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Review of Giorgi et al. Report
"Mainstem Passage Strategies in the Columbia River System: Transportation, Spill, and Flow Augmentation"

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Introduction

The ISAB commends the Council for commissioning the summary report "Mainstem Passage Strategies in the Columbia River System: Transportation, Spill, and Flow Augmentation" by A. Giorgi, M. Miller, and J. Stevenson of BioAnalysts, Inc. (Giorgi et al. 2002). The Giorgi et al. report was created for the Council as a background document in the context of the mainstem program amendments. Council has periodically asked the ISAB and others to provide succinct "white papers" or "State of Science" reports that summarize the latest understanding about topics relevant to managing the fish and wildlife resources of the Columbia River basin in mitigation for the federal hydropower system. The Giorgi et al. report summarizes existing information on three topics that the ISAB and its predecessor advisory groups have debated intensely (and advised the Council about) over the past decade or so.

The Council requested at its April 2002 meeting that the ISAB evaluate the report and the comments on it received from agencies and the public. The Council asked the ISAB to evaluate whether the Giorgi et al. report captures the full spectrum of scientific issues and knowledge related to mainstem passage, and specifically whether it adequately addresses the following questions:

1) What does the scientific literature tell us regarding the benefits, shortcomings, or risks associated with each passage strategy as compared to other passage options?
2) Which aspects of the scientific information are in dispute?
3) What are the critical uncertainties attending each strategy?
4) What is being, or could be done to reduce uncertainty and disputes?

In the context of the public comments, the Council asked how serious are the disputes raised in the public comments, and whether the various opinions are really very divergent.

The summary document by Giorgi et al. has helped update the ISAB's understanding of the issues, and we are confident that it will be useful to the Council and Council staff. The comments help round out the outstanding issues.

We offer the following thoughts as both technical critiques and indications of the implications for the Council and others that arise from the information in the report and the agency and public comments. General thoughts particularly relevant to question 1 are presented in the General Report Evaluation section of the text that follows. We also provide a general evaluation of the comments.

Our more specific thoughts are assembled as an appendix. With respect to the second question, we felt it to be most helpful to list the key findings and conclusions of Giorgi et al. and to address questions 2, 3, and 4 together for each finding and conclusion. We have done this by briefly discussing the comments received for each finding and conclusion,

identifying where no comments were received, and discussing those findings and conclusions where disputes are identified. Where it seemed useful, we provide our own assessments.

Mainstem issues are an important part of the Fish and Wildlife program (FWP), though their prominence has declined on the Council's agenda, since the NMFS Biological Opinion has created other priorities. Earlier attention of FWP planning was directed largely toward enhancing salmon survival in the mainstem where the federal hydrosystem dominated the physical and operational environment, whereas recent focus has shifted toward tributary habitats and artificial production. Debates over the mainstem issues of transportation, spill, and flow motivated specification of measures in the published program documents that, while contentious, formed operational guidelines for the region. Hypothesized relationships between flow and fish survival were critical to the rationale for such guidelines, but the evidence for the respective hypotheses was not conclusive. The 1994 FWP (NPPC 1994) focused on alternative flow-survival hypotheses, with measures formulated to plan for specific tests of these hypotheses. The program called for analytical efforts through the PATH process (a multi-agency analysis group Planning and Analysis for Testing Hypotheses) and the design and implementation of field experiments. The efforts of PATH yielded valuable data syntheses but the anticipated major field studies to test alternative hypotheses to explain differences in fish survival at different flow regimes were never carried out. Unresolved questions about fish passage in the mainstem, especially the flow-survival relationship in relation to policies calling for flow augmentation, brings the mainstem to the Council's attention once again.

General Report Evaluation

Giorgi, Miller, and Stevenson have done a good job of reviewing mainstem passage strategies designed to improve survival of juvenile salmonids in the Columbia River system. Their focus is on review of key studies and analyses that have taken place under contemporary river operations, which were initiated in the early 1990s and formalized as guidelines in the 1995 and 2000 Federal Columbia River Power System Biological Opinions (BO). Their approach was to abstract the key findings of the studies and compare the results. We believe they have largely succeeded in this task, and the resulting report provides information that ought to form the basis of revisions in the Council's Fish and Wildlife Program, as well as guides for upcoming Mainstem and Systemwide project solicitations.

With respect to the ISAB's advisory role for both the Council and the National Marine Fisheries Service, we emphasize that there are many uncertainties in the information used as a basis for the hydropower mitigation actions in the FWP and for the Reasonable and Prudent Alternatives (RPAs) of the Biological Opinion. A concerted effort is needed to reduce the uncertainties. The Giorgi et al. report helps all parties to focus on these uncertainties.

The information reviewed by the Giorgi et al. report was summarized objectively. Findings and conclusions were specified where appropriate based on the scientific

information available. In cases where the results were open to question, these were identified as critical uncertainties and "research opportunities" (often a euphemism for badly needed information). These uncertainties and research opportunities provide a valuable basis for soliciting new work under the Fish and Wildlife Program. The report cites important scientific literature that should be the foundation for new proposals.

Overall, the report was very conservative in drawing statistical conclusions. This fact needs to be understood for proper interpretation of the implications of the report. From a purely statistical standpoint, tests that fail to show statistical significance in data can be definitive in stating that *no effect was found*, yet these tests do not definitively prove the absence of effect.

The report's statistical conservatism affects its value as a synthesis of current understanding. The report is not an "analysis" of the issues, but a compendium of findings to date. The ISAB considers this to be an important distinction. For example, when the report says no significant effect has been detected, this is technically a correct summary of the statistical analyses reported in the individual studies that were reviewed, but it should not be taken to preclude the possibility that an effect exists. The possibility remains that new studies or further rigorous analyses of existing data (in particular, analyses that combine data from several separate studies) would generate statistically significant results or a different answer. Future analyses should put more emphasis on statistical parameter estimation and power analysis, rather than just hypothesis testing.

A further limitation is that the Giorgi et al. report is narrow in the number of hypotheses that it reports (untested, but potentially valid, hypotheses were not discussed). There is much room for additional research, meta-analysis, and synthesis; the Council should not be misled by the apparent conclusiveness of many statements in the report. There are, for example, untested hypotheses related to flow that could significantly alter our view of the situation surrounding flow augmentation policies (discussed further in the appendix). Much recent work and ongoing studies related to different flow regimes and concurrent changes in other factors have not been fully analyzed. This is important work that still needs to be done.

We believe it was wise of Giorgi et al. to focus on the recent studies that were conducted under contemporary system operations. As they point out, there have been significant changes in river operations since the early 1990s, including improved bypass systems at the dams and other measures. In addition, there have been significant improvements in the ability of researchers to measure the effects of these changes on survival of salmonids. However, as several of those who provided comments on the report pointed out, it would perhaps have been useful for the authors to provide more commentary on studies conducted prior to the 1990s. Inclusion of the conclusions from the earlier studies would have been facilitated by reference to a number of documents that have synthesized results up to and into the 1990s such as the National Research Council report Upstream (NRC 1996); the Independent Scientific Group report Return to the River 2000 (ISG 2000); a series of ISAB and PATH reports related to transportation, spill and flow (for ISAB see www.nwcouncil.org/library/isab); and Chapman et al. (1991, 1994, and 1995),

as examples. We are not asserting that inclusion of the earlier studies would have forestalled any current or future disputes among the proponents of diverse management actions that have evolved within the Columbia Basin. However, the fact that for the most part the key conclusions of Giorgi et al. agree with the older studies ought to bolster the Council's confidence in the Giorgi et al. review. We discuss this point further in the appendix.

A very useful contribution that may be extracted from the Giorgi et al. report is the identification of premises that have formed the foundation of the three mainstem strategies for improving survival of juvenile salmonids as they migrate to the sea. These are:

1. Transportation. The premise is that transported fish will survive to returning adults at rates that will exceed rates of inriver migrants (p. 6).

2. Spill. The premise is that since spillways offer the safest passage route at the dams, provision of spill will improve total survival of smolts passing the dams. (While this premise is not specifically stated by Giorgi et al., it is implied in their discussion, particularly their Summary.)

3. Flow Augmentation. There are two premises with flow augmentation:

> a) Increased water velocity leads to increased migration speed, which leads to increased survival of juvenile salmonids.
>
> b) Lowering summer water temperature with cool water from Dworshak Dam leads to improved migratory and rearing conditions for both juvenile and adult salmonids which results in improved survival. (p.60)

The strength of the existing evidence for these premises may be evaluated from the Giorgi et al. report (in answer to the question asked by the Council "What does the scientific literature tell us regarding the benefits, shortcomings, or risks associated with each passage strategy, and as compared to other passage options?"). The evidence can be briefly summarized for each strategy in terms of the scientific information that has accumulated in support of each premise. Briefly, it may be said that the accumulated evidence supports the premises that:

1) transportation by barge from the Snake River increases the rate of return of adult spring/summer hatchery chinook and steelhead, particularly in years of low flow,
2) provision of spill increases the survival rate of migrating juvenile salmonids,
3) flow augmentation designed to increase speed of migration does increase migration speed for most species, but evidence that this leads to increased survival is inconclusive because of the inability to separate numerous interrelated factors that affect survival at the same time,
4) flow augmentation from Dworshak Dam in summer reduces Snake River temperatures, at least within Lower Granite reservoir. The available evidence indicates that temperature effects depend upon the volume of cold water inflow relative to total flow in the Snake River (greatest effect at low Snake River flows) and

that effects of only 1-2 degrees are to be expected as far downstream as Ice Harbor Dam. No biological evidence for benefits to fish survival is available.

The Giorgi et al. summary and the ISAB evaluation of the broader mainstem situation both highlight that a set of well-designed, manipulative, field experiments is needed, particularly for the issue of flow and smolt survival. The low flows of 2001 with the correspondingly low in-river smolt survival for some species and life-history types suggest that, at the extreme, survival of some types of fish is affected by low flows (and/or the numerous other factors that occur in association with it, such as high temperature, low turbidity, slower velocities, less inundation of riparian zones, more frequent and rapid changes in flows in response to load following, and others not yet identified). These experiments must go beyond analysis of existing monitoring data, and include specific hypothesis-testing manipulations. Such experiments are admittedly difficult to conduct. However, experimental designs can make use of extreme conditions when they occur naturally (as in 2001) and some experimental conditions can be created within bounds of water availability and operational constraints. The ISAB can suggest such experimental designs in another forum.

General Evaluation of Comments

The comments from the public and agencies provided additional useful technical information, usually amplifying points made in the Giorgi et al. report, but often, it is our impression, from more of an advocacy position for certain management strategies. Contrary to what was suggested in some of the comments, we did not see any pervasive tendency for selective use of data or misinterpretation of results by authors of the Giorgi et al. report. Genuine technical disagreements occur over possible interpretations of available information for methods of analysis and implementation measures. Giorgi et al. were criticized for not providing the full range of scientific "opinion" on the key issues, yet the intent of the report was to summarize information, not opinion. However, as we noted ourselves above, the report does not summarize alternative hypotheses that have not yet been tested. To the extent that the commentors were seeking more attention to these alternative hypotheses, we concur. The comments can be used, along with the report, to frame the uncertainties and opportunities for additional research.

Several of those who provided comments on the Giorgi et al. report were critical of the fact that the report, as it reviews the passage strategies, deals with an "incremental approach" designed to improve survival of juvenile salmonids at various points as they transit the mainstem. For example, there appears to be universal agreement that spill offers the safest passage route for juvenile salmonids at most projects (The Dalles Dam may present an exception, under some levels of spill), and that any improvement in survival provides an increment of benefit at that project. But two issues are raised by the critics, one a question whether benefits of spill can be measured in the system as a whole, and the other a question whether even at best, these improvements in survival are likely to be sufficient to lead to recovery of the endangered stocks of salmonids in the Columbia Basin, and in particular, the Snake River stocks of endangered anadromous fish.

There are two responses to the criticism on these points, the first is that Giorgi et al. were responding to the assignment they were given (to summarize current information, and not to make policy judgments), and the second is that the information summary is meaningful as it stands because of the management predicament in which we all find ourselves. The predicament is that no measure(s) has (have) been identified that will do more than provide incremental increases in survival of salmon in the basin. Perhaps one exception would be the restoration of salmon in areas where they have been extirpated by blockages to their passage. Other than that, salmon populations have been reduced by an accumulation of increments over a long time period, and the incremental-improvement approach is being used out of necessity by the Council and NMFS to move toward recovery. The approach proceeds on the premise that an incremental improvement in one location will be passed on as a benefit to the next location, accumulating thereby into the potential for a large effect in the system. NMFS' analysis using the CRI modeling effort led to the conclusion that the primary opportunities for major improvements in survival now lie in tributary and estuarine habitat improvement rather than in the mainstem. However, the Giorgi et al. report suggests that there are still improvements to be made in the mainstem, an opinion that most commentors and the ISAB share.

Some comments, particularly those of NMFS, corrected some misstatements in the Giorgi et al. review. Also, the comments indicated a number of details that could have stood further elaboration. Materials not available to Giorgi et al. were suggested for further analysis. These comments, while useful, did not seem to the ISAB to require major changes in either the Giorgi et al. review or our views of it.

Another common theme in some comments was the belief that release of water from reservoirs far upstream in the basin for flow augmentation provide little benefit to downstream migrants yet can have measurably detrimental effects locally in both tailwaters and reservoirs. This was emphasized especially for the reservoirs in Montana that drain through a long chain of rivers, lakes, and reservoirs before the water reaches the migrant corridor in the lower river. The tradeoffs between headwater and downstream effects have been an important part of the flow augmentation debate for some time. The Giorgi et al. report touches on this issue under the heading "Benefits and Risks to other species" (p.78), where the ISG 1996 report is quoted. The commentors have a valid point that deserves further definition of biological effects and risk-benefit analysis. The analyses by Council's Montana staff (several years ago) and the Idaho Department of Water Resources' more recent reanalysis of NMFS' smolt travel time and survival data for the Snake River (Dreher et al. 2000) and the ISAB review of it (ISAB 2001), along with other unpublished analyses cited in the comments suggest that this topic deserves more technical evaluation and better designed experimental studies that might provide more conclusive data. Giorgi et al. conclude that "Comprehensive flow augmentation evaluations are generally lacking, only a handful of studies have attempted to quantify the volume and shape of water provided as FA [flow augmentation], and translate that incremental increase in flows to changes in water velocity and temperature [and thence into changes in smolt travel time and survival]." "The scope of future evaluations needs to more fully address the balance of benefits and risks between anadromous and resident fish resources." And we might add, other water uses.

Conclusions

It is clear from both the Giorgi et al. report and the comments that the mainstem management issues tackled by the report (transportation, spill, and flow augmentation) are not yet resolved, although there is little or no dispute on many component topics (see appendix). Lack of resolution is largely due to a lack of critical information; further resolution requires additional research, experimental manipulation, adaptive management, monitoring, and analysis (evaluation).

For additional conclusions, we return to the questions asked of us by the Council. On the whole, the report does capture most of the full spectrum of scientific issues and knowledge related to the three designated strategies on mainstem passage (transportation, spill, flow augmentation) as reflected in published reports. However, we found some important omissions. For example, Giorgi et al. do not present an adequate discussion of the portion of the flow augmentation strategy that calls for flows out of the upper Columbia River storage reservoirs, particularly with respect to its effects in the lower river. Some recent literature contained in Connor et al. (2001) on effects of summer flow augmentation and other factors on survival of smolts in the Snake River was not reviewed. The issue of mainstem habitat and its effects on healthy smolts (i.e., treating the mainstem as a habitat for feeding, growth, and other life functions during rearing and migration) was not treated (discussion of this topic was a major part of the ISG's Return to the River 2000 science review). This and additional, alternative explanations for the clear degradation in smolt survival at low river flows were not pursued. Although we recognize that this was not the intent of the Giorgi et al. report, we suggest that the single premise offered by Giorgi et al., with respect to effects of volume of flow, i.e. that volume of flow affects travel time which in turn affects survival, while it accurately reflects much of the current thinking in the basin, is not the only possible explanation for low survival at low flow. We offer more on this subject in the Appendix.

We evaluated whether the report adequately addresses the following questions:

1) *What does the scientific literature tell us regarding the benefits, shortcomings, or risks associated with each passage strategy, and as compared to other passage options?*

The report is not an assessment of management options in the literal sense of this question, but a summary of the latest technical and scientific information that is appropriate to such management evaluations. It is a guide to technical uncertainties and needed information, and in that role it provides guidance for needed work on the mainstem. Some of that work could be funded through the Mainstem/Systemwide solicitation for the Council's Fish and Wildlife Program. Evaluation of policies to balance or tradeoff among management benefits and risks was not an obvious part of this study. Clearly, the scientific literature, as represented fairly by the Giorgi et al. report is not sufficient in and of itself to resolve the issues. Focused large-scale experiments, monitoring of management actions, and analyses are needed.

The premises of transportation (for some species and life-history types) and spill are well supported by the available evidence. The evidence available in support of the premises that form the foundation for the flow augmentation strategies are inconclusive. These are the weakest of the foundations for the three strategies, and are the most disputed. It is time to think in terms of new premises that might explain the data, or to design specific experiments to isolate the effects of factors that are interrelated with flow. This is discussed further below and in the Appendix.

2) *Which aspects of the scientific information are in dispute?*
The report adequately identifies most of the problem areas. The comments highlight some of these aspects and add a few more. We have identified these in the appendix. They are:

- Transportation: A question whether all adults are accounted for, issues of "D" and its related factors (e.g., "extra mortality"), changes in homing, relative efficacy of trucking and barging;
- Spill: General applicability of results from The Dalles Dam (whether more spill is always better for fish), use of models to evaluate systemwide benefits of spill, conclusiveness of empirical studies considering all confounding factors;
- Flow: Applicability of migration speed (travel time) to estimating survival, appropriate reach lengths for estimating survival (per project vs. per mile), species specificity of flow-survival relationships, whether inability to tease out exact causes (among co-varying temperature, flow, date, turbidity, etc.) should negate the overall relationship of survival to flow especially in fall chinook, suitability of year-to-year comparisons of survival vs. flow considering other dissimilarities among years, importance of small temperature differences in the river near fish physiological limits, importance of food web issues, relationships between flow rate and delayed survival effects related to migration delay (extra mortality), value of models vs. empirical data.

3) *What are the critical uncertainties attending each strategy?*
The Giorgi et al. report specifically concludes each section with a list of critical uncertainties. We have amplified on these in the appendix. The critical uncertainties are essentially the same as the list of issues in dispute, listed above. There are more uncertainties for flow augmentation than for the other mainstem topics. For flow, we would add the general uncertainty associated with failure to explicitly state and test alternative hypotheses that could offer more promise for resolving the issue than have the debates over current hypotheses.

4) *What is being, or could be done to reduce uncertainty and disputes?*
The report specifically concludes each section with a list of "research opportunities" (needed work). Again, more work is needed to resolve issues of flow than for other issues. The ISAB believes that the list of work required to resolve flow issues needs to be expanded to include hypotheses or premises not treated by Giorgi et al. These hypotheses were not treated because the necessary experiments, monitoring, or analyses have not been done. These hypotheses would encompass the fuller range of scientific opinions

sought by commentors. The ISAB goes further and recommends that both further analysis of existing data and the design of new experiments be given high priority. The ISG (ISG 2000) suggested two premises with respect to effects of flow on survival of juvenile salmonids that they felt merited further study. One, that large and rapid fluctuations in flow, associated with load following might reduce the productive capacity of the near shore zone used by incubating and migrating juvenile salmonids, and two that these rapid fluctuations could lead to stranding of redds and juveniles, such as has been observed in the Hanford Reach. Load following is particularly evident at times when average river flows are low, and might be another factor involved in low survival observed at low flows.

Testing of existing and new hypotheses for the effects of flow on survival and the efficacy of flow augmentation are especially needed. Rather than reacting passively to proposals submitted for research in this area (e.g., through the Mainstem/Systemwide solicitation), the ISAB recommends that the Council return to the strategy outlined in the 1994 Fish and Wildlife Program, which called for explicit statement and testing of hypotheses with the aim of resolving the scientific aspects of these issues (recognizing that there will always be policy issues that go beyond science). The ISAB recommends that the Council, with advice from NMFS, specifically solicit proposals that clearly state existing and novel hypotheses for the effects of flow on smolt survival and provide experimental designs for testing them. The report by Giorgi et al. provides a good start for the existing hypotheses, but innovative thinking beyond this report is needed for other hypotheses.

Appendix

Key Findings and Conclusions of Giorgi et al. with ISAB Analysis of Disputes from Comments (Council Questions 2-4)

In this appendix we list and discuss the key findings and conclusions of Giorgi et al., discuss the main points raised in comments received by the Council during the public comment period, and where necessary or desirable provide our analysis of the findings and conclusions in the context of the comments. The mainstem strategies Giorgi et al. were asked to review are: I. Transportation, II. Spill, and III. Flow Augmentation. For reference to the Giorgi et al. report, we have noted the page(s) where the conclusions can be found.

I. Transportation

Giorgi et al. conclusion regarding Overall Effect on Juvenile Spring/summer Chinook and steelhead:

Barge transportation of hatchery-reared juvenile spring/summer chinook and steelhead collected from Lower Granite and Little Goose dams on the Snake River leads in most years to higher rates of return to the river of adult fish than allowing the fish to transit the river using the passage routes available at the dams. For steelhead, in general the results are more variable than for chinook salmon. Therefore it is difficult to conclude that either transport or inriver passage is more favorable for steelhead. Effects on wild fish are not clear because of small sample sizes. (page 25)

> *Comments:* There is little or no room for dispute of these facts for hatchery spring/summer chinook (with the possible exception of fish from the Dworshak Hatchery, according to the Joint Technical Staff Memorandum). The situation for steelhead is less clear. According to Giorgi et al., the steelhead sample is very small. Only one study had a confidence interval applied to the transported vs. in-river ratio (TIR) estimate, and it was near 1.0. Similar findings were reported in syntheses by NRC (1996) and ISG (2000). The ISG (ISG 2000) found that in cases where sufficient numbers of adult recoveries were made to make a judgment possible, transportation increased (to varying degrees) the survival of yearling hatchery spring chinook to the point of release in 26 out of 36 studies (i.e. Transported/In-river was greater than 1) over the years from 1968 to 1995. In four of the remaining studies, T/I [TIR of Giorgi et al.] was equal to 1, while only six were less than 1. Save Our Salmon (SOS) comments that their concerns with the report have to do with conclusions drawn and management actions that should be taken as a result, rather than to the data analysis (p. 10). A dispute arises over whether there might be a loss of adults that end up not being counted. Two issues raised have to do with 1) measurement of a factor labeled delayed differential effects, D, and 2) possible effects of transportation on homing. The D factor is discussed below. If transportation affects homing ability then the broader return

rate of adults would be even higher than measured to point of release, whether the return rate of hatchery strays is a liability or an asset is itself a matter of debate. The concern raised is the possibility of effects on salmon or steelhead stocks in the streams where the strays may appear. Giorgi et al. acknowledge this as an uncertainty and recommend studies. This is discussed further below.

Giorgi et al. conclusion regarding Lower Monumental and McNary dams:
No clear benefit has been shown for transportation of smolts of spring/summer chinook and steelhead stocks from Lower Monumental or McNary dams. (pages 13, 26)

Comments: Save Our Salmon and the Joint Technical Memorandum agree with this finding. Save Our Salmon recommends that collection of juvenile salmonids at Lower Monumental and McNary dams for transportation should be discontinued. The data for the mid-Columbia stocks at McNary are less convincing, and more study there might be warranted. However, the premise on which a study would be based is unclear. The fact that benefits from transportation decrease as one goes downstream should not be surprising. Transportation can only offset the inriver mortality incurred if smolts are left in the river from that point. Smolts transported from Lower Granite and Little Goose dams are avoiding 6 or 7 dams and associated reservoirs, whereas those transported from Lower Monumental avoid 5 dams and those from McNary avoid only 3. Based on present evidence, the ISAB concurs with the conclusion of Giorgi et al., and supports re-evaluation of these transportation sites.

Giorgi et al. conclusion regarding Use of Trucks:
Trucks are used in place of barges at the beginning and ends of the outmigration when fish are not abundant enough in the collection systems to justify the use of barges. (page 2)

Comments: There were no public comments on this point. However, while this is a description of methods and not a research result as presented by Giorgi et al., it is a point that merits discussion. The ISG (2000) found that return rates of spring/summer chinook and steelhead transported by truck were lower than of fish that transited the river. However, the studies of trucking and barging were done at different times and used different methods, and it is possible that the observed lower survival in truck transportation was due to poorer procedures in early efforts. It would seem to be advisable to discontinue transportation early in the spring when fish are not abundant enough to justify transportation by barge, at least until a new experimental test of truck transportation, using better procedures, resolves the question. Differences in the efficacy of transportation by trucks and barges late in the spring and in the summer are less clear, especially for fall chinook and other anadromous species that have not been studied extensively. The ISAB supports further study of the relative efficacy of trucking and barging, using common study protocols and a variety of stocks and migration times.

Giorgi et al. conclusion regarding Fall Chinook:
The benefit of transportation of fall chinook is an unknown. No mass transportation study of fall chinook has been conducted. Studies using hatchery fall chinook are being planned. Continued research on these important issues is warranted. (page 25)

> *Comments:* There were no comments on this subject. The ISAB points out that uncertainties continue to exist on whether transportation of a high percentage of all anadromous fish will maintain high diversity of life history types of all species of salmon and steelhead in all seasons. The ISAB concurs that study is needed.

Giorgi et al. conclusion regarding Upper Columbia River:
Stocks of chinook, steelhead, and sockeye from the upper Columbia River above Priest Rapids Dam have in some years been intercepted at McNary Dam for transportation to below Bonneville Dam. Under current operating strategies in the BO, interception at McNary Dam is de-emphasized in favor of spill as a passage alternative. There have been no studies since the 1980s. Study designs are being formulated for 2002. (pages 26, 27)

> *Comments:* There were no comments on this point. The ISAB concurs that more information might be useful, but sees no particular urgency (see comment above).

Giorgi et al. conclusion regarding Statistical Foundation:
There are weak statistical foundations for many study conclusions. Rarely have authors specified levels of statistical accuracy and precision of estimates or significance levels between or among estimates. Many of the annual SAR (smolt-to-adult returns), TIR transported to in-river ratios), and D (delayed differential effects; see below) estimates have such poor precision that their usefulness may be questioned. (page 27)

> *Comments:* There were no direct comments on this subject, although it comes into play in evaluation of many studies and specifically in relation to the next finding. The ISAB concurs that a better statistical foundation is desirable. This means, first of all, that more thorough statistical evaluation of data should be expected from all individual studies (particularly with respect to putting confidence intervals on parameter estimates); second, this means that meta-analyses combining data from multiple studies are warranted; and third, this means that future research should consider large scale experiments with designs based on statistical analysis of existing data to ensure that the new experiments are more conclusive.

Giorgi et al. conclusion regarding "D":
The concept of Delayed Differential Effects, i.e. "D", is confusing. Given the poor precision of estimators of D and indirect methods to estimate D, there is no opportunity for sound statistically based inferences with existing data. As a consequence, some may view D to be a confusing and rather abstract parameter that has little intuitive relevance. Furthermore, it appears that except for some modeling applications, D can provide little more information to the manager than prevailing TIR estimates that are used to derive D in the first place. (page 19)

Comments: WDFW agrees that studies are needed to elucidate the variety of parameters included in the parameter D (See below). Save Our Salmon feels that Giorgi et al. downplayed the importance of D and refers to a paper by Bouwes et al. (2002) in which the authors are said to find that mortality of smolts after release from the barges is nearly twice as high as in-river migrants. Giorgi et al. acknowledged that finding, but concluded that even with this loss, the adult return rate of transported smolts is higher than in-river migrants. The Joint Technical Staff Memorandum pointed out that Giorgi et al. did not discuss the issue of possible "extra mortality" of in-river migrants due to the hydroelectric system, although NMFS BO RPA actions were developed to address the issue. The ISAB has commented on this issue previously and concurs that the concepts are confusing and not always helpful.

Both D and "extra mortality" are terms specific to a particular set of models that were analyzed by the PATH project. During the course of PATH, both D and "extra mortality" were estimated in indirect ways, for lack of direct data. Since then, the debate persists, because adequate data have never been collected. In the time since the PATH era, more data have accumulated, there have been improvements in the bypass facility at Bonneville, the PIT tag reading facility at John Day has become operational, and there is some PIT tag collection below Bonneville, but we still do not have adequate sample sizes for estimation of in-river survival rates to below Bonneville.

The debate has perhaps been exacerbated because of drift in what various parties mean when they refer to D or "extra mortality." These hypothetical differential rates, D and extra mortality, are used by proponents of both sides of the argument over the efficacy of transportation, depending upon their belief systems. There is, indeed, evidence in the literature for latent or delayed mortality of fish from non-lethal stresses (at the time of exposure) that might be occurring in the Columbia River, and that might differ between transported and inriver groups. But these latent and delayed mortality measurements are not measurements of differential mortality between transported and in-river fish, as measured in the rates of adult returns to the river. The factors D and extra mortality were proposed only for the comparative survival of returning adults. The factors D and "extra mortality" as used in PATH were largely placeholders for mortality components, or mortality relationships, that *could* be real and *could* be important, if we could define them unambiguously and collect the proper data to estimate them with sufficient resolution.

Giorgi et al. correctly quote from the literature that D can be computed directly from the T/I ratios and independent estimates of inriver survival to below Bonneville Dam. While the controversy over D probably is not that important in the grand scheme of things, there are still legitimate questions about survival of inriver fish in the John Day pool, survival at the newly enhanced Bonneville structures, and, futhermore, growing interest in survival rates in the estuary of both transported and inriver fish that might be well-served by an ambitious

survival study design with a focus that begins well above Bonneville and reaches the ocean plume.

The ISAB concludes that issues associated with "D" and "extra mortality" are not likely to be resolved until studies are undertaken specifically to detect and measure them.

Giorgi et al. conclusion regarding Homing:
Homing of adult salmon is likely to be affected by transportation. There have been studies, limited in scope, that indicate transportation can impair homing particularly for steelhead, sockeye, and fall chinook. A more systematic and comprehensive evaluation of the effects of the mass transportation strategy on homing ability is warranted. One study is being planned. Impaired homing would show itself as a lower return rate of transported fish than expected, which might pose no problem for the transported stock, but some investigators raise the prospect of possible effects on the stock in the recipient stream(s). (pages 23, 25)

Comments: There is general agreement on this point. We concur.

Giorgi et al. conclusion regarding Stress of Transportation:
Stress effects on transported fish are poorly identified. It is difficult to determine, on the basis of available information, whether stress associated with the collection and transportation of juvenile salmon contributes to mortality. Another way of saying it is that there has been no demonstration of an effect on survival. (pages 21, 22)

Comments: The NMFS commented that not all bypass facilities are created equal and that some collection facilities may be contributing to juvenile fish mortality. We concur. There were no other comments on this point. However, the ISAB reiterates a point made in many of its and its predecessor groups' previous reviews of transportation, which is the importance of life-history diversity in evaluating the efficacy of transportation. Every aspect of transportation, including susceptibility of collection, direct mortality, overall stress during collection and transport, and long-term survival may differ among species and life stages. Transportation may be exerting a selective effect among existing stocks that is not desirable for long-term sustainability. We concur with Giorgi et al. that this topic is poorly identified. In years with normal or high flows and better than average in-river survival, it may be better for the fish community to minimize transportation. We reiterate that failure to demonstrate an effect does not prove that there is no effect, most especially if the available data are weak and the available studies have indifferent designs.

Giorgi et al. conclusion regarding Direct Mortality:
Direct mortality in the barges or trucks seems slight. There are no rigorous estimates of this source of mortality. Observers have seen few dead fish upon release. Exceptions are a couple of occasions when barges full of fish sank in the river.

> *Comments:* There were no comments on this point other than the NMFS comment noted above. See ISAB comment above.

II. Spill

Giorgi et al. conclusion regarding Overall Synthesis:
Routing smolts through spillways is generally considered to be the safest passage strategy at Columbia River and Snake River dams. (pages 36-53)

> *Comments:* There was general agreement on this point, although NMFS pointed out that we do not fully understand the mechanisms associated with survival benefits of spill. We concur on both counts. We add that an additional benefit of spill, not mentioned in the Giorgi et al. report or in comments, is that spill accelerates passage "through the concrete." Passage via spill is more rapid than passage through the powerhouse with its delays in the forebay and bypass system. Fish appear to be reluctant to enter turbine intakes, especially in the day, yet move rapidly in spilled water. Over the course of passing several dams, the timesavings could be substantial.

Giorgi et al. conclusion regarding Project Spillway Passage Efficiency:
Spillway passage efficiency varies among fish stocks, varies between day and night, varies with the percentage of river flow passing in spill, varies depending upon the method of measurement, and is project specific. Selecting an appropriate value to be used in predictions required to implement spill as a strategy will involve intense inspection and evaluation. (page 34)

> *Comments:* There was no dispute on this point. It confirms findings of Whitney et al. (1997) in Council Document 97-15. The NMFS comment clarified definitions, although the intent of the Giorgi et al. conclusion seems clear. The ISAB concurs.

Giorgi et al. conclusion regarding Survival in Spill at the Dam:
Numerous studies have shown that survival of juvenile salmonids passed through spillbays or sluiceways is higher than juveniles passed through the turbine intake bypass systems or turbines at particular dams. Flow deflectors that are in place at some dams to reduce total dissolved gas in solution may reduce survival by 1-3%, depending on the dam and species, but survival still exceeds that in turbine passage. (pages 36-38)

> *Comments:* NMFS commented that many of the conclusions were drawn from summary data without reference to error bounds, which could alter results. Also there is a need to balance the additional mortalities from flow deflectors with the survival benefits from lowered total dissolved gas. There were no other comments

on these particular points. The ISAB concurs with the need for error bounds and with the need for assessment of overall survival effects, yet also agrees with the general conclusion of Giorgi et al.

Giorgi et al. conclusion regarding Survival Affected by Spill Volume at the Dam:
Collectively, there is some indication that smolt survival varies with discharge at some dams and in some cases, and that passage benefits may be associated with maintaining spill at moderate, rather than highest, levels. At The Dalles Dam, survival of juvenile salmonids in spill declined steadily, by an estimated 7%, as spill fractions rose from 30% to 64%, relative to the total volume of river flow. There is a strong indication that survival in spillway passage could be maximized by selecting the most benign level of spill. (pages 39, 53)

Comments: The results of the study at The Dalles Dam are a subject of dispute. Save Our Salmon comments that it is probably inappropriate to extend the results at The Dalles to other projects, because, the same phenomenon was not observed at Wanapum, Rock Island, and Little Goose dams, judging by the figures shown in Giorgi et al. They also raise a point about possible flaws in the study at The Dalles. WDFW also observes that this might be a site-specific phenomenon. The Joint Technical Staff Memorandum also raised a point relating to technical and analytical flaws in the study at The Dalles. We agree that it is inappropriate to extend the results of spill studies from one project to others without site-specific verification. The ISAB specifically made this point in its review of spill studies at The Dalles (ISAB 2000-1). However, the ISAB concurs with the point made by Giorgi et al. that the most benign spill level for a site needs to be determined, rather than assuming that more spill is always better.

Giorgi et al. conclusion regarding Survival Estimated Over Several Dams, Empirical Studies
There have been few studies that attempted to develop estimates of systemwide smolt survival attributable to spill. There are conflicting results. The Muir et al. studies (cited in Giorgi et al.) suggest that survival was highest in years when spill levels were highest. On the other hand, Zabel et al. (2001) pointed out that in the time-series they examined, the improved survival associated with a period of spill was time related, and occurred at a similar time in past years, regardless of spill. NMFS concluded that the results of this analysis were inconclusive. Giorgi et al. conclude that it is not possible to isolate spill as a discrete treatment in this kind of analysis, because too many variables affect survival. (pages 11, 12)

Comments: There is agreement on this issue in the Joint Technical Staff Memorandum. The Memorandum indicates that Giorgi et al. should have referenced the comments by the region's fishery agencies and tribes on the severe limitations of this particular application, and provides a website where those comments are available. Save Our Salmon states that care should be taken not to conclude from the NMFS studies that spill was not effective in improving survival. The ISAB concurs there has been difficulty in isolating spill effects

beyond an individual project and suggests that additional research should focus on identifying reasons why it has not been possible in some cases to measure systemwide improvements in survival attributable to spill, even though benefits at individual projects have been demonstrated. Faster passage through the concrete, noted in the general spill conclusion above, needs to be factored into an overall analysis.

Giorgi et al. conclusion regarding Survival Estimated Over Several Dams, Model Analyses:

Giorgi et al. suggest employment of mathematical models, namely computer based models such as CRiSP or SIMPAS to estimate or predict the total mortality experienced by smolts in passing either a series of projects or a single dam. They attempt to identify key issues applying to the use of passage models in spill analysis. They identify a primary concern as being the criteria adopted for selecting the best estimate from a pool of estimates of spill efficiency and survival in spill, among other inputs that will be employed in the model analysis. "There will surely be factions that take exception to the resultant set of estimates." It seems more appropriate for a diverse technical group to develop and apply criteria that would be used for assembling the most representative set of inputs that could be applied as a standard. It is not clear that NMFS employment of the SIMPAS model to evaluate changes in expected smolt survival under four spill scenarios accurately depicted spill related survival, particularly under the extreme low flow conditions experienced in 2001. The only analysis they found that attempts to assess the change in survival for the smolt population subjected to different spill scenarios is the 2001 model analysis conducted by NPPC staff. It may not be totally satisfactory because the SIMPAS model used in the analysis probably needs updating. A number of improved estimates have become available since SIMPAS was constructed. Giorgi et al. doubt that it would be practical to attempt to design manipulative experiments that could isolate spill effects in the complex Columbia River system. (pages 47, 48, 55)

Comments: There is general agreement with the Giorgi et al. finding. Save Our Salmon agrees with Giorgi et al. in their reluctance to endorse the manner in which the NPPC applied the SIMPAS model to endorse maximized transportation and reduced spill as a passage strategy in 2001. ODFW comment that Giorgi et al. should have observed that the weight of evidence, including model analyses by the Fish Passage Center and NMFS, indicates that spill is beneficial on a population level. The Joint Technical Staff Memorandum states that there are severe limitations in the modeling approach.

The ISAB finds that the SIMPAS model is being used in the region for several kinds of applications, some of which are inappropriate or questionable. This model can be an important and useful tool but it should be the subject of an update and verification, as suggested by Giorgi et al. In particular, input values for the SIMPAS model are most often ad hoc guesses and suffer from a lack of real measured data. It is important to build regular updates of the necessary parameter values into an ongoing long term monitoring and evaluation plan. As above, the

effects of speed in passing smolts through the concrete when water is spilled should be factored into modeling.

In general, the ISAB warns against using models in attempts to "compensate" for the absence of critical data. This strategy cannot work satisfactorily for the long term. Without important data, analyses often deteriorate into unproductive conflicts between the backers of competing models that differ because of different assumptions. One proper use of models, when data are inadequate, is to identify which data would be most important to resolving the question, and to determine what would be the most efficient design for obtaining those data.

Giorgi et al. conclusion regarding Adult Passage Impacts:
Observations in the field have suggested that spilling water can alter migratory patterns of adult salmon and steelhead, leading to protracted migration times. The relationship between fallback and spill discharge appears to be dependent upon the year and particular dam. Giorgi et al. conclude that there is some evidence that high spill levels may exacerbate delay and fallback, but were unable to find a study that specifically and explicitly evaluates the effects of the spill program on adult passage.

Comments: There were no comments on this issue. The ISAB concurs.

Giorgi et al. conclusions regarding Uncertainties and Potential Sources of Dispute on Spill:
(1) In spill modeling exercises, values for model parameters should be periodically updated for each dam and species (stock). With notable exceptions, the data are not being systematically compiled and synthesized on a regular basis.
(2) Modeling may be the only practical means to evaluate the probable relative effectiveness of various river-wide spill scenarios. Decisions on which parameter values should be entered into the models require a consensus approach by knowledgeable technical personnel.
(3) Results from empirical evaluations of river-wide spill effects are not conclusive because spill effects are not clearly isolated from other effects. Giorgi et al. do not believe that it is practical to conduct well-designed manipulative (controlled) experiments that could isolate spill effects as a causative factor, due to the complex nature of the river system and its operations.
(4) Effects of spill on adult passage and survival to spawning should be established as a long-term monitoring program.

Comments: WDFW commented that a very useful part of the Giorgi et al. document was the identification of critical uncertainties in the effectiveness of transportation, spill, and flow augmentation on increasing survival of juvenile anadromous salmonids during their outmigration. Save Our Salmon provided a cautionary note to the effect that many of the research needs identified relate to management actions that produce rather small impacts.

The ISAB agrees with item 1, that parameters need to be updated regularly, both to account for possible changes in the system, and to capitalize on the growing mass of data. The ISAB disagrees emphatically with the implication in item 2 that modeling is a solution for the problem of inadequate data (see earlier comment on use of models). The ISAB observes that, with respect to item 3, it should be clarified that Giorgi et al. are apparently referring to a systemwide experiment to measure effects of spill on survival. We share their pessimism about persuading the power system operators to make an investment in dramatically manipulating the entire system. On the other hand, there have been a number of examples of manipulations at individual projects that were experiments designed to develop spill effectiveness relationships. Current approaches to studying this question depend upon natural or programmatic interannual variability in systemwide spill and an after-the-fact analysis, which leaves open a question about interannual variation in survival that might be independent of spill.

We recommend more attention to deliberate experimentation on individual projects, perhaps one at a time, and perhaps rotating among projects, so as to obtain defensible estimates eventually for every project. We also recommend capitalizing on interannual changes in available water to provide systemwide variation (by having contingency plans in an experimental design to respond to water budget events as they occur). The design for monitoring the experiment at any given dam obviously must provide for following the fish for long enough to account for any delayed effects, to ensure that when the parameters are put into an eventual comprehensive model, the whole really will be represented by the sum of its parts. With respect to item 4, we have our doubts about the ability of passive monitoring to resolve the question, and for that reason we recommend experimentation in conjunction with monitoring.

<u>Giorgi et al. conclusion regarding Total Dissolved Gas:</u>
The biological monitoring program has demonstrated that compliance with the TDG limits outlined in the 1995 BO typically results in less than 1% of the juvenile migrants that are sampled exhibiting signs of gas bubble trauma. In contrast, conditions producing involuntary spill (i.e. when river flow exceeds powerhouse capacity) have resulted in TDG levels of 130 to 140 percent for a number of consecutive days, resulting in 3.2 to 3.3 percent of the migrants exhibiting signs of gas bubble trauma. (page 49)

Comments: There were no comments on this issue. The ISAB concurs.

III. Flow Augmentation

Introduction

There are many issues in dispute regarding the relationships between river flow and salmon survival, and regarding the efficacy of augmenting flows to aid salmon survival. The existing literature, summarized by Giorgi et al., only begins to explore the complicated interactions of the amount of water in the river and a multitude of other co-occurring factors that may affect salmon survival. These factors are environmental (e.g., temperature, turbidity, overbank inundation) and operational (e.g., rapid changes in flow at low river volumes as a result of load following). The technical disputes arise mostly because of a lack of information and differing assumptions about unstudied hypotheses, not because of deficiencies in the Giorgi et al. summary. The technical disputes continue to cascade into policy disputes.

Giorgi et al. Premises for the Flow-Augmentation Strategy

Giorgi et al. identify two premises that form the foundation of the flow augmentation strategy: 1) that increases in water velocity (flow) should lead to increases in migration speed, which in turn should lead to increases in survival of migrating juvenile salmonids. and 2) that lowering water temperature (summer) leads to improved migratory conditions for juvenile and adult salmonids, leading to increased survival. (page 60)

> *Comments:* The ISAB finds these premises too narrow, as did the NMFS in its comments. The ISAB does not concur that the question of flow-survival relationships and flow augmentation can be reduced to these two premises. As noted above, there are many untested hypotheses for benefits of higher flows (and flow augmentation). Some of these untested hypotheses were referred to in the comments (e.g., NMFS's suggestions of improved conditions in the estuary, larger Columbia River plume, increased turbidity to reduce predation). The ISAB recognizes others discussed by the ISG in Return to the River 2000 (ISG 2000). The potentially detrimental effects of load following at lower river flows has been discussed by the ISAB previously in relation to the Hanford Reach and Priest Rapids Dam (redd and juvenile stranding). A fuller exploration of premises is needed, which goes beyond the scope and time frame of the ISAB's review of the Giorgi et al. report.

Giorgi et al. conclusions regarding Speed of Outmigration of Juvenile Salmonids:

a) Impoundment of the Snake and Columbia rivers has slowed the migration speed of yearling chinook and steelhead smolts. (page 62)

b) Average river flow explains most of the variability in travel time of sockeye and steelhead smolts as well as sub-yearling chinook migrating through John Day Pool. In the Snake River both flow and level of smolt development are factors that interact to explain the migration speed of yearling chinook smolts. Travel time is more rapid for yearling chinook in advanced stages of smoltification in both the Snake and upper Columbia rivers. However, no effect of flow was found for travel times of yearling chinook emigrating from the upper Columbia River from Rock Island Dam to McNary Dam. (pages 63, 65)

c) The most dramatic responses to a given increment of flow occur at low flows, i.e. increases of flow of 10 kcfs have the largest effect at river flows from 40 to 50 kcfs (reduction in travel time of 5.0 days to 4.2 days) whereas increases of flow from 100 kcfs to 110 kcfs reduce average travel time by only 1/10 of a day. (page 63)
d) In the Snake River, migration speed of fall chinook has been related to flow, temperature, turbidity, and fish size. However, all of these factors are time related, flow decreases, temperature increases, and turbidity decreases, as fish size increases, making it difficult to demonstrate effects of a particular variable with the existing data. (page 64)
e) In the upper Columbia River, from Rock Island Dam to McNary Dam, size of fall chinook is the best predictor of migration speed. (page 64)

Uncertainties and Possible Sources of Dispute over Travel Times: Until NMFS and the Fish Passage Center provide comprehensive analyses covering the years from 1993 through 2001 (subsequent to Berggren and Filardo 1993), the region must rely upon previous investigations to characterize behavioral responses of juvenile salmonids to volume of flow. (page 65)

> *Comments:* The above findings and conclusions do not appear to be in dispute. The Joint Technical Staff Memorandum noted that Giorgi et al. had not referred to a recent study by Connor et al. 2001, which reports that flow can be used to predict travel time for juvenile fall chinook in the Snake River. The ISAB concurs with the findings of Giorgi et al. and also regrets that the authors did not include the recent work by Connor et al. However, even with use of these most recent results the facts available are insufficient to resolve disputes over their application to management decisions on flow, which relate to survival not migration speed. The discussion on survival follows.

<u>Giorgi et al. conclusions regarding Effects of Flow on Survival of Juvenile Salmonids:</u>
Translating river flow or smolt migration rate into smolt survival is the critical issue underpinning the rationale for providing flow augmentation. The foundation for this strategy extends back to a 1981 study by Sims and Ossiander who described a positive relationship between average volume of river flow and average survival of yearling chinook and steelhead during the period of outmigration over the years 1973 to 1979. As noted in the general comments in the main text, Giorgi et al. chose to use mostly recent studies, as better representing the current conditions. (page 65)

> Comments: Although others criticized this approach, the ISAB concurs.

<u>Giorgi et al. conclusions regarding Survival of Yearling Chinook</u>
The NMFS White Paper on smolt survival and flow summarizes two decades of yearling chinook survival studies and flow indices. The authors failed to find a relationship between flow indices and survival for yearling chinook. Similarly, Giorgi et al. report that Zabel et al. 2001 failed to find a flow/survival relationship. In NMFS' White Paper (NMFS 2000) no relationship was found from PIT tag recovery data in the Snake River. Although they found a relationship of flow and migration rate, there was none between migration rate and survival. (page 67)

Comments. Comments from Save Our Salmon, and the Joint Technical Staff were critical of the White Paper and Zabel et al.'s analysis, primarily because those analyses depended upon a per project estimate of survival rather than a per mile analysis, or analysis over a longer reach (Oregon comments) which they feel is more appropriate, and leads to a conclusion that, taking spill into account, survival was flow dependent. The ISAB agrees with the comment that there is a distance effect that must be taken into account, and that per project results are likely insufficient. More analysis is needed.

Giorgi et al. conclusions regarding Survival of Steelhead

In contrast to the results with yearling chinook, the report of Zabel et al. 2001 found a sharp decrease in survival of steelhead during the low flow year 2001, relative to other years during this decade. Giorgi et al. feel that this result was brought about by two factors, the strong effect of low flow that is known to increase travel time of steelhead, and the warm temperatures that occurred early in the steelhead migration. (page 69)

Comments. The comments focused on the data in the Zabel et al. report, which support the premise of a flow/survival relationship for steelhead. The ISAB has not conducted any independent analysis of the recent data, but generally concurs with the findings of Giorgi et al. and the commentors.

Giorgi et al. conclusions regarding Survival of Snake River Fall Chinook Salmon

Three factors were found by NMFS to be significantly related to survival of outmigrating fall chinook salmon from the Lyons Ferry Hatchery. They were temperature, flow, and turbidity in that order of significance. The predictor variables were highly correlated, confounding the ability to identify the causative agents. Size of fish at time of release from the hatchery was also found to be strongly correlated with survival. Giorgi et al. refer to Connor et al. 1998 who, in a study of subyearling chinook from the Snake River above Lower Granite Dam, found that, over the period of years 1992-1995 annual detection rates of the fish at Lower Granite Dam were highest in the two years of average high flow, and lowest in two years of average low flow. (page 70)

Comments. Save Our Salmon commented that Giorgi et al. placed too much emphasis on the interrelationships of variables and that these should not be used as evidence that flow is not a strong factor affecting the observed survival rates. The Joint Technical Staff Memorandum and NMFS referred to Connor et al. 2001, a paper not referenced by Giorgi et al. in which the authors report that summer flow augmentation increased migration speed and survival of juvenile fall chinook salmon in the Snake River. The ISAB concurs with the Giorgi et al. report that the variables are interrelated and flow, by itself, cannot be separated out as the causative factor for survival. Inclusion by Giorgi et al. of the work of Connor et al. 2001 might have helped clarify the problem. Because flow seems to be the basis for differences in some of the other factors, the SOS comments are important. Although researchers have been reluctant to promote the use of simple statistical (regression) models to predict survival of fall Chinook as a function of

flow, the ISAB judges that such predictions are possible and defensible. We note that with more or less the same precision and accuracy, it is also possible to predict survival as a function of water temperature or other factors that are correlated with flow. However, more work is needed to refine our understanding of these (and likely many other) factors to provide persuasive scientific justification for flow augmentation.

Giorgi et al. conclusions regarding General Flow Augmentation Evaluations

Surprisingly few, if any, comprehensive evaluations of flow augmentation have been published, which address all or even most of the significant issues. The annual reports of the Fish Passage Center are deficient in that they fail to estimate the extent to which flow augmentation increased water velocity or decreased water temperature as compared to base condition, nor do they predict the magnitude of fish response in terms of smolt migration speed or survival, as attributable to that incremental change in flow and temperature. The NMFS BO is deficient in this regard, as well. The BO specifies volumes (MAF) for flow augmentation, and prescribes seasonal flow (KCFS) targets, but provides no quantitative analysis describing changes in water velocity, smolt speed or survival benefits that are to be expected as a result of flow augmentation. (Pages 72-73)

Giorgi and Schlecte conducted an evaluation for the years 1991-1995, Snake River flow augmentation volume ranged from an annual low of 1.35 to 2.56 MAF. These volumes were insufficient to sustain the flow targets established by NMFS for the duration of the smolt migration period. Flow augmentation did increase water velocity through Lower Granite Pool an average of 3-13%. During the summer, the increase was more pronounced, with an increase of 5-38% change in water velocity attributable to the addition of flow augmentation water. Corresponding decreases in travel time ranged from 5-16% over the five years included in the study. Dreher (1998) concluded that the volumes of water earmarked for flow augmentation in the Snake River 1) provide only small incremental increases in average water velocity through the hydroelectric system, and 2) are insufficient to meet flow targets in all years. The study was limited in scope. (pages 74-75)

Comments. There were more comments on the subject of flow augmentation than either of the other mainstem strategies. The Idaho Water Users Association noted that the variation in discharge between good and poor water years in the upper Snake River is more than all of the storage in the upper Snake River Basin. They feel that between year survival/flow analysis cannot be used to evaluate flow augmentation effects, due to changes from year to year in other factors affecting survival.

Montana Fish, Wildlife and Parks commented that flow augmentation from large storage reservoirs in Canada and Montana is designed to assist juvenile fish in the Columbia River below McNary Dam. They state that research has not validated the predicted benefits to anadromous fish from McNary Dam downstream. Research has focused on the Snake River. They state that the actual change in water velocity expected in the lower Columbia River as a result of augmentation

from the upper Columbia River is minute. No benefits in terms of temperature amelioration in the lower river could possibly occur, given the distance from the source and the numerous reservoirs that intervene. This is true even though selective withdrawal devices are in place at Libby and Hungry Horse Dams. These are used to regulate the temperature of discharge immediately downstream. On the other hand, they point to significant adverse effects on resident fishes in the upstream storage reservoirs and the streams leading from them into the Columbia River. Montana refers to the quote in Giorgi et al. from the ISG's 1996 draft review (ISG 2000), indicating the potential adverse effects of flow augmentation on biological productivity upstream. See further comments from Montana below with respect to the need for a balanced approach in deciding on flow augmentation strategies.

Giorgi et al. conclusion regarding Effects of Augmented Flow on Water Temperature Leading to Effects on Survival of Juvenile and Adult Salmon and Steelhead-
Model Studies

Models are used to predict probable effects of releases from Dworshak and Hells Canyon dams on water temperature. (page 78)

A. Models predict measurable effects to extend only as far as Lower Granite Dam

1) Expected effects depend upon the volume of base flow relative to the volume of augmentation flow, and depend upon distance from the source.

2) At Lower Granite Dam expected decreases usually range from 1- 4 ^{o} F, but can range to 6-8 ^{o} F. At Ice harbor Dam, the expected decrease in temperature is on the order of 1-2 ^{o} F. Cold water released upstream will tend to sink, suggesting that pockets of cool water might be available as refugia, but cooling throughout the water column will not occur.

Comments. Save Our Salmon commented that even a reduction in temperature as small as 1-2^{o} C can greatly affect survival rates when temperatures are near the lethal limit. The Joint Technical Staff referred to the Connor et al., 2001 report, which is not included in the report by Giorgi et al. That report concludes that flow and temperature together affect survival of juvenile fall chinook in the Snake River. The ISAB concurs with the summary of temperature results by Giorgi et al. but also acknowledges the point made by the SOS and the importance of the Connor et al. 2001 studies. The temperature issue requires additional studies, both empirical and modeling.

B. Drafting water from storage reservoirs for flow augmentation adversely affects resident fishes in the reservoirs and immediately downstream. Expected benefits to anadromous fishes ought to be balanced against ecosystem function and potential risk to resident fishes. Giorgi et al. refer to ISG (1996; now ISG 2000), which calls attention to the potentially negative implications for nutrient mass balance and food web productivity in Flathead Lake, located downstream from Hungry Horse Dam. This issue involves balancing expected benefits to anadromous fish against ecosystem function and potential risk to other native species, including Kootenai River white sturgeon, a listed species. Giorgi et al. states that they did not encounter a comprehensive,

multidisciplinary evaluation of benefits and risks to anadromous and resident fish species and their habitat. (pages 78-79)

Comments: Montana Fish Wildlife and Parks strongly emphasized this point. There were no other comments.

The ISAB notes that we were also asked to review the situation in 1997 (ISAB 97-3). In that (1997) report we noted that NMFS had employed a facilitator to attempt to arrive at an agreement among federal, state, and tribal parties on modification of operations called for in the BiOp (Wright, 1996). One of the Steering Committee Findings was "The need for and level of August flow requirements should be one of the region's top salmon monitoring and evaluation priorities." We agreed with that finding. The ISG in Return to the River 2000 repeated the recommendation.

<u>Giorgi et al. conclusions regarding Uncertainties and Potential Sources of Dispute on Flow Augmentation</u>

1. The NMFS PIT tag-based smolt survival estimates derived since 1993 form a strong basis for examining such a relationship between flow and survival. These efforts should be expanded to include the lower and upper Columbia River where and when possible. (page 81)

Comments. The Joint Technical Staff Memorandum believes that this is a highly questionable statement, since it ignores 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. Save Our Salmon commented that flow is liable to affect survival outside the hydrosystem. The ISAB believes the questions raised are legitimate ones, but do not recognize that the studies referred to are aimed at estimating mortality within the hydrosystem. The other matters raised are at another level of effects. Whether there is a way of addressing them satisfactorily is a more difficult question to answer. Perhaps recovery of PIT tagged adults will help. The high adult return rates of the most recent years do provide large PIT tag sample sizes with a potential for analyzing survival rates of different passage groups after they exit the hydrosystem -- something that was not feasible in years of low return rates. In any case, the ISAB concurs with the Giorgi et al. conclusion and urges that research be conducted toward answering the subsequent issues raised in comments. We recommend continued PIT tagging, with design considerations to include the potential for analysis of post-Bonneville survival of tagged groups with different passage experiences.

2. Giorgi et al. recommendation for further studies of effects of flow.

A) A multi-faceted, comprehensive, updated evaluation of the biological benefits and risks associated with flow augmentation is advisable and is long overdue. (page 82)

Comments. The Joint Technical Team agreed with this recommendation, suggesting that it should include lifecycle modeling to evaluate full effects of flow

on survival. NMFS suggested several other sources of information not available to Giorgi et al. We concur with the recommendation for a comprehensive updated analysis, but repeat our warning about use of models in place of data.

B) Giorgi et al. were unable to find a comprehensive multidisciplinary evaluation of flow augmentation, which attempts to assess and quantify the full set of benefits and risks to anadromous and resident fishes and their habitat. The focus has been on narrow interests of the group affected. Such an analysis should be undertaken. (page 82)

Comments. Primary support for this recommendation comes from Montana Fish Wildlife and Parks. There was no objection from other sources.

An issue raised in the comments from Montana Fish, Wildlife and Parks was the belief that release of water from reservoirs far upstream in the basin for flow augmentation provides little benefit to downstream migrants yet can have measurably detrimental effects locally. This was emphasized especially for the reservoirs in Montana that drain through a long chain of rivers, lakes, and reservoirs before the water reaches the migrant corridor in the lower river. As noted above, the Giorgi et al. report discussed this issue under the heading "Benefits and Risks to other species" in which it quoted a passage from the ISG (1996) draft report Return to the River (now ISG 2000), went on to identify the issue in the Summary on Flow Augmentation where it recommended that "The scope of future evaluations (of flow augmentation) need to more fully address the balance of benefits and risks between anadromous and resident fish resources", and then identified the issue as a Critical Uncertainty and Research Opportunity.

We note that the tradeoffs between headwater and downstream effects have been an important part of the flow augmentation debate for some time. See ISG 97-3 referenced above, as well as ISG 2000. The analyses by Council's Montana staff (several years ago) and the Idaho Department of Water Resources' more recent reanalysis of NMFS' smolt travel time and survival data for the Snake River (Dreher et al. 2000) and the ISAB review of it (ISAB 2001), along with other unpublished analyses cited in the comments suggest that this topic deserves more technical evaluation with a view toward a potential revision in management approaches. We would caution, however, that ability to detect a local effect at a storage reservoir or tailwater, even a dramatic one, should not by itself be a deciding criterion against flow augmentation to achieve downstream benefits. An intense local effect could influence far fewer fish than a more subtle effect that is exerted over many hundreds of miles downstream and which exposes orders of magnitudes more fish. Such considerations should be part of the technical evaluation.

References Cited

Berggren, T. J., and M. J. Filardo. 1993. An analysis of variables influencing the migration of juvenile salmonids in the Columbia River basin. North American Journal of Fisheries Management 13:48-63.

Bouwes, N., R., C. Petrosky, H. Schaller, P. Wilson, E. Weber, S. Scott, and R. Boyce. 2002. Comparative survival study (CSS) of PIT tagged spring/summer chinook; Status report for migration years 1997-2000; Mark/recapture activities. Contract 8712702, Bonneville Power Administration, Portland, Oregon.

Chapman, D. A. Giorgi, M. Hill, A. Maule, S. McCucheon, D. Park, W. Platts, K. Pratt, J. Seeb, L. Seeb, and F. Utter. 1991. Status of snake river chinook salmon. Don Chapman Consultants, Inc. Boise Idaho, for mid-Columbia P. U. D.s.; Chelan County P.U.D., Wenatchee WA, Douglas County P.U.D., East Wenatchee, WA, and Grant County P.U.D., Ephrata, WA 520 pp.

Chapman, D. A. Giorgi, T. Hillman, D. Deppert, M. Erho, S. Hays, C. Peven, B. Suzumoto, and R. Klinge. 1994. Status of summer/fall chinook salmon in the mid-Columbia region, Don Chapman Consultants, Inc. for mid-Columbia P.U.D.s; Chelan County P.U.D., Wenatchee WA, Douglas County P.U.D., East Wenatchee, WA, and Grant County P.U.D., Ephrata, WA 411 pp.

Chapman, D., C. Peven, A. Giorgi, T. Hillman, and F. Utter. 1995. Status of spring chinook salmon in the mid-Columbia River. Don Chapman Consultants, Inc. for mid-Columbia P.U.D.s; Chelan County P.U.D., Wenatchee WA, Douglas County P.U.D., East Wenatchee, WA, and Grant County P.U.D., Ephrata, WA 477 pp.

Connor, W. P., H. L. Burge, and D. H. Bennett 1998. Detection of PIT tagged subyearling chinook salmon at a Snake River dam: Implications for summer flow augmentation. No. Amer. Jour. Fish. Mgmt. 18(3):530-536

Connor, W. P., R. K. Steinhorst, and H. L. Burge. 2000. Forecasting survival and passage of migratory juvenile salmonids. No. Amer. Jour. Fish. Mgmt. 20(3):651-660

Connor, W, P. 2001. Juvenile life history, downstream migration rate, and survival of wild Snake River fall chinook salmon. Ph.D. dissertation. University of Idaho, Moscow.

Dreher, K. J. 1998. A view on Idaho's experience with flow augmentation. Idaho Department of Water Resources, Boise.

Dreher, K. J., C. R. Petrich, K. W. Neely, E. C. Bowles, and A. Byrne. 2000. Review of survival, flow, temperature, and migration data for hatchery-raised, subyearling fall chinook salmon above Lower Granite Dam, 1995-1998. Idaho Department of Water Resources, Boise.

Giorgi, A., M. Miller, and J. Stevenson. 2002. Mainstem passage strategies in the Columbia River system: Transportation, spill and flow augmentation. Report 2002-03, Northwest Power Planning Council, Portland, Oregon.

Independent Scientific Group (ISG). 2000. Return to the River 2000. Restoration of Salmonid Fishes in the Columbia River Ecosystem. Report 2000-12. Northwest Power Planning Council, Portland, Oregon. 538 pp

Independent Scientific Advisory Board (ISAB). 1997. Ecological impacts of the flow provisions of the Biological Opinion for endangered Snake River salmon on resident fishes in the Hungry Horse and Libby systems in Montana, Idaho, and British Columbia. ISAB 1997-3, NWPPC, Portland, Oregon. (See especially Appendix 5 – Effects of drawdown on aquatic systems in reservoirs.

Independent Scientific Advisory Board (ISAB). 2001. Review of Lower Snake River Flow Augmentation Studies. ISAB 2001-5, Northwest Power Planning Council, Portland, OR and National Marine Fisheries Service, Seattle, WA. 14 pp.

National Marine Fisheries Service (NMFS). 2000a. Passage of adult and juvenile salmonids past Columbia and Snake river dams – White Paper. Northwest Fisheries Science Center, Seattle, Washington.

National Marine Fisheries Service (NMFS). 2000b. White Paper: Salmonid travel time and survival related to flow in the Columbia River basin. Northwest Fisheries Science Center, Seattle, Washington.

National Research Council (NRC). 1996. Upstream: Salmon and society in the Pacific Northwest. Report of the Committee on Protection and Management of Pacific Northwest Anadromous Salmonids for the National Research Council of the National Academy of Sciences. National Academy Press. Washington D.C.

Northwest Power Planning Council (NPPC). 1994. Columbia River Basin Fish and Wildlife Program. Portland, Oregon.

Sims, C. W., and F. J. Ossiander. 1981. Migrations of juvenile chinook salmon and steelhead in the Snake River, form 1973 to 1979, a research summary. National Marine Fisheries Service, Seattle, Washington.

Whitney, R. R., L. D. Calvin, M. W. Erho, Jr., and Charles C. Coutant. 1997. Downstream passage for salmon at hydroelectric projects in the Columbia River basin: Development, installation, and evaluation. Report 97-15, Northwest Power Planning Council, Portland, Oregon.

Zabel, R. W., S. G. Smith, W. D. Muir, D. M. Marsh, J. G. Williams, and J. R. Skalski. 2001. Survival estimates for the passage of spring-migrating juvenile salmonids through

Snake and Columbia River dams and reservoirs. National Marine Fisheries Service, Seattle, Washington; draft for Bonneville Power Administration, Portland, Oregon.

List of Comments

Committee of Nine and Idaho Water Users Association. Letter from John Simpson of Barker, Rosholt & Simpson and Norm Semanko of the Idaho Water Users Association to Mark Walker of the Northwest Power Planning Council dated March 8, 2002 (3 pages).

Joint Technical Memorandum (CRITFC, IDFW, ODFW, USFWS, WDFW, YIN). Letter from Earl C. Weber, Stephen Petit, Shane Scott, Steve Parker, Ron Boyce, and Howard Schaller to Mark Walker of the Northwest Power Planning Council dated March 19, 2002 (12 pages).

Montana Fish Wildlife and Parks. Letter from Brian Marotz to Mark Walker of the Northwest Power Planning Council dated March 8, 2002 (7 pages).

National Marine Fisheries Service. Letter from Brian J. Brown to Northwest Power Planning Council dated May 28, 2002 (7 pages).

Oregon Department of Fish and Wildlife. Letter from Raymond R. Boyce to Mark Walker of the Northwest Power Planning Council dated March 20, 2002 (10 pages).

Save Our Wild Salmon. Letter from Nicole Cordan to Mark Walker of the Northwest Power Planning Council dated March 19, 2002 (1 page with 30-page attachment; Bouwes et al. 2002 listed in reference section).

U.S. Fish and Wildlife Service. Letter from Howard Schaller to Mark Walker of the Northwest Power Planning Council dated March 20, 2002 (2 pages).

Washington Department of Fish and Wildlife. Letter from B. Shane Scott to Mark Walker of the Northwest Power Planning Council dated April 1, 2002 (3 pages).
