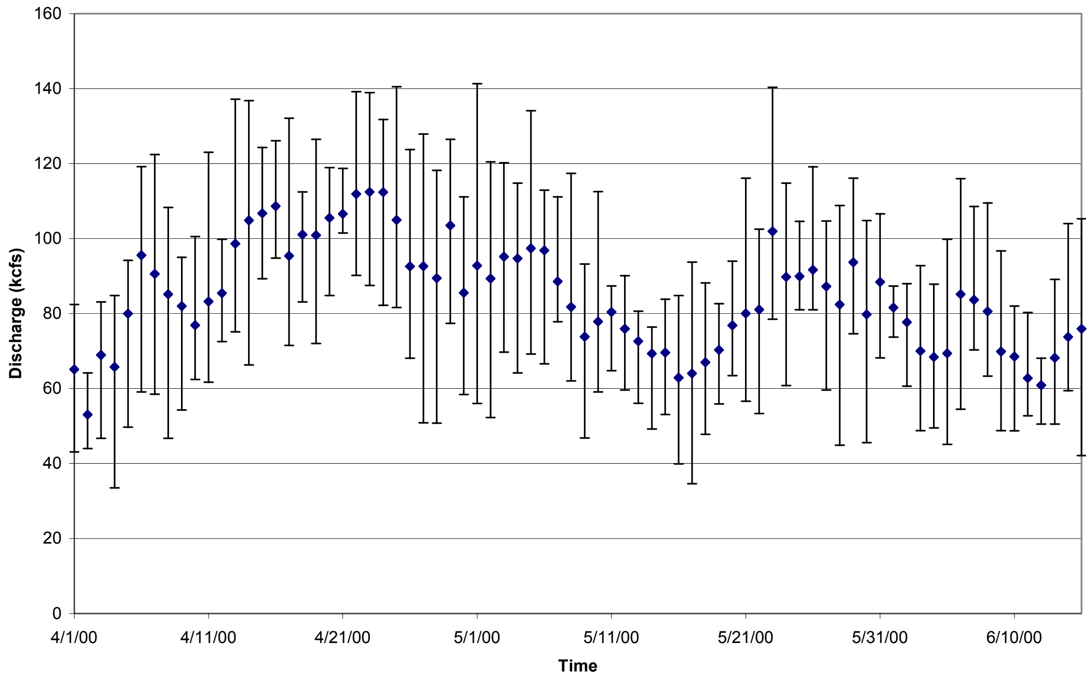
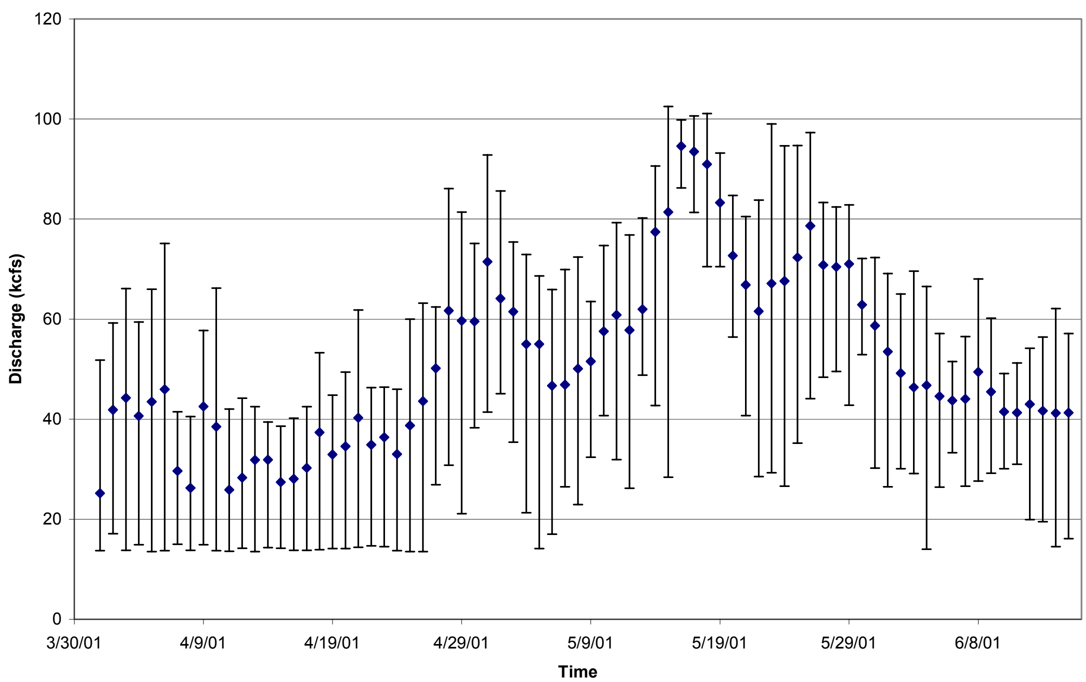
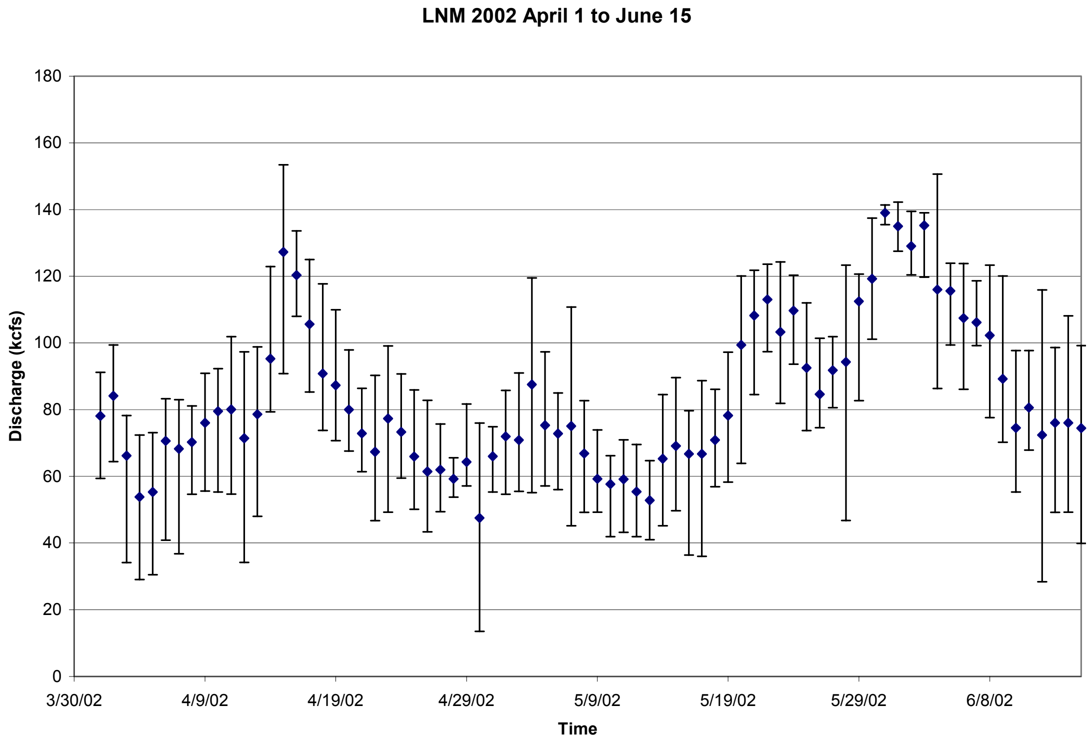
Time

LNM 2000 April 1 to June 15



LNM 2001 April 1 to June 15





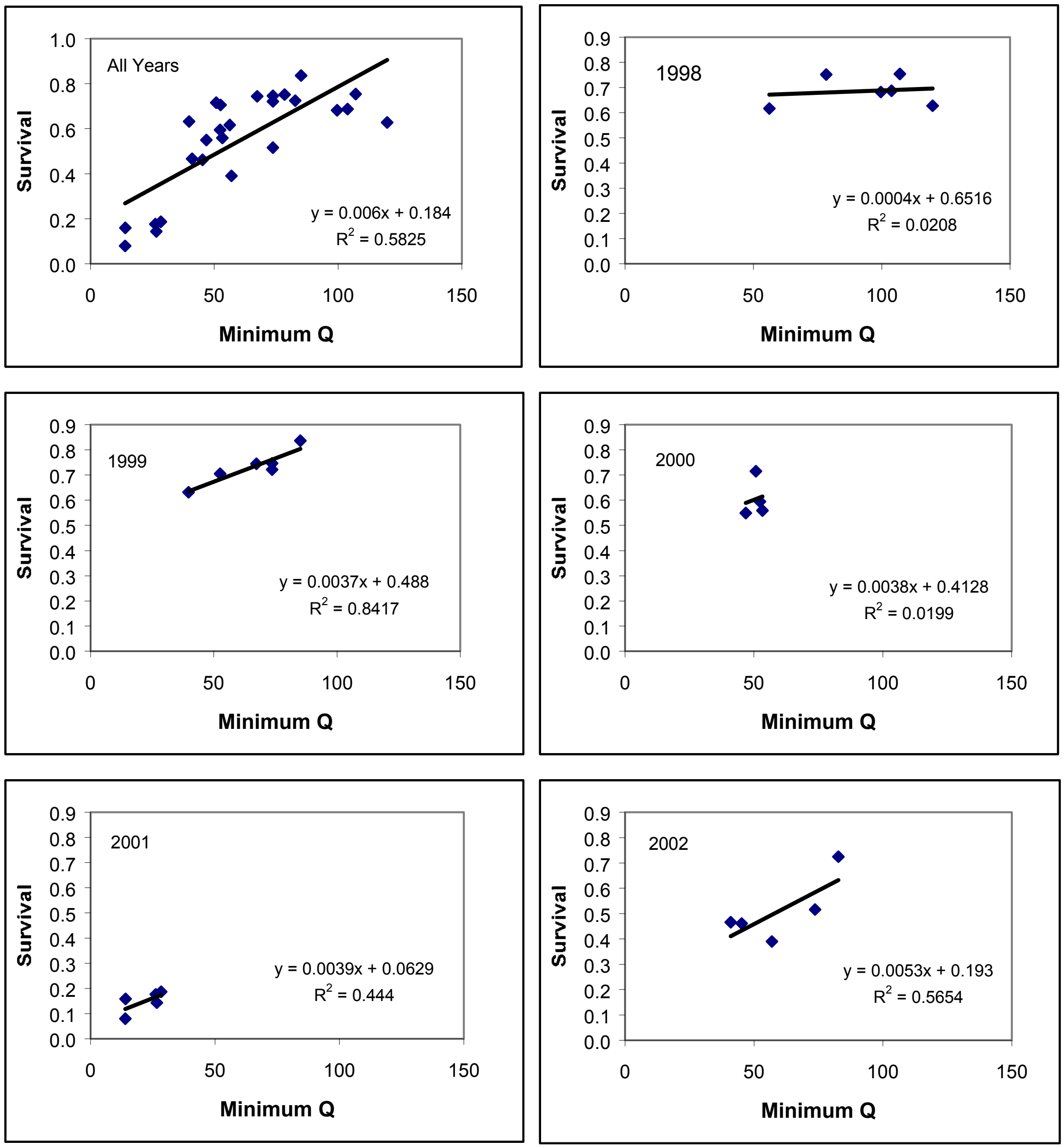
Analysis:

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:

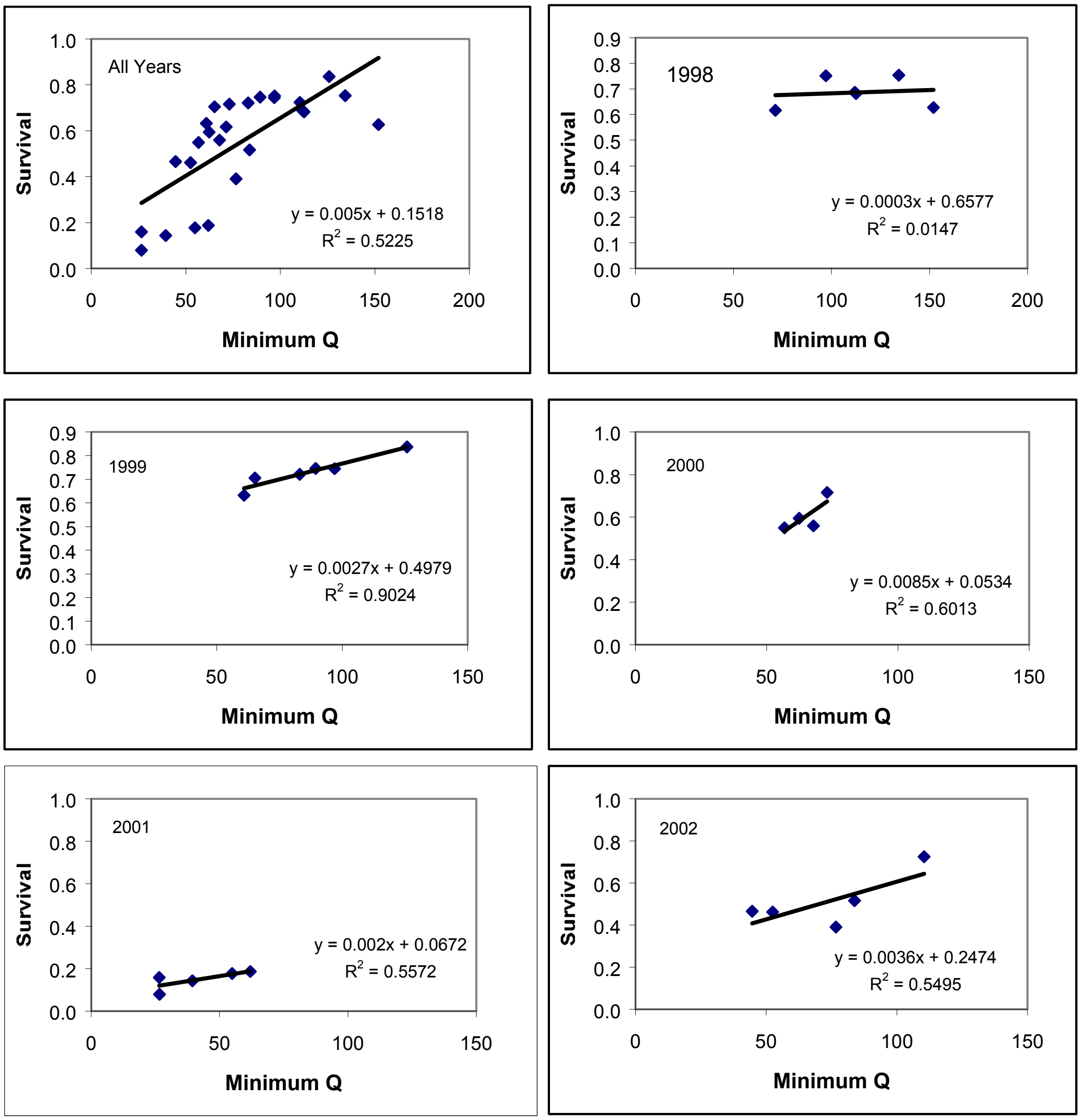
1) the minimum hourly flow observed during the time period;
2) a weekly average of the minimum hourly flows observed in a day;
3) the average of the daily flows for the period;
4) the maximum hourly flow observed during the time period;
5) a weekly average of the maximum hourly flows observed in a day.

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.

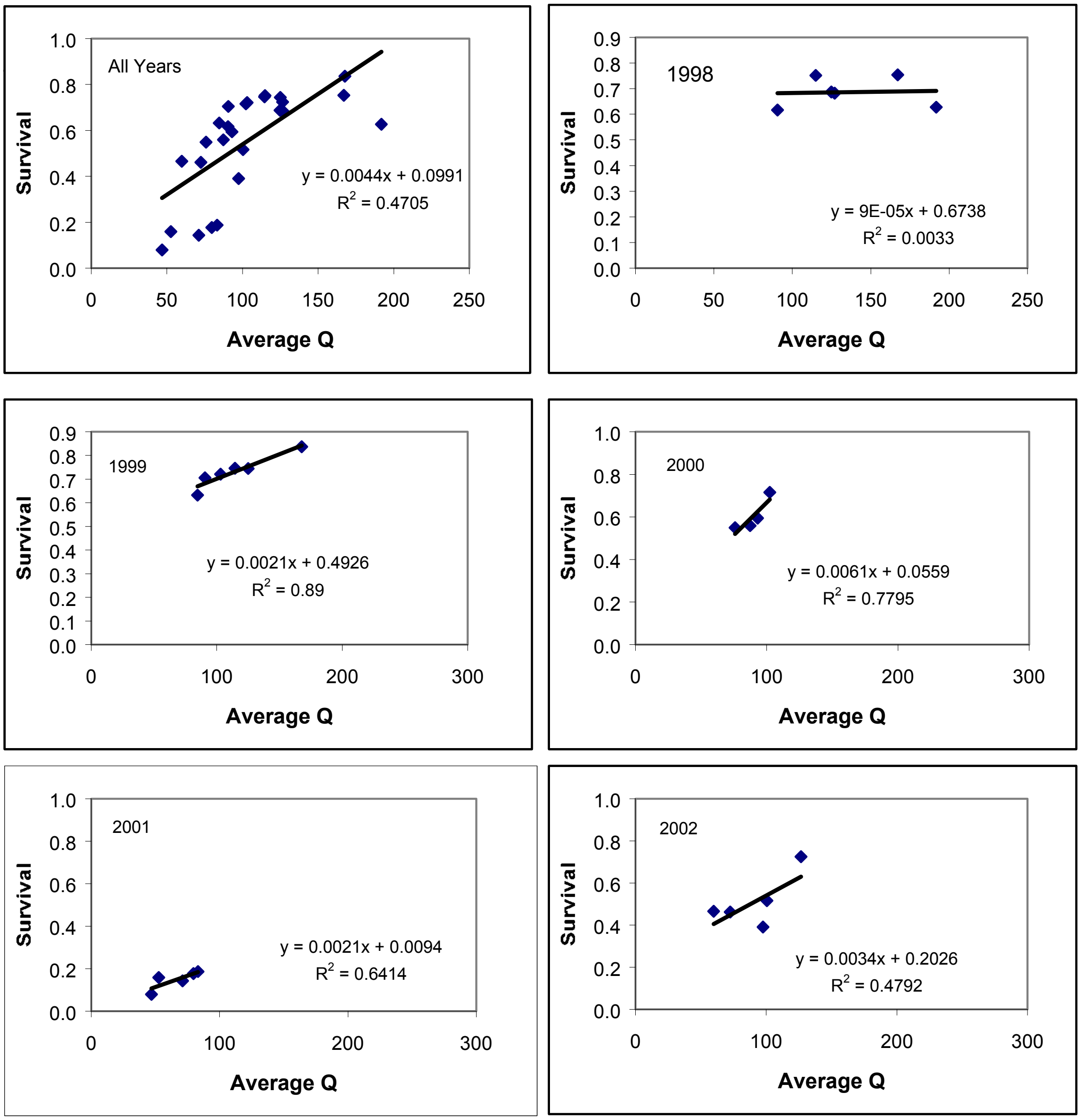
Steelhead Survival LGR to MCN versus Minimum Q at Lower Monumental Dam



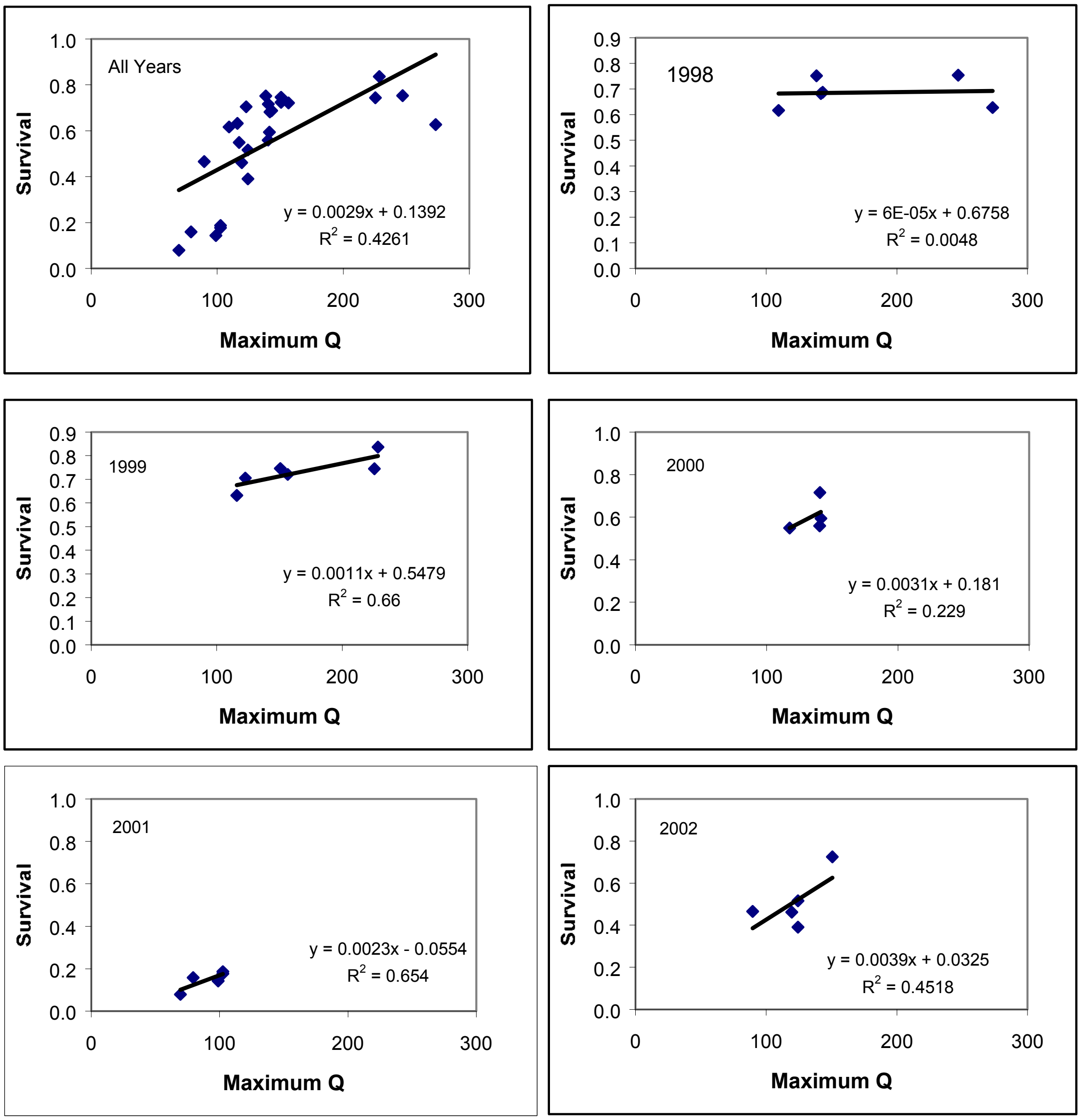
Steelhead Survival LGR to MCN versus Weekly Avg MinQ at Lower Monumental Dam



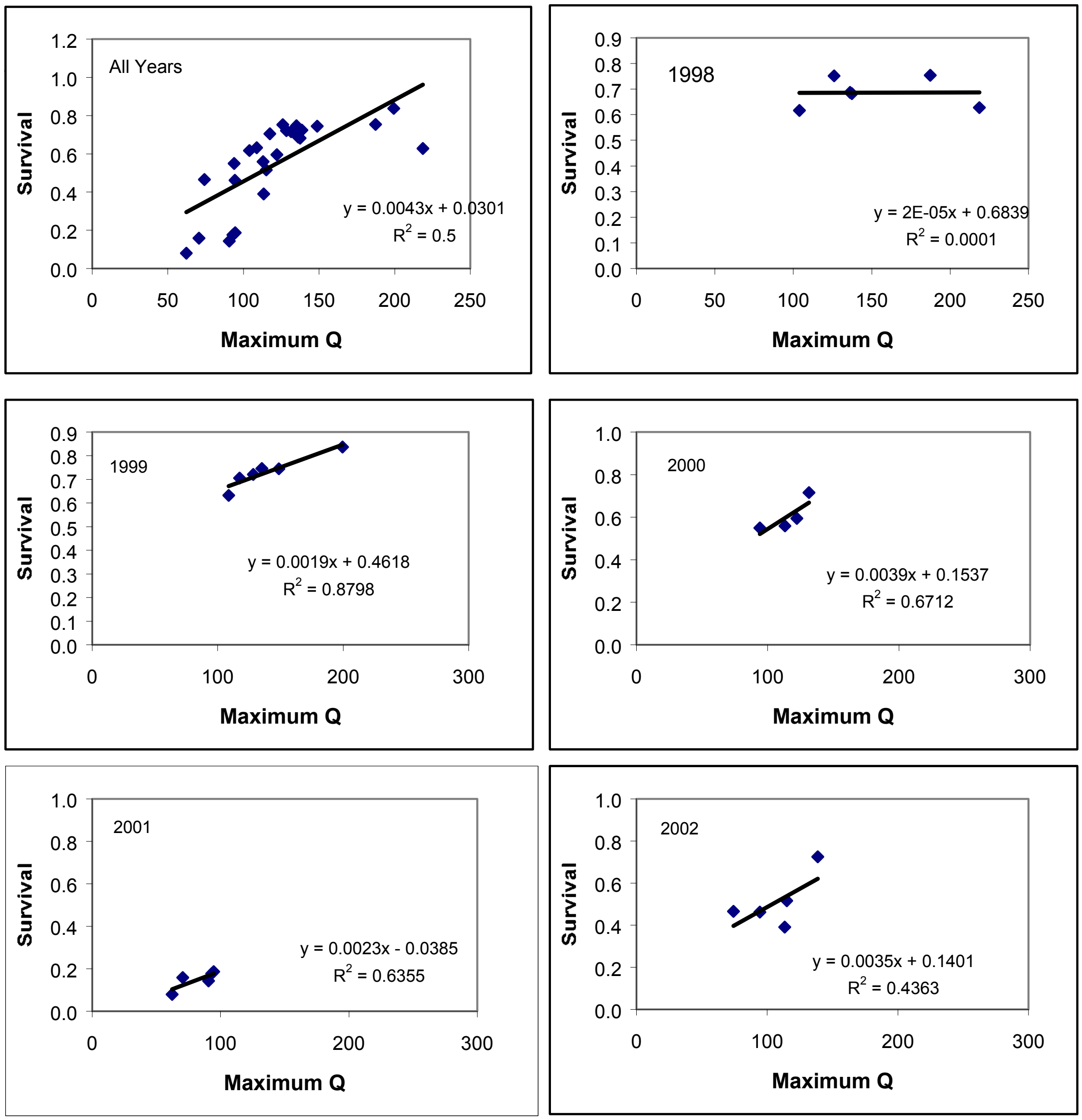
Steelhead Survival LGR to MCN versus Weekly Avg Q at Lower Monumental Dam



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

Michele DeHart
Fish Passage Center Manager

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

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January 10, 2003

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

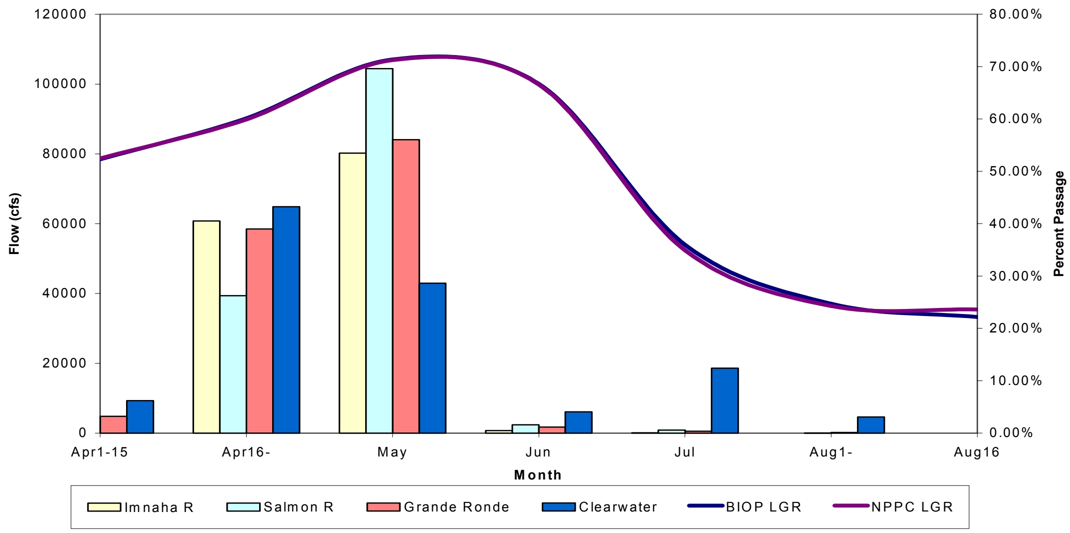
Dear ISAB Members,

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).

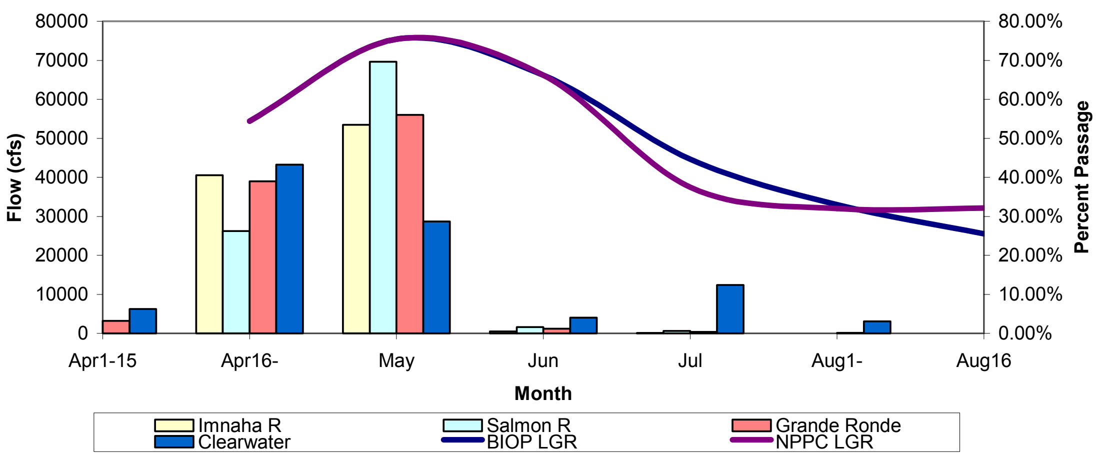
Additionally, at the meeting we expressed concern regarding the range of timing exhibited by the different stocks of salmon. We told the ISAB that we would provide them with that information for consideration during their present review. The following graphs depict the timing of specific stocks together 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.

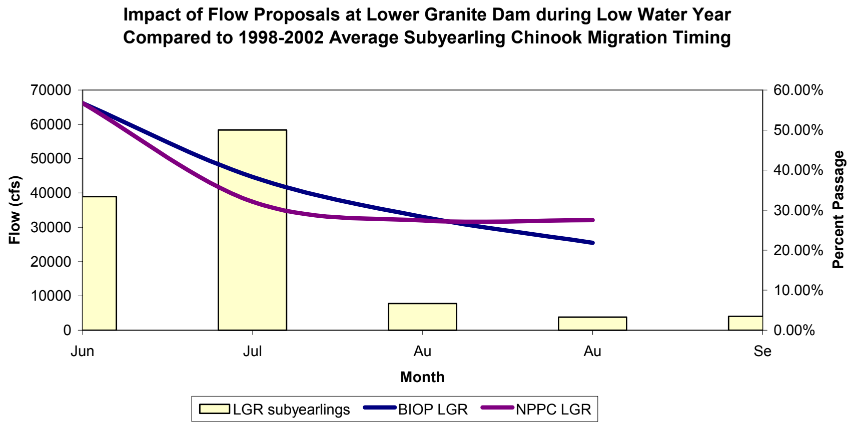
The first two graphs look at arrival time at Lower Granite Dam of yearling and subyearling chinook stocks migrating over the entire spring and summer periods for available PIT tag information. The third graph focuses on the summer period and the migration timing of subyearling chinook. As seen from the 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

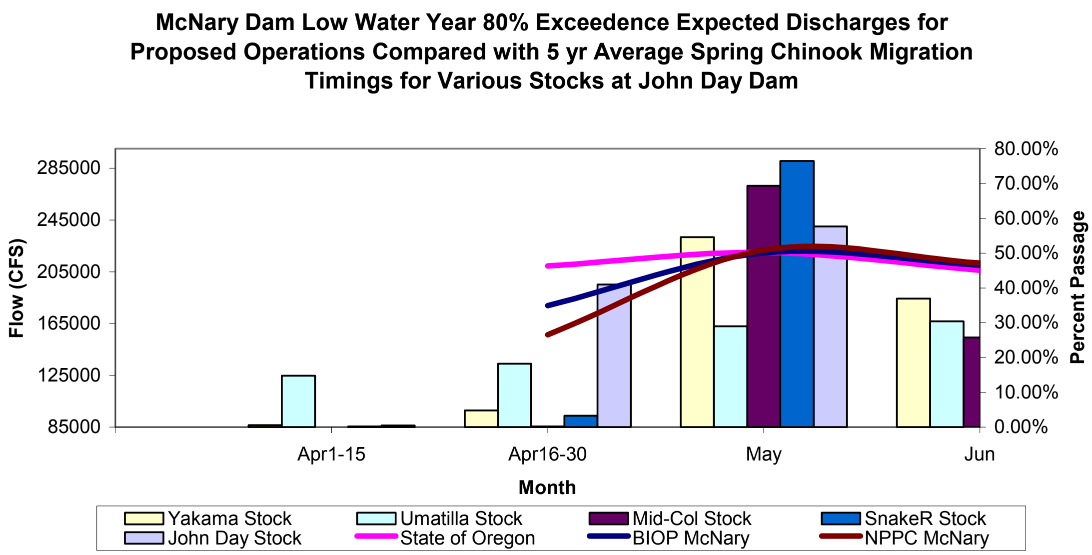


Impact of Flow Proposals at Lower Granite Dam during Low Water Year Compared to Chinook Migration Timing

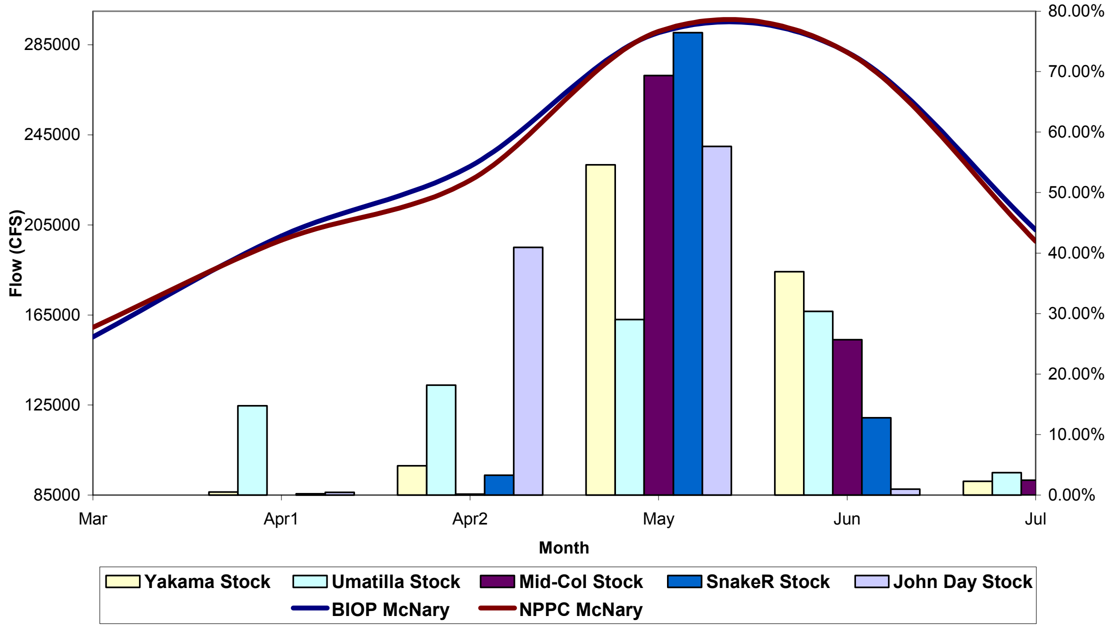




The next two graphs show the migration timing of chinook stocks in the Lower Columbia River. Here we can see that while the second half of April is not normally characterized as a significant passage period for spring migrating juveniles as a whole, it does represent a period of time when significant 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 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

Michele DeHart
Fish Passage Center Manager

ATTACHMENT A

Documentation of December 17th, 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 Figures3, 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 at 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 be 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 12th, 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.

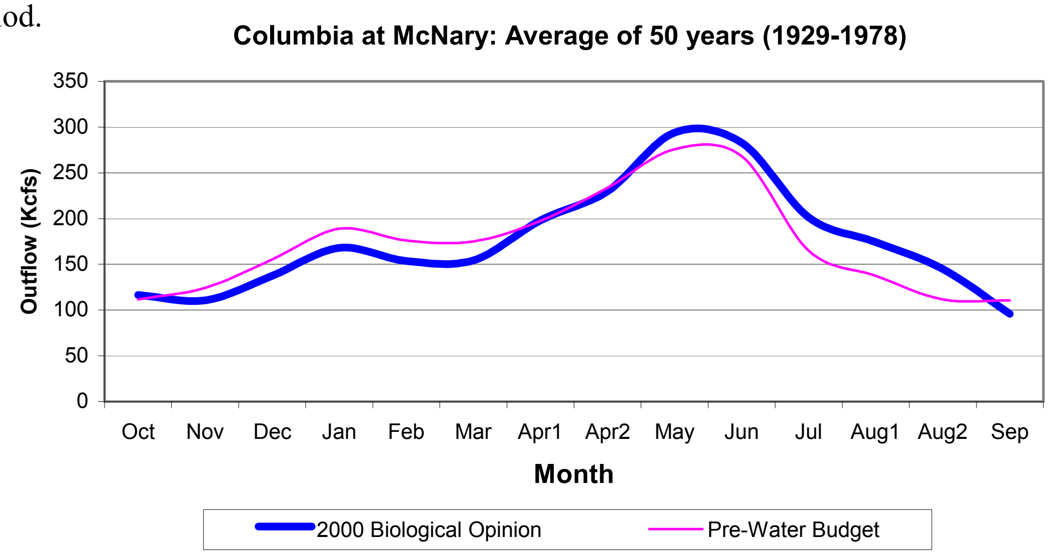
The FPC identified these issues in memorandums to the Fishery Managers in 1992 and again in 1995 that the problem of excessive overlapping of PIT tagged release groups as they migrate through the study reach will not allow discrete partitioning of the incremental effects of environmental or biotic variables 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 10th 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.



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

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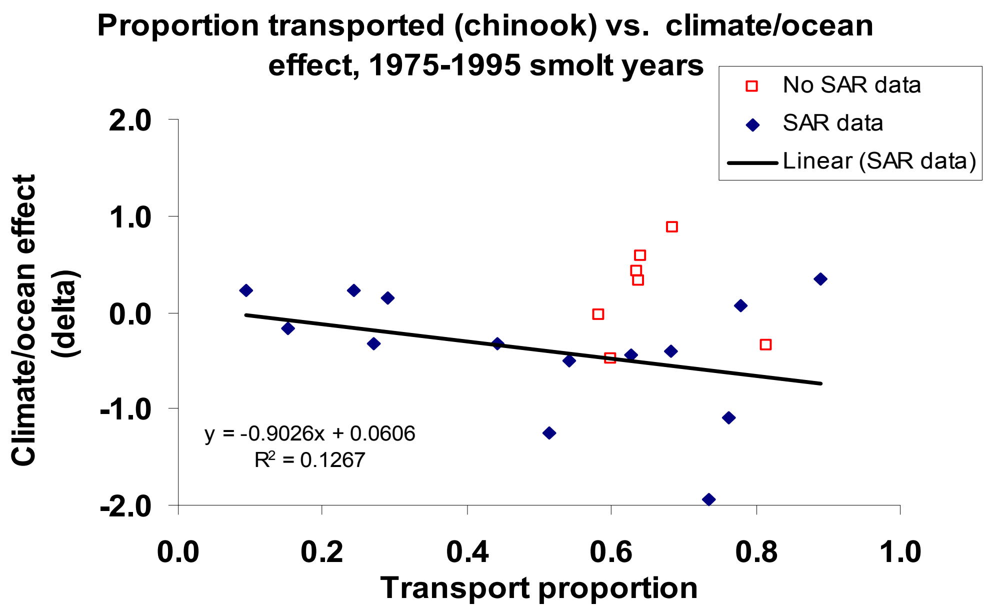
December 17, 20002

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:
μ represents the relative difference in mortality between upriver and downriver stocks;

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

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

where;

a	**=intrinsic rate of population growth 'Ricker a'**
δ_t	**= common year effect (climatic/ocean effect)**
X_n	**=direct hydrosystem mortality for lower river stocks**
μ_t	**=differential mortality (relative difference in mortality between upriver and downriver stocks)**
$_t$	**=year**

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

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

μ	**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**

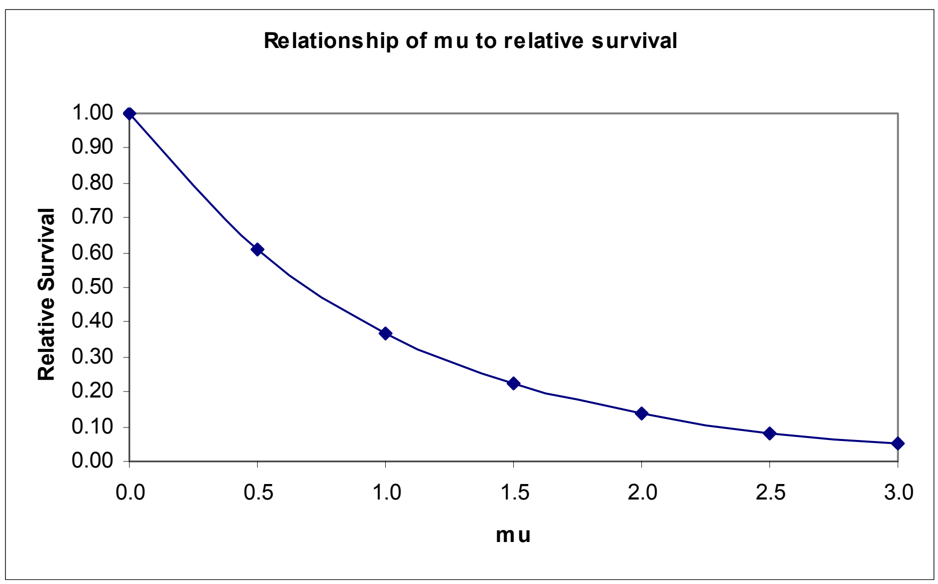


Figure 28 indicates that relative hydrosystem mortality increased with increased water travel times

ISAB Question XV part 1

In the Model from figures 29-31 where;
δ is defined as common year effect (climatic/ocean effect)
from Deriso et al. (2001) see derivation from description of µ

ln(SAR) = WTT + delta or ln(S/S) = WTT + delta

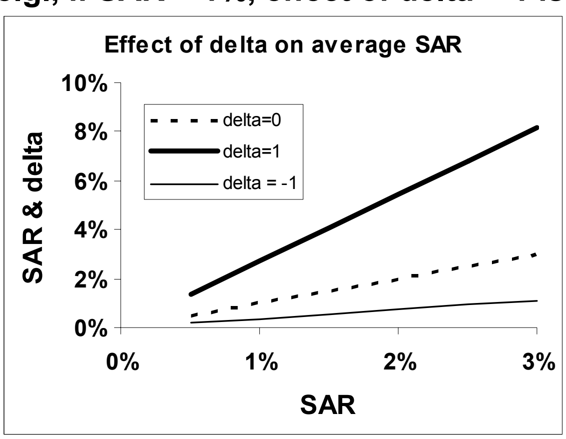
effect of delta is additive to ln(SAR) and productivity (ln(R/S) or ln(S/S))

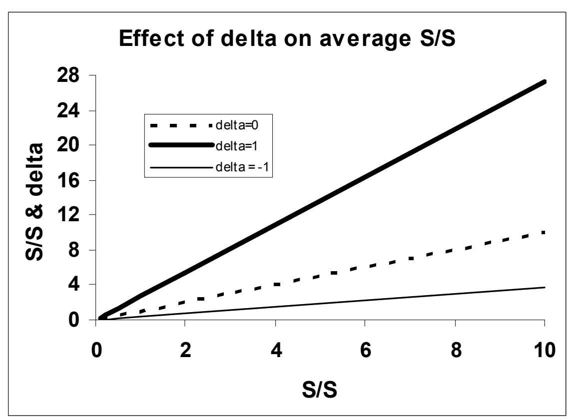
ln(SAR) delta=0	ln(SAR) delta=1	ln(SAR) delta = -1	ln(S/S) delta=0	ln(S/S) delta=1	ln(S/S) delta = -1
-5.30	-4.30	-6.30	-2.30	-1.30	-3.30
-4.61	-3.61	-5.61	-1.61	-0.61	-2.61
-4.20	-3.20	-5.20	-0.69	0.31	-1.69
-3.91	-2.91	-4.91	0.00	1.00	-1.00
-3.69	-2.69	-4.69	0.69	1.69	-0.31
-3.51	-2.51	-4.51	2.30	3.30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

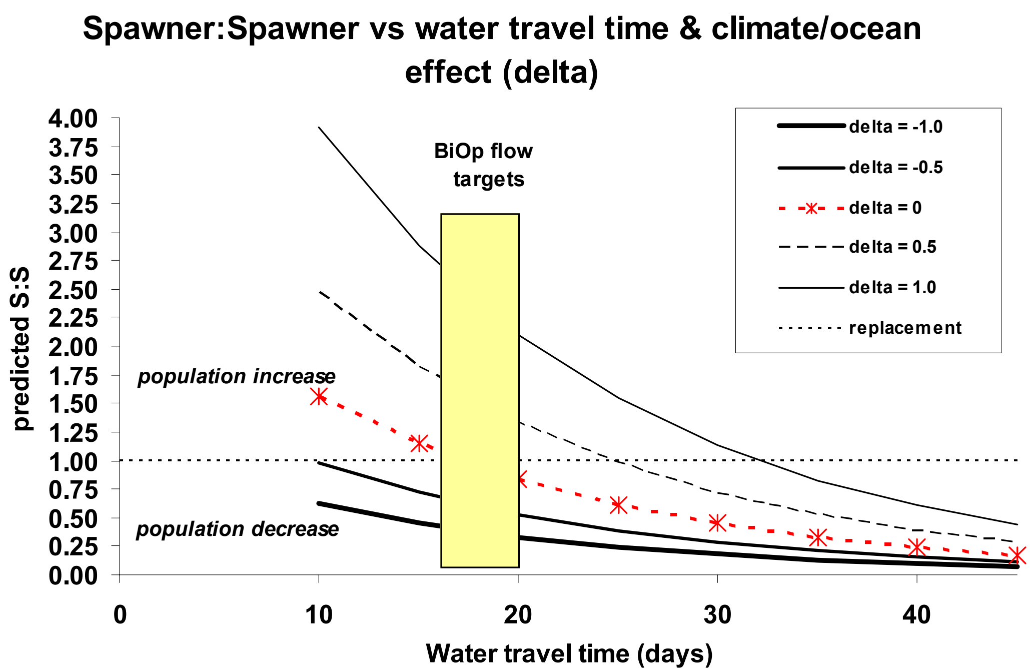
effect of exp(delta) is multiplicative to SAR and R/S or S/S

SAR delta=0	SAR delta=1	SAR delta = -1	S/S delta=0	S/S delta=1	S/S delta = -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







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