Joint Technical Staff Memorandum

CRITFC IDFG ODFW USFWS WDFW YIN

March 19, 2002

Mr. Mark Walker
Northwest Power Planning Council
851 SW 6th Ave., Suite 1100
Portland, Oregon 97204

Dear Mr. Walker:

The technical staffs of the Columbia River Intertribal Fish Commission, the Idaho Department of Fish and Game, the Oregon Department of Fish and Wildlife, the Confederated Tribes and Bands of the Yakama Nation, the US Fish and Wildlife Service and the Washington Department of Fish and Wildlife have reviewed the report entitled, "Mainstem Passage Strategies In the Columbia River System: Transportation, Spill and Flow Augmentation", prepared by Giorgi et al, BioAnalysts, Inc. for the Northwest Power Planning Council. We offer the following comments on the report for the NWPPC consideration in the current fish and wildlife program amendment process.

The report summarizes study results conducted to date and offers general conclusions regarding spill, flow and transportation passage strategies and uncertainties associated with each of those strategies. Giorgi et al. rely in part on a manuscript in draft by Zabel et al. and on a NMFS manuscript (Sandford & Smith in press), which has not been available for review. Extensive technical comments have been provided to NMFS on the NMFS Zabel et al. draft, (attached) which directly relate to their application in the report prepared for the NWPPC. NMFS has not yet addressed the technical comments on the Zabel et al. draft. These technical comments would also apply to Giorgi et al. The following points summarize our detailed technical review and discussion.

- We agree that spill is the safest and best means of project passage for juvenile salmonids.
- We agree that there is a flow travel time relationship for downstream salmonid migrants.
- The narrow focus of emphasis on incremental benefits of short term passage RPAs obscures the real predominant management issue of the long term rebuilding of listed and unlisted stocks of anadromous fish.
- The treatment of survival relative to spill and flow is incomplete and can only be utilized within a limited context. The narrow focus and selective incorporation of information do not support management decisions regarding these passage strategies. However, by incorporating a broader scope of analyses from recent PIT tag information support is strengthened for flow and spill as protective measures for listed populations.
- The uncertainty regarding the transportation passage strategy is only partially addressed.

General Comments

In general the Giorgi et al. report supports the short term RPAs included in the NMFS Biological Opinion and the current operation of the FCRPS, but the Giorgi et al. summary does not include adequate discussion of uncertainty of the present short-term passage strategies of achieving long-term recovery of listed stocks. The Giorgi et al. report emphasis on incremental analyses of the benefits of short-term passage strategies obscures the uncertainty of accomplishing recovery in the long term. The Giorgi et al. strategy document does not recognize the fact that the NMFS Biological Opinion relies heavily on off-site mitigation. Short-term passage strategies with the present hydrosystem configuration included in the Opinion are unlikely to achieve recovery unless highly optimistic assumptions about potential offsite mitigation can be achieved for habitat and hatcheries.

The authors fail to portray the poor status of salmon stocks in the Snake and Upper Columbia River. There is no mention of the fact that spring/summer chinook stocks typically fail to replace themselves with recent recruit/spawner averages (geomeans R/S) well below one. The authors do not cite recent works that have estimated probability of extinction or time to extinction. For example, Oosterhout and Mundy (2001) calculated the time to extinction for Snake River spring/summer chinook stocks to be on average approximately 18 years. The replacement rates for upper Columbia River spring chinook stocks are also extremely low (Ford et al. 2001).

Giorgi et al. are selective in their use of available analysis and emphasize incremental benefits analysis. State and tribal fishery managers have previously provided comments and concerns regarding the shortcoming of incremental analysis and its inappropriateness in fish passage management decisions. Discussions of the incremental benefits of the present fish passage mitigation RPAs do not address the question of long-term recovery in a life cycle context. Giorgi et al. are selective in the presentation of information, excluding alternative analysis and neglecting to illuminate recent findings such as the adverse impact of repeated project bypass passage. In addition some CSS study conclusions were not included which would affect the context of the discussion of the transportation passage strategy.

Regarding the discussion of spill, we agree with the overall report conclusion that spill is the safest and most effective means of passage at the projects and that spill affects smolt travel time. In the discussion of spill and survival in 2001, Giorgi et al. discuss findings from the Zabel draft. Again, extensive comment was provided to NMFS, which would apply to the report. A clear benefit of spill was observed during the 2001 migration. This along with other spill passage data provide an indication that spill for fish passage should be provided in all flow years, including years when the Biological Opinion flow target is not met. The Giorgi et al. report does not address the issue of summer spill in the Snake River. This is an issue that is planned for study.

We agree that current transportation studies indicate that delayed mortality appears to be occurring on both wild and hatchery fish that are transported. We agree that the data indicates that transportation at all present sites may not be advisable given present results. In addition, the report relies on a NMFS transportation manuscript that is not yet available to the public and the Comparative Survival Study status report, which is available to the public. Since the NMFS manuscript is not available it is difficult to comment on the Giorgi et al. use of those results. However, Giorgi et al. were selective in their use of the CSS study results, omitting mention of some of the other key findings regarding the impact of transportation on wild stocks and the failure to meet the 2%-6% return rate requirement to achieve recovery.

Giorgi et al. address flow augmentation and conclude that flow is directly related to smolt travel time, which accurately reflects regional scientific agreement. Giorgi et al. rely heavily on the draft Zabel et al. 2001 manuscript in other aspects of the flow survival discussion. The comments provided by the state and tribal salmon managers on Zebel et al. (attached) apply to the Giorgi et al. document. Giorgi et al. conclude that there is no flow survival relationships on the basis of the Zabel et al per-project survival analysis of freeze brand and PIT tag data combined. There are significant technical problems with this approach, which extrapolates short reach survival to the whole hydrosystem, which tends to overestimate survival for the whole hydrosystem passage corridor. Because project reservoirs differ in length and survival is not estimated over the same number of reaches, comparisons over an average per project survival will not be consistent because the unit of comparison varies. A comparison over an average per mile survival will be more consistent because a mile is a unit that is constant. We can expand the average survival per mile to length of the hydrosystem, which is also constant, to characterize how changes in water travel time affect survival through the hydrosystem. These components of the Giorgi et al. report should be considered cautiously.

Specific Comments

Executive Summary

p. vii. "…reaching SAR levels in 1999 that approach and in some cases exceed the 2% minimum recovery threshold… This suggests that neither transport nor inriver migration conditions may be a bottleneck to recovery, when marine-based survival is at some adequate level": PATH identified the 2%-6% SAR range as the range within which Snake River spring/summer chinook stocks should fluctuate, rather than just reach occasionally. The suggestion that neither transport nor inriver survival is a bottleneck to recovery in good ocean years is inappropriate without supporting life cycle modeling, and contrary to results of the PATH modeling. The PATH FY98 report (Marmorek et al. 1998, p. 41) actually concluded, "…median SARs must exceed 4% to achieve complete certainty of meeting the 48-year recovery standard, while meeting the 100-year survival standard requires a median SAR of at least 2%."

p. x. Premises for flow augmentation: The diagram describes the premise for flow augmentation, however the report does not adequately identify that inriver survival of smolts within the hydrosystem is only a part of the issue. While the report emphasizes only inriver survival (through portions of the hydrosystem) vs. flow, analyses of SARs or life cycle survival (adult recruits per spawner) are needed to capture the hypothesized full effect of flow on survival. This is because water velocity affects fish migration speed, affecting the cumulative exposure to stressors, synchrony of estuary arrival with the smolt's physiological state, and smolt condition (sufficient energy reserves necessary for survival in the saltwater). The NMFS whitepapers (NMFS 2000) present considerable evidence that SARs and life cycle survival are correlated with flows and velocities experienced by smolts during their migration through the hydrosystem, and should be referenced in this report.

Transportation

The authors discussion of the transportation passage strategy does not adequately illustrate the significant uncertainty regarding transportation. Significant available information regarding the transportation information is not included in the report. The report correctly indicates that transportation results to date from Lower Monumental and McNary dams raise the question of continuing transportation at those sites. The report does not adequately address the data available regarding the transportation of wild fish. Those results indicate that transporting wild fish does not provide a benefit over in-river migration when adequate spill and flow are provided for in-river migrants.

Delayed mortality is the reason that the benefits of transportation are less than originally hypothesized when compared to in-river migrant mortality. Extra mortality of in-river migrants due to the hydrosystem is not discussed in the report but NMFS Biological Opinion RPA actions were developed to address this issue.

Although Giorgi et al. refers to the lower SARs of fish passing through bypass systems, this result is utilized as an argument for transporting fish. However, the bypass systems at the collector projects are primarily designed and operated to collect fish for the transportation program. Giorgi et al. fails to recognize this as a component of the transportation program and a potential factor in transportation returns.

The authors highlight limited individual hatchery group returns that are near the minimum 2%, hypothesizing on this basis that the ocean and not the hydrosystem is the limiting factor on adult returns. Salmon stocks throughout the northwest benefited from good ocean conditions in 1997 through 1999. The effects of the hydrosystem, passage through four additional dams, are evident when smolt to adult returns of Snake River versus Yakima River fish are compared relative to the 2% to 6% recovery range. This comparison indicates the likely magnitude of the impact of the hydrosystem even in years of good ocean conditions.

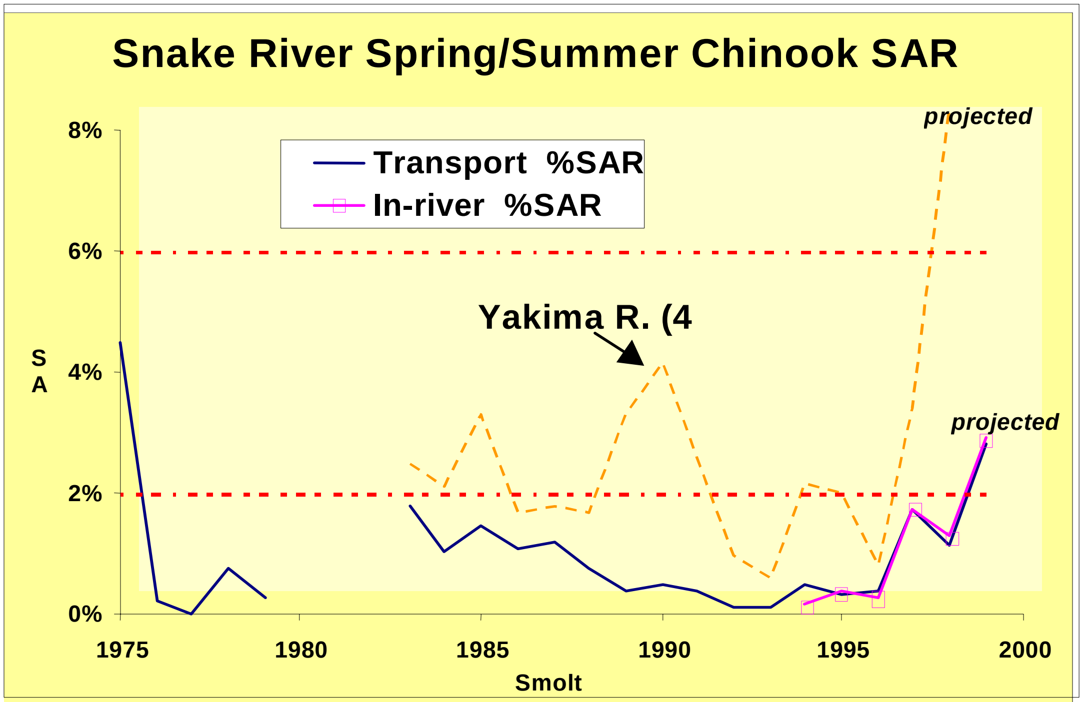


Figure 1. Smolt-to Adult-Return (SAR) rates for Snake River spring/summer chinook stocks and for Yakama River Spring Chinook.

As indicated in Figure 1, Snake River spring/ summer chinook rarely meet or exceed the two percent minimum suggested by PATH. Although they migrate past four dams, the Yakama stock often meets or exceeds the minimum. From 1988 through 1999, the average SAR for the Snake River fish was 0.75 percent as compared with 2.75 for the Yakima fish for 1988 through 1998. (Note: No data for the Yakama stock in 1999) Figure 1 illustrates the potential drawback of comparing only the SARs of transport and inriver migrants.

p. 7. Test D<Vc: This proposed hypothesis test is redundant with and less direct than a test of TIR>1.0. The primary purposes of estimating D are to document a portion of delayed hydrosystem mortality (if D<1, transported smolts incur more delayed mortality than in-river fish), and for use in life cycle modeling to evaluate effectiveness of alternative management options with respect to survival and recovery of listed species. Also, caution needs to be used for V_c values, particularly when expanding per project rates. The per project method tends to overestimate survival rates.

p. 7. Discussion on D: The report should clarify that D is only part of the delayed mortality picture. Evidence also exists for delayed hydrosystem mortality to inriver fish (termed "extra mortality" in PATH and the BiOp). There is evidence of substantial delayed mortality among the inriver migrants that overlays the relative comparisons represented in Ds and TIRs (Schaller et al 1999; Deriso et al. 2001; Budy et al. 2002).

p. 8-9. TIR ratios from LGR and LGO only: The report's emphasis on TIR ratios from LGR and LGO is somewhat misleading. The overall effectiveness of the transportation program *relative to inriver passage* is best reflected by overall TIR ratios (T_0/C_0). [TIR estimates for fish transported from all dams-T_0]

p. 11. Hatchery chinook transported from LGR and LGO have yielded TIR estimates greater than or equal to 1.0: Note that this does not apply to all hatchery stocks (e.g., Dworshak). Again, T_0/C_0 is the more appropriate metric to report for TIRs to reflect overall relative effectiveness of the transportation program.

p. 15. Figure 6: The plotted geometric mean (0.60) for inriver control hatchery chinook appears to be incorrect.

p. 15-17. Intra-annual changes and SARs, TIRs and Flow: The review is incomplete on these topics. The report cites two NMFS studies that did not identify a relationship between SARs or TIRs and flows. However, no reference was made to the NMFS whitepaper (NMFS 2000), which presented substantial correlative evidence between adult return success and inriver flow and velocity conditions. In addition, PATH retrospective analyses showed a significant relationship between water travel time and the differential stock performance ("mu") of Snake River and downriver stocks (Deriso et al. 1996; 2001). Since dam completion, Snake River stocks survived only about 1/3 as well as downriver stocks, and the performance gap narrowed in high flow years and widened in years of poor flows. (Schaller et al. 1999; Deriso et al. 2001)

p. 17. Differential delayed effects (D-estimates): The range of D's given in the first paragraph (wild chinook 0.63-0.73; wild steelhead 0.52-0.58) were only from NMFS estimates for the BiOp, and should not be attributed to Bouwes et al. (2001). Wild chinook D estimates reported by Bouwes et al. were somewhat lower than the NMFS estimates, equaling 0.57 for 1994-1999, and 0.51 excluding 1994. Also, V_c until recently cannot be measured directly and needs to be estimated by expansion. This makes it difficult to determine if V_c differs significantly from D.

p. 17. "The key issue is whether D differs significantly from Vc" (inriver survival): We disagree with this inference. This implies that TIR is all that matters, which is counter to both the PATH and BiOp analyses and conclusions. Testing of TIR is best done directly, rather than using D and Vc. D alone is useful to demonstrate a portion of the total delayed mortality effect from the hydrosystem, but is only part of the delayed mortality picture. If D<1.0, transported smolts die at a greater rate in the estuary/ocean than their inriver counterparts. Further, both D and delayed mortality of inriver fish ("extra mortality") are influential in determining effectiveness of alternative management options (NMFS 2000; Marmorek et al. 1998).

p. 19-20. Collectively D estimates suggest that differential delayed effects are nearly always indicated for transported fish of either species, as indicated by dominance of values < 1.0. However, that is not necessarily bad, if D > Vc: The first sentence is accurate. Problems with the inference in the second sentence are addressed above.

p. 20. Quantitatively robust estimates of SAR, TIR and D requires increased PIT tagging (which may be impractial) and relying on improved natural cycles with larger adult sample sizes: Should note that Comparative Survival Study (CSS) will increase sample sizes in 2002-2004 migrations to improve precision of estimates. Also, analysis of SARs requires a long time series incorporating both good and poor natural cycles.

p. 21. Mechanisms contributing to delayed differential effects for transport: The report only addressed delayed mortality for transported smolts relative to inriver migrants, but neglected the delayed mortality that inriver smolts may suffer as a result of the hydrosystem ("extra mortality"). The PATH weight of evidence process (Marmorek and Peters 1998) and Budy et al. (2002) and Schreck (2002) presented substantial evidence for the occurrence of and mechanisms for delayed hydrosystem mortality.

p. 25-26. Summary of TIRs for LGR, LGO, LMN and MCN: The equivocal transport results for wild fish from all dams, and hatchery fish from lower dams tend to support a spread the risk approach, given current hydrosystem configuration and RPA actions. There is little evidence that either transportation or inriver passage routes have been resulting in adequate SARs for survival and recovery (Bouwes et al. 2001). Either transport or inriver SARs need to be improved substantially and consistently, before one passage route could be favored under RPA conditions.

p. 25. "…reaching SAR levels in 1999 that approach and in some cases exceed the 2% minimum recovery threshold… This suggests that neither transport nor inriver migration conditions may be a bottleneck to recovery, when marine-based survival is at some adequate level": This statement is not supported by existing life cycle survival analyses. See above comment on this statement in the executive summary at page vii.

Spill

We agree with the general conclusion that spill is the safest and most effective route of passage for downstream migrants. Our comments on the Zabel analysis of the benefits of spill in 2001 are attached. Past studies have shown that studies of incremental benefits of spill are not useful in management considerations because they are difficult to conduct with sufficient precision to determine incremental effects and small differences in survival or passage efficiency. In addition project-by-project spill studies do not capture the cumulative effects of spill on juvenile survival, survival to adult and travel time. Giorgi et al. discussed The Dalles spillway survival study but declined to incorporate discussion of the significant technical and analytical issues with those results and their application. (The Dalles spillway survival study comments, http://www/fpc.org_docs.htm)

p. 33. Use of models to evaluate spill options, reference to NPPC (2001) staff issue papers as an example: The report should also reference joint technical staff comments by the region's fishery agencies and tribes on the severe limitations of this particular application (available at http://www/fpc.org/fpc_docs.htm).

p. 36. "Based on these data, we conclude that spillways are the safest passage routes at dams where these types of evaluations have been conducted": This statement is well supported and should also be referenced at p. 41-42 in relation to the NMFS 2001 study and hypotheses explaining the pattern of increased survival during the spill period at John Day Dam.

p. 41-42. NMFS 2001 spill analysis and temporal survival patterns: The final report should also reference the Fish Passage Center comments (Feb. 28, 2002) on the draft NMFS 2001 analysis, pointing out that these temporal patterns in previous years also coincided with periods of higher spill and/or flow. Given that spillway passage routes are the safest (see above), there is a strong biological mechanism to explain the observation of increased survival during the spill period at John Day Dam in 2001 (and previous years).

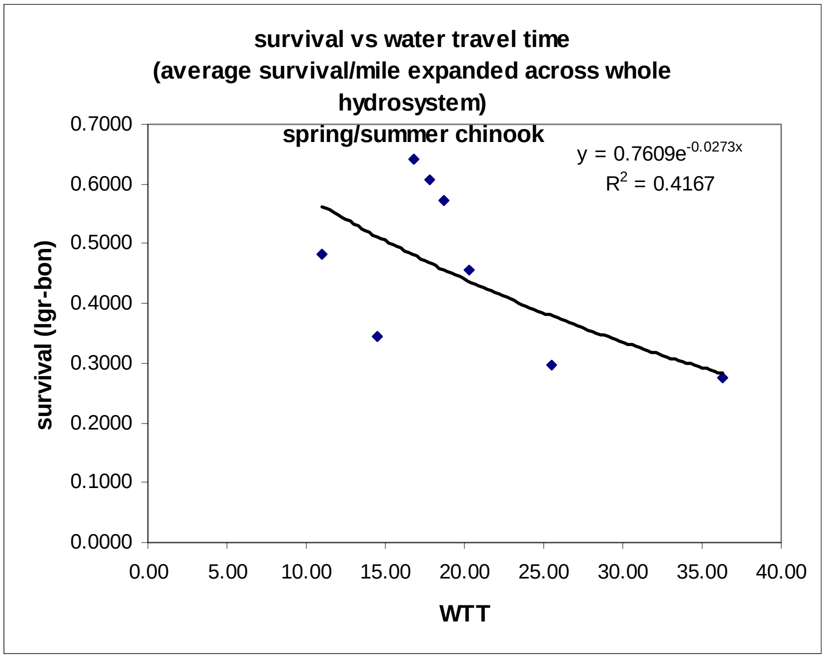
p. 48. NPPC 2001 staff analysis of spill scenarios: As noted for page 33, the report should also reference joint technical staff comments by the region's fishery agencies and tribes on the severe limitations of this particular application.

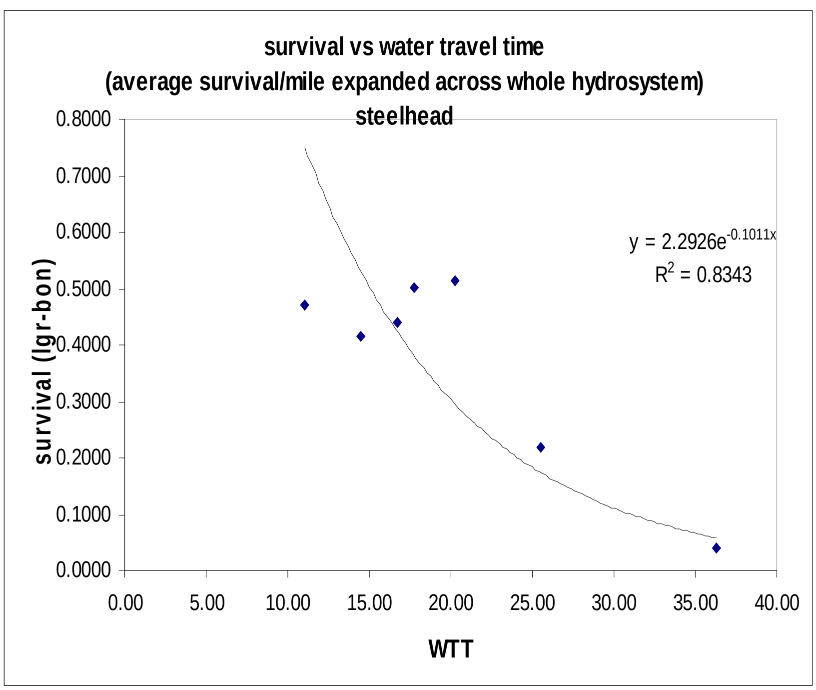
p. 61. Two aspects to biological window, ecological/environmental condition of estuarine and marine waters and physiological preparedness for smolts to adapt to seawater: Additional mechanisms that should be mentioned in this section include altered fish condition due to migration delay (depleted energy reserves) and chronic or accumulated stress from delay and multiple dam passage (Marmorek and Peters 1998; Budy et al. 2002). Years of high flow and spill tend to reduce migration delay, promote passage by less stressful routes (spillways), and conserve the smolt's energy during migration (Congelton, COE Transport and Delayed Mortality Workshop, Feb. 2002). These effects likely would be manifest outside the hydro system during estuary and early ocean rearing. Yet the report sections 3.1 and 3.2 generally ignore adult return data in favor of reach survival estimates. The report should reference the NMFS (2000) white papers to document the existing correlations between SAR and recruit per spawner information and flow or water velocity during the smolt migration.

Flow Augmentation

The Giorgi et al. report discussion on flow augmentation as a passage strategy discusses travel time and limits discussion of survival and flow for spring chinook to a per project analysis from Zabel et al. Our specific comments on the Zabel et al. draft are attached. The selective inclusion of information and analysis on flow and survival precludes other analysis that provides additional insight and basis for management decisions. Giorgi et al. did not include information from the PATH Retrospective Report on Spring Chinook (Marmorek, 1996) which suggested a strongly flow dependent survival relationship. In addition alternative analysis should be incorporated to provide a broader base for future fish passage management and mitigation decisions. In addition Giorgi et al. refers to summer flow augmentation regarding juvenile fall chinook migrants as "equivocal". Giorgi et al. neglects to include recent available studies that provide strong evidence that flow augmentation is clearly beneficial for juvenile fall chinook migration rate and survival.

For spring migrants, an alternative analysis to that performed by Zabel et al. also shows benefits of higher flows. If survival per mile is regressed against average water particle travel time and average proportion spilled over the length of the migration season a significant relationship is observed for both spring/summer chinook and steelhead. Survival estimates for yearling chinook were from CSS (Bouwes et al 2001) in 1994-2000 and NMFS (Zabel et al. 2001) in 2001; steelhead survival estimates were from NMFS whitepapers for 1994-1999 and NMFS (Zabel et al. 2001) in 2001. Stepwise regression results for spring/summer chinook indicated survival per mile was moderately dependent ($r^2=0.54$; $p<0.04$) on a combination of water travel time and spill (interaction term).. Stepwise regression results for steelhead indicated survival per mile was strongly dependent ($R^2=0.98$; $p<0.005$) on water travel time, spill and the interaction of spill and water travel time. These analyses bring an additional facet to the consideration of flow augmentation as a passage strategy. The following plots show that flow is an important component for steelhead and spring/summer chinook survival through the hydrosystem.


survival vs water travel time
(average survival/mile expanded across whole hydrosystem)
spring/summer chinook
y = 0.7609e-0.0273x
R2 = 0.4167
survival (lgr-bon)
0.7000
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
WTT


survival vs water travel time
(average survival/mile expanded across whole hydrosystem)
steelhead
y = 2.2926e-0.1011x
R2 = 0.8343
survival (lgr-bon)
0.8000
0.7000
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
WTT

P 65. Recent investigations: Giorgi et al suggest that strong correlation among the predictor variables flow., water temperature, turbidity and fish size confound the ability to identify the factors that affect downstream migration rate of fall chinook salmon smolts. Giorgi et al. do not include a recent analysis to determine the factors affecting downstream migration rate of wild Snake River fall chinook salmon smolts (Connor 2001). In the Connor analysis the predictor variables release fork length, release water temperature, flow and distance traveled in riverine habitat were not correlated. Year-by-year (1995 to 2000) multiple regression models indicated that these four variables explained from 62 to 86 % of the observed variability in downstream migration rate (N range 119 to 569; all P values <0.0001). Downstream migration rate was predicted to increase as flow increased. Connor (2001) concluded that migration rate will increase as flow increases provided when prerequisites for seaward migration are met, and fall chinook salmon are behaviorally disposed to move downstream.

p. 67-68. NMFS per-project survival vs. flow analysis: The FPC Feb. 28, 2002 comments on NMFS 2001 draft report point to serious flaws with the per-project survival analysis. The per-project survival estimates may be very misleading because they are derived from differing length reaches in different years. In 2001, per-project survivals for short reaches would have grossly overestimated survival through the entire hydrosystem (FPC 2002). An alternative means of comparing survival among years, using the data sets with consistent reaches over years did demonstrate a relationship between flow and reach survival (FPC 2002). Also as noted above, reach survival are not expected to reflect the full influence of flow or water velocity on survival. The report does indicate the correlation between travel time and flow for yearling chinook salmon, and the possibility that other benefits may accrue from swifter migration at higher flows, and research efforts to investigate such mechanisms. The report should also reference the NMFS (2000) whitepaper that document the existing correlations between SAR and recruit per spawner information and flow or water velocity during the smolt migration.

p.70. Snake River fall chinook salmon
Giorgi et al suggest that strong correlation among predictor variables, flow, water temperature, and turbidity confound the ability to identify the factors that affect survival of fall Chinook salmon smolts. In a recent analysis to determine factors affecting survival of wild Snake River fall Chinook salmon (Connor 2001), the predictor variables flow and water temperature were not correlated and both variables entered into a multiple regression model fit to describe survival., Flow and temperature explained 92.3% of the observed variability in survival (Years 1998-2000; N=12 within year replicates; P <-0.0001). Based on this regression model, survival was predicted to change by approximately 3% with each change of 100 m^3/s in flow when temperature was held constant. The change in survival was approximately 7% for each 1^{o}C increase or decrease in temperature when flow was held constant. Connor (2001) concluded that flow and temperature assert their influence on survival simultaneously.

p. 72 Flow Augmentation evaluations
Two analyses were available prior to the submission of the Giorgi et al review to the NWPPC. The first analysis was based on multiple regression, and the results indicated that downstream migration rates for Snake River fall chinook salmon would decrease from 0.1 to 0.2 km/day if summer flow augmentation was not implemented from Dworshak Reservoir and reservoirs upstream of Brownlee Dam (Connor 2001). This translates to the average fish taking from 1 to 5 days longer to pass Lower Granite Dam without the aid of summer flow augmentation. The second analysis was also based on regression modeling and it indicated that summer flow augmentation increased survival of fall Chinook salmon smolts up to 24 percentage points (Connor 2001). Connor (2001) concluded that summer flow augmentation increases migration rate and survival of fall chinook salmon smolts passing downstream in Lower Granite Reservoir.

p. 80. "Flow effects on smolt survival based on PIT tag estimates acquired since 1993 provide the most relevant data set for characterizing smolt survival dynamics through the impounded mainstem Snake and Columbia rivers": This is a highly questionable statement since it ignores the delayed effects due to migration delay, synchrony of smolt arrival into the estuary, and overall impacts of stress and bioenergetics on ultimate survival to adult. In addition to evidence in the NMFS (2000) whitepapers mentioned above, the PATH results indicated that stock performance was related to the water travel times experienced during the smolt migration (Deriso et al. 1996, 2001). This information was also summarized in the joint technical staff memos on the NPPC 2001 migration issue paper (available at http://www/fpc.org/fpc_docs.htm).

p. 81. "In the Snake River, the NMFS PIT tag-based survival estimates acquired since 1993 form a strong foundation for examining and defining such [flow-survival] relationships": The reach survival estimates form only a partial basis for such examination and definition (see above comments).

P81 and 82. Critical Uncertainties On pages 81 and 82, Giorgi et al wrote that absent a well-designed experiment, we would likely be left with the equivocal results we now have. This conclusion contrasts with the conclusion presented by the Independent Scientific Advisory Board on April 27, 2001 (ISAB 2001): "Flow augmentation should continue, largely because Connor's studies show benefits for wild fish and the NMFS studies show high correlation of flow and survival in a designed study."

p. 82. "A multi-faceted, comprehensive evaluation of the biological benefits and risks associated with flow augmentation is advisable. Wherever possible, quantitative analyses should be undertaken. The effort will require physical and smolt passage modeling": Should include life-cycle modeling to evaluate full effects of flow on survival.

Conclusion

To conclude the Giorgi et al. report represents a well-organized but incomplete summary of recent studies, although many specific components of the report should be considered within a limited context in fish passage management determinations The challenge for the region is the prioritization of research opportunities to management decision check points to arrive at definitive actions and long-term decisions. The Giorgi et al. report does not present any compelling new information, which would cause us to question the flow and spill measures in the Biological Opinion. In fact, our analyses of the most recent PIT tag information and analyses for fall chinook by Connor (2001), strengthen support for flow and spill measures as effective in protecting listed salmon and steelhead populations. Thank you for the opportunity to provide comments. We hope they will be helpful in the Program amendment process.

Sincerely

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