

Reservoir Operations/Flow Survival Symposium Proceedings

Northwest Power & Conservation Council Offices
Portland, OR
November 9-10, 2004

1. Greetings and Introductions.

The Northwest Power and Conservation Council-sponsored Reservoir Operations/Flow Symposium was held on November 9-10 at the Council's Portland offices. It was moderated by Chip McConnaha. The following is a summary (not a verbatim transcript) of the discussion that took place during the symposium. Anyone with questions about these notes should contact Bruce Suzumoto at 503/222-5161.

Moderator Chip McConnaha said the purpose of today's symposium is to review the scientific information associated with the question of flow impacts on summer migrants in the Columbia River as a result of adoption of operational changes by the Council to the operation of Libby and Hungry Horse reservoirs. Specifically, the Council and NOAA Fisheries have asked the members of the Independent Scientific Advisory Board to evaluate the Council's hypothesis on this issue, as well as a series of questions that have been posed by NOAA Fisheries.

The hypothesis the Council has asked the ISAB to address is the following, McConnaha said: that "...the proposed operations will significantly benefit listed and non-listed resident fish in the reservoirs, and in portions of the river below these reservoirs, without discernable effects on the survivals of juvenile and adult anadromous fish when compared with ordinary operations under Biological Opinions." In addition, said McConnaha, we are being asked to consider a series of four detailed questions from NOAA Fisheries, which Bob Lohn will speak to in a moment.

McConnaha described the procedures and "rules of engagement" for today's meeting. He then asked Montana Council member Ed Bartlett to make a few opening remarks.

Bartlett said he was here to represent the Chair of the Council, Judy Danielson, who is fogged in Boise. He said the role of the Council at this symposium is to listen. We are very pleased to see you all here; on behalf of the Council, I thank you very much for your willingness to help us answer the questions that have been posed. The Council's expectation is that this will be more than a review of the science; rather, we hope it leads to next steps – what do we do with this information, and which information gaps is it most crucial for us to address? Frankly, in my opinion, our hypothesis is a good one, Bartlett said; with your help, we can make it work and take the proper next steps in the region to answer the questions posed. He thanked Bob Lohn for his July 19 letter to Danielson; as most of you are aware, that's why we're here today, Bartlett

said.

McConnaha then introduced NOAA Fisheries Regional Administrator Bob Lohn. First, a bit of history, said Lohn – as most of you know, more than three decades ago, a correlation was observed between the level of flow when juveniles were moving down through the Snake and Columbia Rivers, and the ultimate survival of those fish to the adult stage when they returned. This gave rise to the flow/survival hypothesis. That hypothesis probably still retains a good deal of truth – we can see reasons why years of high flow generally correlate to higher adult returns. However, over time, one develops more sophistication in teasing out the difference between correlation and causation, and beginning to find out what other factors might be interwoven that could have an effect. As we look over flow/survival generally, if you include spring flows, you would see that those were correlated with years of higher spill. We know now that successful juvenile travel down through the system is critical, and that, absent the most recent technology, spill often provided the most successful survival, Lohn said.

Second, sometimes – though not always – years of high flow tend to coincide with weather conditions that produce better ocean conditions, Lohn continued. That’s something it’s good to recognize, he said, and certainly, since roughly 2000, we’ve been enjoying the benefits of those conditions. However, we need to acknowledge that running the Columbia River harder doesn’t necessarily change the weather, or translate into better ocean conditions, although system operations may have an effect in the estuary. Third, said Lohn, we recognize that flow itself is intertwined with three variables: velocity, temperature and turbidity. Recent work on the Lower Snake would indicate that, among the three, velocity isn’t always the most important element. All of those factors, then, lead us to the point of reconsidering these things, Lohn said – not reconsidering them in the sense that we will suddenly see the light and say that flow has no relationship to juvenile survival; I think it is well-established that it does. The goal is to be more precise in understanding what is driving that survival, so that we can deliver the benefits juveniles need, more articulately, more effectively and, one hopes, more efficiently – perhaps even at lower cost.

So how does this impact the Biological Opinion, and why does it matter? Lohn said. Is this one of those occasions in which the region argues about an issue, and while that may shape the issue, doesn’t really change practice? I would argue that this is quite the reverse; it is my strong intention that the results of this symposium have direct practical application in how we as a region operate the river, said Lohn. The current BiOp will be finalized on November 30, Lohn said. The basic structure, and the actions in the 2004 BiOp, are essentially unchanged. It is based primarily on a modeled approach, one that correlates all of the information we have on fish survival, and essentially models two conditions. One, the so-called “reference operation,” attempts to model the best operation for the survival of juvenile fish, without regard to other kinds of limitations, such as generating power, flood control and other needs. We know we can’t go to that extreme, Lohn said, but it provides a baseline for comparison. That results in what we call a gap, he explained; the federal agencies are defining mitigation that will help fill the gap.

The new BiOp is more specific than the last BiOp, mainly because, over the last 10 years, we have not been idle in gathering information, Lohn continued. While I wouldn’t say by any means that our model is perfect; however, I would say that it is a better description than we could

have had four or five years ago. The idea is to draw a picture of which things affect fish most.

A factor in that approach is the flow/survival relationship, Lohn said. In effect, the results are driven by a static spreadsheet that talks about how fish survive as they approach different dams under different conditions, as well as the passage routes available at each project. You see the differences when there is more and less spill, more and less turbine operation, etc. Another thing that drives these models is, how survival is affected by the flows themselves, he said. While for spring we have some reasonably good information, for summer, that information is less clear. Our intention is to take the information generated in this symposium and use it to inform our modeling effort, he said, adding that, in terms of time pressure, the BiOp will be revised on a yearly basis. We will use the science whenever it becomes available, Lohn said.

Something I face constantly in carrying out my tasks is recognizing that, as a representative of a federal agency, I am in the curious role of being a steward of a region whose resources are best cared for by the region itself, said Lohn. In the face of uncertainty or gridlock, it will fall to me to make this decision, and if necessary, I will make it, and we will defend it as appropriate. However, it would be infinitely preferable to draw upon the wisdom of the region, and in the event of scientific uncertainty, to draw upon the policy preferences of the region. That is, where the science is not clear, to listen to those who are empowered to opine on these subjects, and find out what they desire, Lohn said. I come here with a high respect for both the science represented at this table, as well as the policy wisdom of the Council, said Lohn.

Which brings us to the question, Lohn said. This summer, the Council's Mainstem Amendments posed a question we felt unable to answer: the Council appeared, in our interpretation, at least, to have adopted language that would have required real-time measurement within the river of the effects of a modest change in flow. After talking with our technical people, on a one-year, in-season basis, we didn't feel that we could assure the Council that we had instrumentation or models to detect that, instantaneously and within one year. It's a big river, and our ability to detect even flow effects within the river is limited. Our ability to determine the biological consequences of those flow effects for a class of outmigrating juveniles is even more limited, Lohn said. An in-year survival difference of 1% is simply something we don't have the tools to measure, at least not on a real-time basis, he said. However, the Council's hypothesis deserves to be pursued; that is why we asked them to convene this symposium. Our thought is that, even if we don't have the tools to measure this phenomenon in real time, empirically, within one year, could we nonetheless for a good scientific basis for anticipating these effects, then test that hypothesis?

Lohn then went through the four questions posed in his July 19 letter:

1. What is the "state of the science?" What information is available and applicable to this question? On which of these points is there consensus, and on which is there widespread disagreement?
2. Which of the attributes that are currently unknown or in general dispute are most important to decision-making about the hydrosystem? What kinds of further research are needed to resolve them?

3. Is there an experimental design, practical and feasible for implementation in the next water year, that would allow meaningful testing of the Council's hypothesis? If so, how would the experiment best be structured? This question interests me greatly, Lohn said.
4. In modeling projected effects of flow operations on listed and non-listed fish – especially in instances where empirical measurements are not available or not practical or feasible – what are the relative strengths and weaknesses of the available models? Is there credible scientific information indicating that certain models (and modeling assumptions) are likely to be more reliable than others?

A final comment on the uses of science, said Lohn – I think it is very important to maintain the distinction between policy and science. In separating these functions, there is great integrity. Today we want to understand the state and limitations of our current knowledge, and how we can best apply and use that knowledge. It is the function of science to tell us the limits of knowledge, Lohn said. It is also extremely important to be told what we do know, and how it might best be applied. What we know and what we don't know are equally important in today's discussion. Having bounded the uncertainty, it becomes a fertile area for policy decision-making. That is an area in which the advice of many is welcome, but because it is a place where much knowledge ceases, you are left to build a decision less on science and more on practical judgement as to how best to address and resolve that uncertainty. That's an area in which I would ask this group to cease its function, and turn matters over to the Council.

I hope this process is both challenging and liberating, said Lohn; it is a time when we can speak freely about what the state of our knowledge is, and what weight we should give to it. Thank you, very much, Lohn said.

2. Describe Alternative/Goals.

McConnaha briefly reviewed today's agenda. Dick Whitney then offered an ISAB response to Lohn's comments, noting that the ISAB is keenly aware of the distinction between science and policy. We recognize that our role is to identify the scientific facts – the best information available --something we've been doing since 1989, to NOAA, the Council and CRITFC, said Whitney. Those are the policy bodies we recognize, and to whom we will report, he said. The ISAB has been an example to all of us in handling many highly contentious issues with accuracy and integrity, said Lohn.

A. Amendment Description and Upriver Biological Effects. Jim Litchfield distributed copies of System Operational Request 2004 MT-2, the so-called "Montana SOR." He described the historical and policy background for this SOR, then went through a PowerPoint presentation, touching on the following major topics:

- Montana's objectives: implement the Council's mainstem recommendations for Libby and Hungry Horse; evaluate, to the extent possible the biological and physical effects of changes; provide improved ecosystem conditions in both rivers and reservoirs in Montana, minimize any potential impacts on fish in the Lower Columbia in driest water

years.

- Montana's SOR: intended to provide stable flows in Montana during July, August and September; draft Libby and Hungry Horse 20 feet from full by the end of September – driest 20th percentile years; adjust flows gradually in response to changes in actual flows; follow ramp rates and minimum flows for bull trout.
- Forecast BiOp flows on June 9 (graph)
- Forecast flat flows on June 9 (graph)
- Libby outflows – 2004 (graph)
- Hungry Horse outflows – 2004 (graph)

Litchfield then offered the following conclusions:

- The scientific issue is NOT the difference between survivals between flood and drought years!
- The questions for this symposium are focused on the feasibility of measuring flow changes in the Lower Columbia in the 1% to 5% range
- Physical changes in flow – over what period?
- Biological changes in reach survivals?

The question of whether or not there is a flow/survival relationship is much larger than the issue of whether or not the small change Montana's proposed operation would cause creates measurable impacts that are worthy of concern, Litchfield said. As a statistician, I am somewhat puzzled by this emphasis on measuring, said Dan Goodman. We know that there is an enormous amount of variation in smolt survival, driven by things other than flow – so much so that small changes in survival that are driven by flow are not going to be resolvable. We will not be able to separate out the signal from the background noise in an experiment that restricts itself to small perturbations and measures them over a small number of years – that's just not feasible, mathematically. It is absolutely guaranteed that these kinds of effects are not going to be measurable, Goodman said, but that doesn't mean that they aren't real. I think we should be focusing, instead, on whether we have evidence that there should be a real effect, on the average, in the long term, even if we can't measure it, relative to the noise in the short term. I'd appreciate any clarification you can offer, Goodman said.

McConnaha noted that the Council used the word “discernable,” rather than “measurable –“ there is some difference there. Tomorrow we will be trying to get into this question in the course of the discussion of the models and of experimental design. However, you raise an excellent point, one we should keep in mind over the next two days, said McConnaha.

Brian Marotz then provided a presentation titled “Monitoring the Effects of NPCC Mainstem Amendments on Resident Fish in Montana.” He touched on the following major points:

- Libby reservoir elevation through the year (graph)
- The effects of Libby drawdown (photo of shoreline)
- Alternative 1: flat flow of 12.5 Kcfs through August 31 (graph of reservoir outflow and

- elevation, April 1-Sept. 30)
- Alternative 2: steady decreasing flows from 16 Kcfs to 6 Kcfs (graph of reservoir outflow and elevation, April 1-September 30)
- Alternative 3: steady decreasing flows (graph of reservoir outflow and elevation, April 1-September 30)
- Alternative 4: flat flow at 10 Kcfs following the sturgeon pulse (graph of reservoir outflow and elevation, April 1-September 30)
- Alternative 5: double peak operation – sturgeon pulse followed by a drop to 7 Kcfs, followed by an increase to 14 Kcfs (graph of reservoir outflow and elevation, April 1-September 30).
- Primary production – Libby reservoir (bar graph) – lowest under Alternative 2, highest under Alternative
- Zooplankton production (bar graph)
- Benthic production – highest under Alternative 3; lowest under Alternative 5
- Kokanee growth (bar graph) – similar results under all five alternatives

Goodman noted that he was struck by the lack of error bounds in any of these graphs – we’re going to need to talk about that, he said. These results are from Montana biological model LRMOD, developed by Dr. Dan Gustafson, yourself, and a few other people Marotz replied. When it comes to the fish growth model, in the 1996 report, we determined that you would be compounding error at every trophic level, and by the time you get to fish growth, error bars would be meaningless. But because it’s a component model, you can see that each trophic level is responding logically. When we built the model, we used empirical data; we then got new data and verified the model. The components are acting reasonably. You do compound error when you get to fish growth, said Marotz; that was a major problem for us. If you use a model like this to rank alternatives, even if there is bias in the model, if you use the same model to look at all alternatives, you can nullify some of the error you’ve introduced, because you’ve put the same bias into each alternative you compare, without error bars. I don’t think it’s possible, said Marotz.

And what does the vertical axis represent? asked another participant. The total change in weight – annual growth, between Age 1 and Age 2 kokanee, Marotz replied – that’s why you don’t see much change. And which alternative is closest to hat the Council is proposing? McConnaha asked. Alternatives 1 and 4 are close, Marotz replied, although the types of adjustments you see in Alternatives 2 and 3 would probably be typical of natural conditions.

Moving on, Marotz touched on:

- Mean lower river flow, pre- and post-impoundment (graph)
- White sturgeon tiered flows, April-July (graph)
- Natural inflow to Libby reservoir (graph)
- Libby dam discharge through the year (graph)
- The Kootenai River subbasin (map) in the context of the river model Montana has developed, showing wetted perimeter vs. flow, over time – it takes substrate about 30 days to recover productivity once it is re-wetted.

- Daily discharge variability, before and after Libby Dam was built (graphs) – much higher daily variability now that the dam is in place, yielding a much wider varial zone in the river
- Discharge alternatives 1-5 (graph)
- Kootenai River benthic biomass units under each of the five alternatives (bar chart) – highest under Alternative 1, lowest under Alternative 5
- Kootenai River, 1989 – discharge vs. benthic biomass over time (graph)
- Bull trout (photo)

Marotz said short-term flow reductions must be avoided if possible; alternatives that minimize reservoir drawdown are preferable, as are operations that yield a flat outflow during the productive summer period. That's what we're after, said Marotz; the alternatives we've asked for yield just that result.

3. Questions and Clarification.

When you showed the before-and-after curve, said Whitney (“Mean lower river flow, pre- and post-impoundment”), it showed quite rapid fluctuations in the “before” portion – you said they were dependent on load following, but those fluctuations seemed to be more frequent than they were in the figure you showed later. Are you using a different time period in the second set of slides? Yes, Marotz replied – all of the alternatives I looked at were from 2004, and the time period we're looking at in the day-to-day change was a 10-year block of time before the dam was in place, and a 10-year block after. The reason I show that slide is to illustrate the fact that, before, you would see, flat, stable flows all summer, and you would only see a lot of daily variation during the spring freshet. During the summer, the varial zone was thinner. Now, because we're doing a lot of day-to-day operations, that produces a much wider varial zone during the summer.

So the curves that you and Jim Litchfield showed us are daily average flows that do not reflect the load following patterns? Chuck Coutant asked. Yes, Marotz replied – those are daily average flows. So when you're modeling “stable flow,” it really isn't stable flow within a day? Coutant asked. No – in fact, it could be an average, Marotz replied. Do we have daily load following around those curves that were being drawn? another ISAB participant asked. Most of the time, no, Marotz replied, but there was a period in September when we had a short-term fluctuation due to a mechanical problem that caused Libby outflow to drop to 1.7 Kcfs. If you looked at the daily average on that day, it wouldn't pick that up, he said.

Another question – do we have daily load following throughout the year? Coutant asked. Does the blue line reflect the daily average flow, or within-day load following? The BiOp ramp rates preclude hourly load following at Libby and Hungry Horse, said Tony Norris of Reclamation. However, you will see weekly ramping within the BiOp ramp rates; they'll drop a unit over the weekend, for example, and then bring it back up again on Monday. We follow the BiOp ramp rates for load following at those projects. How extreme are those? asked another ISAB participant. If you look at the ramp rates specified in the BiOp, it will give you an idea of the magnitude, Norris replied. Cathy Hlebechuk of the Corps' Reservoir Control Center said that,

in the early 1990s, in the winter, there were daily load shaping activities. Now we've started weekly shaping, with four units operating during the day and three at night. In September, when we dropped down to 1.7 Kcfs, that was in response to a transmission emergency. Normally we don't do any daily shaping, except in the winter, Hlebechuk said. And the ramp rates – are those a percentage of flow? asked another ISAB participant. No, Hlebechuk replied – from 4 Kcfs-6 Kcfs, the rate downward is about 500 cfs per day; from 6 Kcfs to 9 Kcfs, it's 1 Kcfs per day; from 10 Kcfs to 17 Kcfs it's slightly faster. The lower you get, the slower you can ramp down, but you can ramp upward more quickly, Hlebechuk explained.

What would be the effects of the stable flow alternative – Alternative 4 – on burbot in the Kootenai, compared to the existing double-peak operation? asked Pete Bisson. We focus on burbot during the winter, Marotz replied, keeping flows down. The flat flows we're talking about here would take place during the biologically productive summer months. In the winter, we end up with a double peak in reverse, because we're lowering flows and velocities to allow the burbot to move. Often, during that time, the operators are trying to evacuate water for flood control, so what happens is that we hurry up and get rid of as much water as possible before the low-flow period begins for burbot, then ramp flows up again once the low-flow period is past. Fortunately, it's not a very biologically productive period, so there is less impact than there would be if you saw a double peak during the summer, Marotz said. In the winter, the surface can go up or down, with very little effect on fish...

How does this operation change flows in the mainstem Columbia? asked Glenn Traeger. That's the next topic on the agenda, McConnaha replied. Briefly, said Marotz, when you release a big pulse of water from Montana, by the time it reaches the Montana border, and Kootenai Lake in British Columbia, which acts as a notched weir – the higher the elevation of the lake, the more water that can come out through Roman Narrows and Cora Lynn Dam – it flattens out the pulse. The same thing happens further downstream below Flathead. By the time that water reaches the mainstem, it's a very small difference – if you send 20 Kcfs downstream, by the time it reaches the mainstem, it measures about 6.8 Kcfs. Also, said Hlebechuk, Kootenai Lake operation is another consideration – depending on whether it is drafting or filling, that has a major impact on what happens in terms of water from Montana reaching the mainstem.

I'm getting some mixed signals between you and Mr. Litchfield, said Dave Statler – he expressed a preference for flat flows through the summer, while your productivity information seems to indicate a preference for an operation that would mimic a natural, receding hydrograph through the summer. Actually, I don't think there is disagreement between what Jim said and what I have said, Marotz replied – we worked on the proposal for a flat operation, which you see in the SOR. We knew, however, that there was a difference between modeled predictions and what's actually going to hit us, in terms of water delivery. We knew that when you have a model run that shows a flat flow of 10 Kcfs, by the time you actually get into that period of the year, and experience the actual flows, there would have to be some adjustments. The most important thing to remember, if you're going to make adjustments, is to make them one-directional, without a lot of adjustments up and down, to avoid detrimental impacts to the benthos. Is there a preference, biologically, over the summer, for a flat outflow, rather than for a naturally receding outflow? Statler asked. Yes, Marotz replied – we would prefer to see a flat flow, to maintain

biological production.

Do you have any idea of the relative primary productivity of that reach of the Kootenai, pre- and post-dam construction? Margaret Filardo asked. There is always going to be a tailwater effect below a reservoir like this, Marotz replied; both Libby and Hungry Horse do have a highly productive tailwater fishery because of the food that's entrained through the dam. As far as nutrients delivered to the system, there are studies that have looked at the relative productivity of the river, and it is well documented that the reservoirs become a nutrient sink. The net productivity of the river is reduced by the nutrient sink upstream, Marotz said.

4. Translating Changes In Flow to Changes in Velocity, Temperature.

A. Water Velocity. John Fazio led this presentation, titled "Libby and Hungry Horse Operation Under the Fish and Wildlife Program," which summarized the modeling he has done of the physical aspects of the Montana operation. He touched on the following major topics:

- Montana operation – October through June, July-September
- Caveats: this is a preliminary analysis; used observed inflows at Libby and Hungry Horse to calculate target flows, which yields an optimistic estimate; did not change constraints at any other project
- 50-year average end-of-month elevation at Libby, July-September, under the BiOp and Montana proposed operation (graph)
- 50-year average end-of-month elevation at Hungry Horse, July-September, under the BiOp and Montana proposed operation (graph)
- End-of-September elevation distribution at Libby under the BiOp and Montana proposed operations (graph)
- End-of-September elevation distribution at Hungry Horse under the BiOp and Montana proposed operations (graph)
- Summer flows at Libby – natural flows (graph)
- Summer flows at Libby – 2002 version of the BiOp (graph)
- Summer flows at Libby – 2004 version of the BiOp (graph)
- Summer flows at Libby – Montana operation (graph)
- Summer flows at Hungry Horse – natural flows (graph)
- Summer flows at Hungry Horse – 2002 version of the BiOp (graph)
- Summer flows at Hungry Horse – 2004 version of the BiOp (graph)
- Summer flows at Hungry Horse – Montana operation (graph)
- Average volume added to natural flow at Libby and Hungry Horse, July-September, under the BiOp and Montana operations (bar chart)
- 50-year average flows at Libby and Hungry Horse added together, BiOp vs. Montana operation (table)
- Major dams on the Columbia River (map)
- Lag time for reservoir action (hours) (map) – 91 hours from Hungry Horse to McNary, 60 hours from Libby to McNary
- 50-year average flow at McNary, BiOp vs. Montana operation (-8.3 Kcfs in July, -7 Kcfs

- on August 1, -5.6 Kcfs on August 2, +0.9 Kcfs in September
- Average change in flow, Montana operation vs. BiOp, system reaction (table)
- Average volume added to BiOp flows from Libby, Hungry Horse and the rest of the system (bar chart)
- Travel time from McNary – volume/flow method, flow and travel time (A surrogate for water particle travel time – +0.4, +0.5, +0.7 and -0.2 days, respectively, in July, August 1, August 2 and September (table)
- Fish travel time – PIT-tag information from DART – McNary to Bonneville for Snake River spring chinook (6.23 days), Mid-Columbia fall chinook (5.69 days) and Snake River fall chinook (6.03 days) (table)
- Approximate reservoir volumes (kaf) – Grand Coulee, Libby, Hungry Horse, Dworshak (table)
- Average end-of-month elevation at Grand Coulee, BiOp vs. Montana operation, July-September (bar chart)

I usually assume that there is more cooperation between what's going on at Grand Coulee and in Montana – are there operational changes that could happen at Grand Coulee that would improve the flow situation at McNary? asked Lyman MacDonald. Sure, Fazio replied – we could ask Grand Coulee to pass the water through. What would you do, operationally, to improve the situation? Lyman asked. In talking with NOAA Fisheries staff, Fazio replied, they have said that releasing the water sooner – prior to September – would provide greater biological benefit. Lohn asked about the need for cooperation from the Canadian projects; Fazio agreed that that would be a necessary component of such a change in operation.

What about the biological effects of the Montana operation on chum spawners below Bonneville in November and December? Coutant asked. I don't expect that the Montana operation would have a significant impact on chum spawning, Fazio replied.

I may be naive, but why did the BiOp ask for regulation of flow out of the Montana projects, rather than out of Grand Coulee? MacDonald asked. We take water out of Grand Coulee first, Fazio replied; there are years that we don't take flow augmentation from Libby and Hungry Horse at all. The answer to your question is that we could take a different approach, and draw water proportionally from all three projects, for example. If you change the rules in the BiOp, it would be possible to take more water out of Grand Coulee. Lohn noted that there are practical constraints, such as ferry operations, exposure of cultural resources and houseboat operations, that preclude the region's ability to use Grand Coulee as the "big bucket" for downstream flow augmentation. That has been looked at extensively by many parties in the region, Lohn said.

B. Temperature Modeling. Ben Cope of EPA described temperature modeling in a presentation titled "Available Models and Ability to Estimate Change." Cope touched on the following topics:

- The one-dimensional energy budget model (diagram)
- Stream cross-section, illustrating surface heat exchange processes (diagram)

- Boundaries and topology (diagram)
- One-dimensional temperature models – provide cross-sectional average temperature estimates (with sample data)
- Models used for the Columbia River studies – MASS1 (Battelle), RBM10 (EPA)
- Columbia Basin temperature monitoring sites (map)
- How to estimate incremental impacts – model is run on existing conditions of selected year (s), change one boundary condition – inflows
- Sample temperature data from the Clearwater River mouth through time, 1992
- Simulated and observed temperatures at Grand Coulee, 1990-1994 (graph)
- Error estimates for existing Columbia River models: RBM10 – mean difference = 0.04 degrees C; standard deviation 1.3 degrees C; MASS 1 – root mean square error = 0.59-1.52 degrees C
- Estimated water temperature impacts of various operational scenarios at Lower Granite Dam, June-October (graph)
- Will an action affect river temperature? Building an answer to the question (flow chart) – biologists define a significant temperature change, experts asked what is the likelihood that action will result in significant change; use RBM10 or MASS1 to examine changes in WA domain, extend RBM10 or MASS1 upstream to incorporate the entire system, test it and examine effects.

Cope noted that both models stop at the Canadian border, which means it is not possible to use the existing models to directly estimate the change in lower river temperatures caused by changes in operation at the Montana projects, although the models can develop indirect estimates of such impacts. Cope said one question he heard earlier this morning had to do with the idea of “measurable” vs. “discernable” change. From where I sit, the phrase I would use is “reasonably predictable,” in terms of modeling the effects of flow change on temperature, he said. It may not be measurable, he said, but the idea is that you would have confidence in the model. He asked whether there is an interest in researching temperature changes immediately below the projects where the operations are being changed. Finally, said Cope, when you talk about the “flattening” effect on flow changes as water releases proceed downstream, the same phenomenon applies to temperature effects.

McConnaha noted that, presumably, the effect of these flow changes on temperature will be largely with respect to travel time, given the fact that the gallon of water that is released from Montana will not be the same gallon of water once it reaches McNary. Cope replied that the temperature is going to be slightly different at the Canadian border, but the net effect, or difference, will not be zero.

You mainly talked about the change in temperature as you go down through the system, said Coutant – Chip’s question mainly focused on what’s happening within particular reaches, and the break coefficients across the boundary as a function of flow and travel time. That puts an incremental focus on it that is slightly different than what you presented to us. Given the kinds of flows John was talking about, are there going to be discernable differences in the increment between, say, McNary and John Day? If you change the flow at the boundary, the model is going to give you a slightly different answer, in terms of estimated temperature, Cope replied. Whether

that's an answer of great significance to you depends on your perspective. Travel time is captured within the model framework, and the change in flows Montana is proposing will change, ever so slightly, the geometry of the river, its surface heat budget, etc. For a river this size, the change will be very, very small. Getting back to the incremental thing, when we looked at the Columbia for the TMDL, one question was the influence of tributaries on mainstem temperatures – how much, for example, would you have to change the operation of the Yakima system in order to significantly change water temperatures in the mainstem Columbia? The answers are sometimes surprising, but in general, it is very difficult to effect a significant change in the temperature regime of a system the size of the Columbia.

Jim Adams discussed the Corps' WQAL model, which is being developed by Mike Schneider. It is unlikely that you would actually be able to see a measurable change in difference in water temperature at McNary as a result of a small change in operations at the Montana projects, said Adams.

You probably don't see much change in water temperature between McNary and Bonneville, observed Whitney. What usually happens between those projects? If you mean absent any flow augmentation, we see gradual temperature changes as you move downstream – fractions of a degree C, increasing through the summer and decreasing through the fall, Cope replied. We can run long-term simulations and show you how it works at each dam, if that would be useful, he said.

MacDonald asked about the coordination of flow augmentation among all of the storage reservoirs – what's the process for doing that coordination during the year? The BiOp sets certain constraints for both filling and drafting, Fazio replied; in general, the BiOp wants to see the storage reservoirs – Grand Coulee, Libby, Hungry Horse and Dworshak – as full as possible by early April, up to their flood control elevations, before the migration season begins. After that, there is a period of refill; under the BiOp, the goal is to refill the storage projects by June 30. Then, for Lower Columbia flows, Grand Coulee is drafted first, then Libby, then Hungry Horse, to their operational drafting limits, usually by August 31. The amount of water you get for flow augmentation is set for both the spring and summer periods; we attempt to refill the reservoirs by the end of June so that we have a full tank for the summer period. In the best case, we provide about 12 MAF from the reservoirs for flow augmentation; on the average, it's closer to 6 or 7 MAF.

Why don't we hear the same complaints from the State of Washington that we do from Montana? McDonald asked. We do hear them, Fazio replied – that's why the Mainstem Amendments specify a target retention time for Grand Coulee, to improve nutrient production in Lake Roosevelt. The same is also true for Dworshak in Idaho, added Roger Schiewe.

When you modeled the BiOp, did you take the augmentation out at a consistent rate in July and August? Filardo asked. The way we model the BiOp case is to calculate the volume of water above the draft limit on June 30 and distribute it consistently through July and August, replied Schiewe. Could you model the change in travel time under the BiOp case and Montana's proposed operation? Filardo asked. I don't think it would significantly change the travel time,

Schiewe replied, because the flow change would not be very large. Travel time would likely increase slightly under the Montana operation. Libby is a very complicated project, with conflicting demands between sturgeon and anadromous fish flow augmentation, added Hlebechuk – the fact that we release high flows for sturgeon in June, then go to minimum outflow to try to refill Libby by June 30, before ramping outflow back up for salmon flow augmentation in July and August, is what causes the double peak. When you modeled the sturgeon pulse and the anadromous flow augmentation, did you separate the two? Hlebechuk asked. Yes, Roger replied. Fazio added that Libby refills by the end of June in only about a quarter of the model runs.

We have spent a lot of time modeling flows and travel time, said Chuck Coutant – it would be nice to have some real data on velocities. Could you summarize what information is available on velocities, and who's collecting it? Velocities are not consistent across the cross-section of the river, so how can we calculate changes in velocity? What I think I heard was that no one is collecting that data, McConaha observed. It's the assumptions that kill you, said Coutant – we've spent decades studying this question, and my question is, why aren't we collecting the data that the fish are really responding to? If the fish are responding to changes in velocity, we ought to be measuring velocity and collecting that data. Ken Tiffan said the USGS is collecting that fish travel time, flow and water velocity data, at least on the Snake; much of it will be summarized in Billy Connor's presentation later today.

Chris Van Holmes from the University of Washington asked whether the effects of reservoir stratification and the differential effects of spill flow vs. powerhouse flow have been studied. Not specifically, Cope replied; the reason we use one-dimensional models in this case is because of the scale of this particular question. There are two-dimensional models, such as CEQUALW2, available, which can get at that question.

Marotz said he had seen a two-dimensional transect for McNary, correlated with for flow. If you assume that the shorelines are used for rearing, and not for migration, so you subtract out that part of the channel, and you assume that anything below 30 meters is too deep, because 85% of the fish move above that, those are very low-velocity zones, he said. That migrational "tube" was then measured at a range of flows, from high to low; I took a little wedge, and if you deduct 20 Kcfs in flow, dropping from 200 Kcfs to 180 Kcfs, it changed the average velocity within that fish travel "tube" by 1.3 cm/sec, Marotz said.

5. Status and Presence of Affected Anadromous Stocks.

A. Stock Status. John Stein of NOAA's Northwest Science Center provided a presentation on the status of the Columbia River chinook stocks. He touched on the following topics:

- Snake River wild chinook returns, 1962-2002 (graph)
- Climate, 1970-2003 – Pacific Decadal Oscillation, warm years vs. cool. Bottom line: ocean conditions in the north Pacific are extremely difficult to predict
- Temperature trends – Pacific Northwest – land temperatures have increased over the last

- century
- Precipitation trends – Pacific Northwest – decreasing over time
- Average mean flows – low flows, trend in flow since 1750, based on tree ring data (graphs) – severe droughts occur about every 50 years in the Northwest; it has been about 50 years since the last one
- Viable salmonid populations – partition the ESU into independent populations etc.
- Hierarchical criteria – ESA status, stratum status, population status, population attributes (flow chart)
- Lower Columbia chinook abundance, hatchery and wild, 1980-present (graph)
- Abundance of various populations – Coweeman fall, Kalama River spring, Lewis River fall – 1975-present (graphs)
- Lower Columbia chinook status, by population, vs. goals set by the Recovery Board (graph) – no populations are currently above the “moderate risk” status
- Status summary: no populations currently viable, all need considerable improvement
- Snake River fall chinook adult returns, hatchery and wild, 1962-present (graph)
- Abundance targets for various populations – Marsh, Minam, Imnaha (graphs)
- Snake River spring/summer chinook adult returns, 1962-present (graph)
- Interior Columbia spring/summer chinook – number of VSP impairments (map)
- Interior status summary – all populations have at least one, and most have multiple, VSP parameters to improve.

So your bottom line is that this proposed change in flow from the Montana reservoirs is worth worrying about? Coutant asked. Yes, Stein replied.

B. Fish Present in River at Key Index Sites. Filardo provided a presentation titled “Stocks Present in the Lower Columbia at Key Index Sites.” She touched on the following topics:

- Present tagging programs do not allow a precise breakdown, by stocks, of the population of subyearling chinook passing Lower Columbia dams in August. Our analysis of the presence of various stocks is based on PIT-tag passage data, hatchery release schedules and tributary trap collections.
- The 95% passage date at Lower Granite Dam for the run at large (hatchery and wild combined) and the wild PIT-tagged fish, 1994-2004 (table)
- Historic vs. 2004 subyearling passage at Lower Granite Dam (histogram)
- Snake River subyearling passage at Lower Monumental – 5%, 50% and 95%, 1994-2004 (table)
- Average subyearling chinook timing at McNary Dam (graph)
- Snake River basin wild fall chinook passage timing at McNary Dam, 1995-2004 (graph)
- From the December 15, 2003 memo “Juvenile Fish Passage in the Lower Columbia River in August – Washington Stocks:” PIT-tagged wild subyearling chinook from the Yakima Basin, Hanford Reach and Tucannon River have been detected at McNary, John Day and Bonneville Dams in August; PIT-tag subyearling chinook releases from Rock Island and Rocky Reach dams are a combination of hatchery and wild-origin fish and provide some of the largest numbers of detections at Lower Columbia dams during August

- PIT-tag detection data in the lower river during August indicate the presence of subyearling chinook marked in the Yakima Basin and in the Hanford Reach (there is no systematic marking of Hanford Reach wild subyearlings – only opportunistic marking), as well as Tucannon River-origin subyearlings. Fish from these systems have been detected at McNary, John Day and Bonneville during July and August. Large number of hatchery and wild subyearlings marked at Rock Island and Rocky Reach are also detected at the lower river projects at that time.
- Subyearling population index at McNary Dam for August 1992-2003 (table)
- Yakima River basin wild fall chinook passage timing at John Day Dam, 1998-2004 (graph)
- Hanford Reach wild fall chinook passage timing at John Day Dam, 1998-2004 (graph)
- Fall or unknown-race chinook from the Klickitat River trap, collections, 1996-2000 (table)
- Percentage of subyearling chinook migrants observed during August, Snake River, Yakima River, Hanford Reach, 1995-2004 (table)
- Travel times for subyearling chinook detected at McNary Dam in August, 1997-2003 (table)

Filardo then offered the following conclusions:

- The historic passage data indicates that a significant proportion of the summer migration is present in the Lower Columbia River in July and August; that proportion varies significantly from year to year in response to a number of factors, including, but not limited to, flow.
- The number of fish present at a given project is a function of operations at the projects upstream. The presence of juvenile fall chinook in the Lower Columbia and Snake rivers is largely a function of the transportation program. The efficacy of transporting juvenile fall chinook in the Lower Snake is currently under evaluation; if a spread-the-risk policy is adopted in the future, or if a greater emphasis is placed on in-river migration, significantly higher numbers of juvenile fall chinook will be present in the Lower Columbia during July and August.

Any idea why we're seeing the trend in timing reverses itself, from sooner to later, and now from later to sooner? Coutant asked. I couldn't even begin to speculate, Filardo replied, although it may be that the supplementation fish, which we're seeing more of in recent years, are larger and ready to move out sooner. However, the supplementation fish are not marked in such a way that we can't distinguish them from naturally produced fish? Goodman asked. A sub-portion of the supplementation fish are marked each year, Filardo replied; however, when those supplementation fish return to spawn, they do so as a part of the wild natural population. This has been going on for several generations, she added.

What proportion of the Snake River fall chinook are transported? McConnaha asked. Between 80 and 90 percent, Filardo replied. Can you identify what percentage of the stocks you mentioned as being present in the lower river during July and August are listed under the ESA? Litchfield asked. The Snake River and Clearwater stocks are listed, Filardo replied. The other

stocks are not listed for protection? Litchfield asked. Not yet, Filardo replied.

The data that shows an earlier timing of outmigration for subyearling Snake River fall chinook could be a function of the vast majority of those being Snake River PIT-tagged fish, and a lesser percentage of Clearwater-origin fish, said Statler. The Clearwater stocks, to my knowledge, show no such trend toward earlier migration timing. That's correct, Filardo replied – that's why the passage index for the run at large is always later than it is for PIT-tagged wild Snake River fall chinook.

We see adult return rates increase for fish migrating later, observed Russ Kiefer – one thing that would be helpful is not just the numbers, but the change in SARs across the season, from earlier outmigrants to later outmigrants. It could be that, though fewer fish are migrating later in the season, they are more valuable, because they return at a higher rate. Some of that information is available, said Filardo.

What are these fish doing during this period? McConnaha asked – are they feeding and growing? For the most part, they're actively migrating, Filardo replied; they're also eating and growing. I would be interested in knowing the effects of additional flow on returning adults, said another participant. If I could answer that question, I would love to do so, Filardo said – when you mark only 7,500 wild Snake River juvenile outmigrants, as we did this year, you don't get many adult returns. But that's the million-dollar question, she said.

Do you regard the apparent movement toward earlier subyearling migration since 2000 as coincidental with the regime shift, or in response to that? asked Bisson. We don't have any information on earlier regime shifts, so I don't know for sure, but the answer is, probably, to some extent, Filardo replied.

All of your information is based on the fish coming out of the Snake? another participant asked. The information I showed you was a combination of PIT-tagged fish out of the Snake, the Yakima, and the John Day, Filardo replied. We also have information on the PIT-tagged fish we release at Rock Island. Eric Merrill asked about the late-migrating subyearling fall chinook, and a comment he had heard to the effect that they are almost as large as yearling chinook. The later-migrating subyearlings from the Snake do get fairly large, Filardo replied. But those aren't naturally-produced fish? Merrill asked. Correct, Filardo replied – they rear above Lower Granite, but once they pass that project, they're moving through the system. But they're staying above Lower Granite for some time, rearing and growing, then migrating later, as opposed to fish that emerged later? Merrill asked. I don't necessarily know the answer to that, Filardo replied – all I can say is that, by the time they're detected downstream, their average size is larger.

6. Biological Responses to River Conditions and Flow Augmentation.

A. Downstream Migration and Juvenile Survival as Related to River Conditions. Billy Connor then provided a presentation on the effects of summer flow augmentation on the migratory behavior of and survival of Snake River juvenile fall chinook. One major concern is the detrimental temperature impacts of releases from Brownlee Reservoir and the Reclamation

projects if that water isn't released early enough in the season, Connor said. He touched on the following topics:

- The study's history
- The study's goals: relate actual discharge to water velocity, and relate water velocity to how the fish move downstream, using an acoustic Doppler current profiler to measure velocities at transects at three-kilometer intervals from Lower Granite to a point 90 river-miles upstream, over a wide range of discharges. Actively migrating fish were captured and radio-tagged at Lower Granite, transported back upstream and released. Their progress downstream was then monitored using fixed-array radio-tracking stations.
- Mean water velocity vs. distance from Lower Granite Dam (graph)
- Velocity vs. flow in various reaches of Lower Granite reservoir (graph), showing that, as flow increases, velocity increases
- Median fish travel rate vs. mean water velocity, Lower Granite reservoir, June and July, 2002 (graph), showing that, as velocity increases, fish travel rate increases
- Effects of flow on rate of travel through Lower Granite reservoir (table and cross-sectional velocity profiles), showing that the fish respond to increasing discharge, but that this effect diminishes as the fish approach the forebay

Connor then described his research into the effects of flow and travel time on survival. He touched on:

- Migration timing, flow and temperature in Lower Granite reservoir, by cohort (histogram)
- Survival and temperature, 1998-2003
- Survival and flow, 1998-2003
- Survival and fork length at tagging (1998-2003) (graphs)
- The best model for predicting survival, by factor (temperature, fork length and flow) (table)
- Flow and temperature with and without flow augmentation (graph)
- Estimated increases in survival with augmentation, by cohort – up to 19.2% (histogram)
- Estimated changes in survival of Cohort 4 in 2002, by scenario (histogram)
- Predicted result of incremental decreases in flow augmentation – down by 17 % with no summer flow augmentation (graph)
- Points relevant to this symposium: incremental decreases in flow decrease velocity, which decreases rate of travel, especially in upper reservoir reaches, but to a much lower extent in forebays; incremental decreases in flow (hence velocity) accompanied by incremental increases in temperature likely reduce survival.

Tom Berggren then described his research on subyearling chinook travel time and reach survival in the Lower Columbia River. His presentation touched on the following topics:

- Introduction – the Montana Plan shifts 10 Kcfs from August into September, in the Columbia; does a 10 Kcfs reduction in Columbia River flow in August have negative impacts on subyearling chinook still migrating downstream toward the estuary in

August? Data on subyearling chinook PIT-tagged and released at Rock Island Dam for the FPC's smolt monitoring program provide evidence that flow reduction in August is not a good idea since negative impacts to subyearling chinook may occur

- Topics of discussion – August flows indexed at McNary, travel time of PIT-tagged subyearling chinook from McNary to Bonneville in August, etc.
- August McNary flows, 1964-2004 (graph)
- July-August McNary flows (July-August flows are becoming more similar now) (graph)
- Subyearling chinook travel time, McNary to Bonneville, 1997-2004 – travel times are significantly faster when BiOp-level flows are provided, significantly slower when flows are lower, as in 2001 (bar chart)
- July 1-August 15 Priest Rapids flows, 1998-2004 (graph)
- Yearling chinook travel time, Rock Island to McNary, 1998-2004 – travel times significantly faster when flows are higher, significantly slower when flows are less (bar chart)
- Yearling chinook mortality is higher in August (graph) – survival drops over the season in all years, but the worst impacts occur in lower-flow years
- Yearling chinook survival, Rock Island-McNary, 1995-2004 – July releases = higher survival with higher flows (bar chart)
- Yearling chinook survival to flow relationship estimated Rock Island-McNary survival vs. average flow at Priest Rapids (histogram) – for July releases, Rock Island to McNary survival rates increase with flow.

Berggren then offered the following conclusions:

- Recent August flows at McNary have receded to pre-BiOp levels
- Travel time trends may be confounded by increasing mortality over the season
- Reach survival is higher with better flows
- There is a significant ($P=0.078$) survival/flow relationship
- Removing 10 Kcfs from the Lower Columbia in August would likely have negative impacts on survival.

Can you talk about why you wouldn't want to use your regression to predict an effect? asked Goodman. You could develop a rough prediction, but ideally you would like to see the data tighter around a predictive equation, if you're going to actually use this for predictive purposes. There is enough noise – there is more going on than just flow to impact survival – that it would be difficult to predict a numerical response under a given flow regime, Berggren replied. The point is that, if fish respond to flow, and you're removing flow at a time when flows are already lower than, ideally, they should be, that's the worst time to reduce flows. So your misgivings have to do with the scatter, or low R-squared? Goodman. A lot of it has to do with the scatter, Berggren replied; it wasn't really created with the idea that it would be used as a predictive equation. Even within the years, you get this year decrease. The reason I chose to focus on the July releases was so that, at least, within each year, we have good continuous representation, from year to year. Your July releases are passing through the area in August? Coutant asked. They will be present throughout that entire period, yes, Berggren replied. If you're uncomfortable with using this equation as a predictive tool, are you at least confident as

far as the direction of change? McConnaha asked. Yes, Berggren replied – survival will be lower at lower flows. And do you feel that the scatter around your regression line is consistent with the error bars around the points? Goodman asked. Yes, Berggren replied, although ideally you'd like more years, if you were going to be using this for predictive purposes. And would you feel comfortable leaving us a table of the numbers – the estimate and standard error estimate for each of those years? Goodman asked. Yes, replied Berggren – I'd be happy to send that to you. MacDonald suggested that, as a follow-up, Berggren might consider developing a regression with the data points weighted by the inverse of the variance or standard area, putting a confidence interval around the red line and deleting the other bars.

Next, Steve Smith provided a presentation titled “Fall Chinook Salmon – Lower Snake River and Columbia River.” He touched on the following topics:

- Lower Snake River fall chinook – wild and reared at Lyons Ferry Hatchery, detected at Lower Granite and returned to the river, weekly pooled groups, survival and travel time between Lower Granite and Lower Monumental dams, “exposure index” based on Lower Monumental passage timing (mean, during middle 50% of passage), 1995-2001, typically June 8-August 16
- No estimates for 2002 (poor fish quality); flow/travel time/survival analysis not updated for 2003-2004
- Survival estimates are really joint probability of migrating as subyearlings and surviving; the analysis does not account for “holdovers.”
- River conditions at Lower Granite Dam, 1995-2001 (clarity, temperature and flow) (graphs)
- Lower Snake River – median travel time vs. date at Lower Granite Dam, 1995-2001 (graph)
- Lower Snake River – estimated survival vs. date at Lower Granite, 1995-2002 (graph)
- Lower Snake River – median travel time, Lower Granite-Little Goose, vs. river indices, 1995-2001 (indices)

Smith offered the following conclusions for the Lower Snake:

- Definitive conclusions are not possible
- Sparse, highly-variable data
- Interactions between extreme flow conditions and life-history traits (1997, 2001)?
- Migration rate increases as fish move downstream

Moving on to the Lower Columbia River, Smith touched on the following topics:

- Run-of-river fish collected and tagged at McNary
- Mostly Hanford Reach, a few hatchery
- Weekly pooled groups
- Survival and travel time between McNary and John Day Dams
- “Exposure index” based on McNary dates and John Day passage timing (mean during release and during middle 50% of passage, respectively)

- 1999-2002, typically June 19-July 30
- River conditions at McNary Dam, 1999-2002 – water clarity, flow, spill, temperature (graphs)
- River conditions at John Day Dam, 1999-2002 (graphs)
- Median travel time vs. river conditions, 1999-2002 (graphs)
- Estimated survival vs. river conditions, 1999, 2001, 2002 (graphs)

Smith then offered the following conclusions from his study of the Lower Columbia River:

- Definitive conclusions are not possible
- Sparse, highly-variable data
- Can't discern the effects of conditions from generalized year effects
- Tentative conclusions from the Tech Memo include: travel time likely depended on water velocity; flow had larger incremental effect at low flows than at high; travel time may affect survival, due to predation, there is a possible threshold temperature of about 20 degrees C.

Goodman noted that, if he was a betting man, he would bet on the upper left-hand regression on the Lower Columbia estimated survival vs. river conditions page. Also, he said, with respect to your conclusion that travel time may affect survival due to predation, why does it have to be predation? If mortality occurs at a constant rate over time, the more time that elapses, the more fish die, particularly at higher temperatures. I guess I probably should have said “possibly predation,” Smith replied. He also offered a bar chart showing smolt-to-adult return rates for fish marked above Lyons Ferry and returning in 2001 and 2002. He noted that the highest SARs are found among non-detected fish and fish that were not detected in their first year after tagging, which appeared to overwinter, and were then detected in the second year after they were tagged. We're starting to get some adult return data that suggests higher adult returns from later migrants, Smith added; that work is not yet complete, but it is interesting.

B. Reservoir-Type Fall Chinook Salmon: An Exception to the Rules. Connor led this presentation, titled “Investigating Passage of ESA-Listed Juvenile Fall Chinook Salmon at Lower Granite Dam During Winter When the Fish Bypass System Is Not Operated,” touching on the following major topics:

- Results of analyses on juveniles – ocean-type (smaller) and reservoir-type (significantly larger)
- Scale pattern analysis (samples)
- Adult collection – collected adults at Lower Granite Dam, 1998-2003; sampled scales, measured fork length and estimated gender
- Results of analyses on wild adults (6 return years representing 11 brood years) – percentage of returning adults vs. brood year, 1993-2001 (bar chart)
- Results of analyses on hatchery adults (6 return years representing 10 brood years) – percentage of returning adults vs. brood year (1994-2001) (bar chart)
- Gender composition was independent of juvenile life history type, whereas age

- composition was dependent on juvenile life-history type (e.g. – wild males) (table)
- Size composition was dependent on juvenile life-history type – fork length vs. age at return (histogram)
- Conclusions: there is no typical juvenile life-history type for fall chinook salmon in the Snake River basin; rather, two alternatives – namely, ocean-type and reservoir-type; both of these alternative juvenile life histories are important to the recovery of fall chinook salmon in the Snake River basin; very little is known about reservoir-type juveniles
- Speculative details on ocean-type juveniles: discontinuous shoreline rearing; rapid dispersal into Lower Granite reservoir; discontinuous downstream dispersal
- Example of an actively-migrating radio-tagged juvenile fall chinook salmon (map)
- Observed rates of seaward movement for wild ocean-type subyearlings PIT-tagged in the Snake River in 2003 (graph)
- What determines life-history type? Probability of becoming reservoir-type vs. passage date at Lower Granite, Little Goose and Lower Monumental (graph)
- Speculative details on reservoir-type juveniles: discontinuous shoreline rearing, rapid dispersal into Lower Granite reservoir, discontinuous downstream dispersal, disrupted/delayed seaward movement, discontinuous downstream dispersal, active seaward movement as yearlings
- Example of an inactively-migrating radio-tagged juvenile fall chinook salmon (map)
- Median fish travel rate vs. mean water velocity (graph)
- When do reservoir-type juveniles pass the dams (various graphs and diagrams)
- Juvenile detection histories of adults that were PIT-tagged as juveniles, percentage detected and never detected vs. detection history
- 1996 releases – number of detections vs. date of 1997 passage, Lower granite to Bonneville (graph)
- Observations on releases of PIT-tagged hatchery fall chinook salmon subyearlings
- SARs estimated Lower Granite to Lower Granite (transported: 0.51; bypassed, 0.56; known reservoir-types, 1.35; never detected?)

Connor then posed the following management and research questions:

- Which are the primary reservoirs used by reservoir-type juvenile fall chinook?
- What is the passage timing of reservoir-type juvenile fall chinook in reservoirs?
- How abundant are reservoir-type juvenile fall chinook? (Preliminary estimates: 13% to 39% for the Snake River, 1998-2003)
- How much turbine mortality occurs during winter passage at dams?
- How does flow augmentation, spill, etc. influence the prevalence of reservoir-type juveniles?

Connor noted that the SARs for known the reservoir-type Snake River fall chinook are roughly 2.5 times higher than the SARs of subyearlings that were transported or bypassed. The fish that were never detected make up the largest portion of the adult returns in a given year; however, because we don't know how many of those fish there were to start with, we can't calculate their SAR, Connor said.

Given these ratios in the SARs, a reasonably high percentage of Snake River fall chinook are choosing this life-history, which means that our estimates of in-river survival don't mean a thing, Goodman observed. I'm not sure we can say that yet, Connor replied. You are familiar with our cohort analysis; the fish in the later-migrating cohorts are the ones that will become reservoir-type subyearlings, in all likelihood. If survival decreases as temperatures increase, then those later cohorts are surviving at a lower rate. In reality, I think that what we'll see is that the relationship is not going to go away, but the slope is going to change, Connor said. He added that size and the migration timing of the reservoir-type subyearlings probably facilitates higher survival to the sea.

If we're seeing SARs on the order of two and a half times higher for reservoir-type subyearlings, yet the actual number of returning adults is split approximately 50-50 between fish that began life as reservoir-type and ocean-type fish, that tells me that a reasonably high fraction of those fish are choosing the reservoir-type life history, said Goodman. If they are leaving the screen while you develop your survival estimates, that's a pretty big hole. It's a hole, Connor agreed; it is something we need to investigate further. We have done some preliminary estimates that suggest that, from 1998 to 2003, between 13% and 39% of the Snake River subyearling fall chinook that survived adopted the reservoir-type life history. You're absolutely right when you say that, in the case of that 39% estimate, if 30% of those fish were undetected, for whatever reason, our survival estimates could be meaningless, Connor said. That's why Steve always refers to it as "the probability of surviving and migrating as subyearlings." It's a big issue, and we don't really have a handle on it at this point, said Connor.

What we really need is a combined survival estimate for the entire cohort, Whitney observed. Do you see a shift toward this more successful life-history type? McConnaha asked. I think we'll continue to see both, but the percentage will vary considerably from year to year, Connor replied – I wouldn't say that one or the other is taking over. One thing this does say is that, as we're splitting hairs based on models of a small change in flow, on this hand, we have a very large difference we have to reconcile, said Coutant. Connor agreed, noting that the paper he and his research partners are in the process of publishing concludes that summer flow augmentation has enabled, or at least enhanced, the ability of fall chinook to adopt the reservoir-type life history. In the Snake River especially, temperatures can exceed 25 degrees C in late summer, and without that thermal refuge, those fish would likely have left the reservoir. The bottom line is that we do believe that flow augmentation plays a role in the reservoir-type life history, Connor said.

Coutant said Ben Cope had made the point that it is up to the biologists to decide what temperature threshold is important. In this case, Coutant said, the temperatures we're seeing both spatially and temporally make a significant difference. He observed that the 0.2-degree difference that was predicted from increased flow out of Brownlee could be very important to the reservoir-type fall chinook – in other words, this may be more of a temperature story than it is a flow story. Connor said he supports the September release of cold water from Dworshak, for exactly this reason – to protect the reservoir-type fall chinook in Lower Granite reservoir from the "rebound effect" that comes from ending Dworshak flow augmentation on August 31.

The SAR data you showed was based on PIT-tag data collected from 1994 to 2000, excluding 1999? another participant asked. That's correct, Connor replied. That data was collected, then during a period of fairly significant El Niño effects? the participant asked. Correct, Connor replied. I hope, then, that you plan to continue to collect those data, since conditions have shifted somewhat in the interim, the participant suggested. We do propose to continue to collect scales, said Connor.

Do we see anything like this in the Columbia? McConnaha asked. In the context of the Montana proposal, can you extrapolate anything from your work that might apply to the Columbia? Just that, to the extent that they might help lower temperature, higher flows would probably be beneficial, Connor replied; however, for this life-history type, flow is less important, because those fish don't want to outmigrate at that time. Various participants noted that reservoir-type subyearlings are found in the Upper Columbia.

With respect to regression, and estimating a date at which fish later in the season would decide not to smolt or not to outmigrate, that's probably a valid observation in terms of migration speed, said Statler. However, while those fish might not be migrating as fast, they would probably still be exhibiting the characteristics of the fall chinook, migrating downstream and feeding as they go. It may not be as simple as, they simply stopped migrating – these fish are found at various levels downstream. However, because the collection facilities at the dams are not operating at that time, we don't know much about what those fish are doing, Statler said.

I was confused, through all three presentations, about the time periods at which fish were being measured, said Litchfield – sometimes it was June and July, sometimes it was July and August, and I didn't hear anything about September. I'm also having trouble linking any of this up to the proposed flow changes. All Montana is proposing is a shift in the timing of the delivery of the same volume of water that would normally be delivered in July, August and September, he said; however, it would be released at a flat rate following the sturgeon pulse. Do you see any significant biological impacts if Montana provides the same volume it normally would, but spreads the delivery evenly over the three months, rather than providing the bulk of the flow in August? Litchfield asked.

None of us were trying to analyze the effects of the Montana proposal, specifically, Smith replied. There is no data on Snake River subyearlings migrating through that reach in September, except perhaps the travel time stuff I showed. Most of the run-of-river fish would be out of the McNary-John Day reach before September, Smith said. As far as trying to assess the impacts of Montana's proposed flow changes, I would be comfortable using some of the regression relationships I've developed to at least get an idea of the differences you might expect to see in travel time and survival. They would at least give you some idea, said Smith. We heard earlier that the Montana proposal might result in a velocity reduction of 0.6 cm/sec in the lower river; if that's correct, and my calculations are correct, that would increase the normal 6-day travel time for Snake River fish from McNary to Bonneville by 2.4 hours, Smith said.

Have you seen an increase, over time, in the percentage of fall chinook choosing the reservoir life-history type? Chuck Pevin asked. No – the percentage has varied from year to year,

Connor replied. Pevin noted that, in the Upper Columbia, during the 1990s, researchers have noted an increase in the percentage of reservoir-type fish; it's possible that we're witnessing an adaptation to the reservoirs that might ultimately be beneficial to the fish.

How much of this change is due to natural selection? MacDonald asked. Also, would we be better off to maintain as consistent an environment as we can in the reservoir systems, to see if fish have enough genetic elasticity to do their thing? In our paper, we took the position that this life history was evidence for some adaptation to the changes in habitat, Connor replied. With respect to your first question, I would suggest that you ask Dr. Goodman how many generations it would take for that sort of evolutionary shift to occur.

What fraction of the fall chinook have been transported in recent years? Goodman asked. By the time they reach the Lower Monumental tailrace, it ranges between 90% and 96%, Connor replied. That being the case, said Goodman, I believe transportation is going to foreclose the option of the reservoir-type life history for that individual, said Goodman. If we're imposing a 90% tax on that life history through transportation, and that life history is still producing 50% of our returning adults, I believe that's telling us that that life history has an overwhelming advantage. One caveat, said Connor – we can't determine, through scale pattern analysis, whether or not these fish overwintered in fresh water downstream of Bonneville. It could be that some of the adults we're counting as reservoir-type simply didn't migrate once they were released from the barge. Otherwise, I see your point, said Connor. We also see very high SARs on the fish we transport late in the season, added Bill Muir, so it may be as much a factor of fish size and migration timing as it is what you do with them, management-wise.

One misconception, said Kiefer – I see people looking at these SARs and concluding that a yearling fish is three times as likely to survive as a subyearling fish. In reality, we don't know the mortality rate on those yearling fish from April, as age 0 fish, to April of the following year, when they outmigrate as yearlings. We don't really know whether having a smaller number of fish outmigrate as yearlings is actually improving adult return rates compared to having a larger number of fish outmigrate as subyearlings, even if their SARs are lower, he said. The group discussed the feasibility of extrapolating the subyearling-to-yearling mortality rate using PIT-tag data from fish tagged as subyearlings; Smith noted that, at least at present, the sample size simply isn't large enough to support a scientifically-valid study.

I would still like someone to clarify for me the flow augmentation operation out of the various storage reservoirs, including Grand Coulee, said MacDonald, and how those releases are coordinated. I don't know why Grand Coulee is drafted first, for example, he said. That's a very complex subject, said McConnaha; he suggested that John Fazio be asked to address it directly with the ISAB some time after this symposium.

McConnaha noted that one of the things the NOAA Fisheries letter specifically asked was, what are the points of agreement on the science? He said some of the areas that he took away from today's session as points of consensus include:

- The predictive power of making incremental changes is pretty low – everything has small

sample sizes and large error bars, and our ability to make incremental predictions is fairly low Goodman said he disagrees with this point

- Although the predictive power of small increments may be low, it appears that in the Snake, the Mid-Columbia and the Lower Columbia, water velocity does impact fish migration speed. In general, higher velocities lead to shorter travel times and more rapid downstream migration.
- Travel time decreases – the fish move faster – the farther the fish move downstream
- There is a flow effect, with lower survival generally associated with lower flow. However, the lower survivals seen at lower flows may actually reflect the conversion of some of those fish to a reservoir-type life history, rather than mortality, so we don't really know how accurate those survival estimates are, Goodman observed.
- Temperature decreases survival, and the time-tested 20-degree C threshold, above which survival begins to drop, still appears to be valid
- The new information on reservoir life history may make many existing survival estimates inaccurate.
- We don't yet have the data in hand to resolve the impacts of the reservoir-type life history; this would indicate that the mechanisms currently in use are inadequate to deliver the data we need. A different design will be needed to resolve this issue (Goodman).

McConnaha encouraged the other symposium participants to consider the question of consensus conclusions.

C. Delayed Effects on Outmigrants. Jim Congleton of the University of Idaho led a presentation on his field studies of the delayed effects of the hydrosystem (physiological changes) on migrating juvenile spring/summer and fall chinook. Among his major topics (for spring/summer chinook):

- The study's hypothesis: Snake River salmonids are adapted to conditions that are very different than the conditions in the present-day migration corridor; what used to be a two to three-week migration to the sea now takes seven to eight weeks, on average.
- Spring/summer chinook do not residualize, and feed little on their way downstream, in contrast to fall chinook migrants. Spring/summer chinook metabolize their carbohydrate and lipid reserves, and sometimes their protein reserves, during migration. Any metabolization of protein reserves (e.g. – muscle) performance capabilities may be compromised.
- Mitigating factors: availability of food en route and the degree to which fish use it
- Study background and methodology: PIT-tagged Comparative Survival Study (CSS) fish from Dworshak, Rapid River and McCall hatcheries are used; study began in 1998; fish are diverted at Lower Granite and Bonneville dams to obtain samples at 6-7 day intervals for springs, 10-12 days for falls. Sample fish are assessed for energy reserves, blood chemistry and other physiological indices over the season.
- Field study body composition data – length vs. lipid mass
- Travel time vs. lipid reserve data (McCall fish)
- Lipid mass for McCall, Rapid River and Dworshak fish at Lower Granite and at Bonneville, 1999-2003 – the fish use up to 72% of their lipid mass by the time they reach

Bonneville

- Protein mass for McCall, Rapid River and Dworshak fish at Lower Granite and at Bonneville, 1999-2003 – the fish use up to 21% of their protein mass by the time they reach Bonneville
- Field study conclusions: lipid reserves were depleted the earliest, and to the greatest extent, in the lowest-flow years; the rate of protein use increased once lipids were depleted, and was greatest in 2001.
- Lab study swim test results: fish captured at Lower Granite; one group fasted, one was fed; nutritional indices monitored after two, three and four weeks.
- Unfed fish lost weight, while the fed fish gained weight
- Blood chemistry results: plasma total protein responded consistently to food intake; declined by half in fish deprived of food for four weeks; plasma alkaline phosphatase is the one variable that responds quickly to food intake.
- Lab data vs. field data: condition factor higher in unfed lab fish than in the fish reaching Bonneville Dam; migrating fish obviously use more energy than lab fish; body lipid mass also declined more in the migrating fish than in the unfed lab fish; plasma total protein was similar between unfed lab fish and migrating fish; plasma alkaline phosphatase was higher in the migrating fish than it was in the unfed lab fish, which implies that the migrating fish were feeding to some degree.
- Conclusions: some nutritional indices declined to an even greater degree in migrating fish than in fish fasted for a month in the laboratory, suggesting limited food intake in the migrating fish; data did not suggest that food intake increased in warmer, lower-flow years.
- Swimming performance and saltwater challenge results
- Mean time to fatigue in fixed-velocity swimming test, 2001 and 2002 (the Dworshak fish fared worst)
- Gill Na⁺, K⁺ -ATPASE activities in migrating fish captured at Lower Granite Dam (graphs)
- Overall conclusions – blood chemistry indices indicated low rates of food consumption by migrating fish; depletion of lipid and protein reserves did not seem to be counteracted by increased food availability later in the season; depletion of energy reserves would be most likely to affect survival for later-migrating fish.

Congleton then moved on to results from his fall chinook field studies. He touched on the following points:

- Temperature, fork length and condition factor of 0-age chinook salmon passing Lower Granite dam, 2000-2003 (graphs) – good growth in warmer years, less in cooler; no apparent drop in condition factor during migration; there appear to be two life-history types; lipid reserves of migrating fish are depleted, as in spring/summer chinook
- Gill Na⁺, K⁺ -ATPASE activities in migrating fish captured at Lower Granite Dam, 2000-2003 (graphs)
- Summary: lipid reserves of 0-age chinook salmon that migrated through the hydropower system in early summer, 2002, were depleted, but protein reserves were maintained; gill Na⁺, K⁺ -ATPASE activities were higher in 2002, an intermediate temperature and flow

year (there was more)

I like what you've done, but can you summarize the relevance of your work to the operational choice we've been asked to consider? Coutant asked. I'm not sure how it fits, but based on this data, fish that remain in Lower Granite, throughout the summer, seem to be doing well physiologically, Congleton replied. The fall chinook that migrate don't seem to be as affected, in terms of depletion of energy reserves, as the spring chinook salmon we looked at a few weeks earlier, at least in 2002 – they seem to be different from spring chinook salmon, and may be feeding more along the way. How did you arrive at your suggestion that later-migrating fish don't make it to Bonneville? asked Whitney. I didn't say that, Congleton replied – I think what I said is that those fish don't appear to be moving.

Have you looked at any wild fish? asked Pete Bisson. We have looked at some wild spring chinook, Congleton replied; they do seem to feed better, and maintain their protein reserves better, than the hatchery fish.

Jeff Yanke then led a presentation titled “Temperature-Dependent Survival, Growth and Physiology of Juvenile Snake River Fall Chinook Salmon.” Among the highlights:

- Historic and current spawning areas – the construction of Hells Canyon Dam blocked the most productive fall chinook spawning areas
- Delays in life-history events – production has been shifted to the margins of historical range, to areas of lower-growth opportunity; Hells Canyon smolts typically migrate later; the reservoir system delays outmigration
- Juvenile survival – 1998-2003 (survival vs. mean daily water temperatures at Lower Granite (graph))
- Primary research interest: evaluate temperature effects on juvenile survival and growth in a laboratory setting
- Study methodology/experimental design, using Lyons Ferry hatchery stock and three temperature treatments
- Sampling: temperature acclimation, experimental samples (bi-weekly and weekly), recorded and examined mortalities; random subset of fish removed from each tank; each fish bled from caudal artery.
- Survival at 16 degrees and 20 degrees – more than 99% of fish survived
- Survival at 24 degrees – fish began to decline after about 30 days in 2002 and 2003; no detrimental impacts seen in 2004
- Survival at 28 degrees – fish began to die as soon as temperatures reached 26 degrees
- Growth rate – rapid and steady growth seen; fish grew best at 20 degrees C
- Physiology – blood chemistry analyzed for 18 different metrics as a surrogate for condition factor
- Factor analysis – partitions highly-correlated variables into smaller groupings called “factors; factor scores are then created for quantitative analysis. Factor 1 (the “nutritional” factor) includes cholesterol, calcium, total protein, etc. Factor 2 included a variety of body enzymes.
- Factor 1: nutritional status (bar chart) – fish in the 16 degree and 20-degree treatment

- groups did well; fish in the 24-degree group declined
- Factor 2: Tissue damage
- Preliminary conclusions: 26 degrees is lethal to chinook; exposure to temperatures above 24 degrees is detrimental; the research supports the 20-degree C tailrace water temperature threshold. Factor analysis appears useful for analyzing a large blood plasma dataset. In terms of temperature effects on physiology, the research indicates that exposure to temperatures above 24 degrees has a detrimental impact, physiologically.

In response to a question from Coutant, Yanke said the research indicates that fish seem to do all right at 20 degrees C, but begin to be detrimentally impacted once the temperature hits 24 degrees. Where the real threshold lies, we don't know at this point, he said, noting that 2004 was the last year of his study.

Bruce Suzumoto noted that, from an operational perspective, it might be useful to use Congleton's work and Billy Connor's to look at the question of when reservoir-type fall chinook begin to predominate over ocean-type subyearlings, in order to optimize operational strategies such as flow augmentation, spill and transport through a greater understanding of when these activities would produce the greatest benefit. It may be possible to do that in the future, Congleton observed.

D. Adult Passage. Chris Peery led a presentation titled "Effects of Summer Flow Reductions in the Upper Columbia on Adult Salmonid Migrants." He noted that this research was begun by Ted Bjornn some years ago, so there is a fair amount of data available. Among the highlights:

- Question: what impacts will shifting Columbia River flow from summer to fall have on adult salmon and steelhead migrants?
- Area of concern: Mid- and Lower Columbia River
- Stocks of concern: sockeye, summer and fall chinook, steelhead, Pacific lamprey
- Considerations: Direct and indirect effects from changes in flow and temperature
- Historical and recent flow, spill and temperature patterns at McNary Dam (graphs)
- What stocks will be affected most? 10-year average counts at McNary for chinook, steelhead, sockeye and coho, shad and Pacific lamprey (graphs)
- Higher flow slows adult passage time, retards run timing, and reduces survival in the system – days to pass from Bonneville vs. mean flow in April and May; median date vs. mean discharge at dams (graphs)
- Spring/summer chinook, downstream release – multiple-reach escapement vs. mean flow at Bonneville, April-July (graph)
- Temperature: spring/summer chinook: passage rates faster with warmer water up to 19 degrees C; for steelhead and fall chinook: passage rates slower, with straying higher in warmer water (graphs)

Peery offered the following summary of his work on adult migrants:

- Lower flow correlated with faster travel times and higher survival

- Lower flow correlated with warmer water temperatures
- Warmer water correlated with faster travel times for spring and early summer chinook salmon, and slower travel times, increased straying, and lower survival for steelhead, fall chinook and sockeye
- Indirect effects on energetics and gamete development are unknown
- As flow is reduced, the proportion of juveniles transported will increase – potentially lower survival and more fish barged as a result?

Peery also touched on future research needs:

- Delayed effects of summer flow reductions on reproductive potential (pre-spawn mortality, gamete quality)
- Rearing conditions in the Hanford Reach
- Potential changes to spill, bypass, transported fish proportions.

Have you done any work targeting the actual flow change we're talking about here? Coutant asked. It's pretty small, and the question it would be useful to have an answer to is, how sensitive is your analysis to such small increments of change? I think temperature is a more critical factor than flow, in this case, Peery replied; as Jeff just said, temperatures above 24 degrees appear to be very detrimental. The other aspect of this is the effects of the temperatures encountered during migration on reproductive success and fecundity – that research is just getting underway.

Can you explain why there is an inverse relationship between flow and rate of adult migration? Bisson asked. The fish have to use more energy when they swim against a stronger current, Peery replied – fallback is also a factor. Is anyone doing any work with lamprey? McConnaha asked. We've done some, Peery replied, thanks to funding from NOAA Fisheries and the Corps. Obviously there's a lot we don't know about lamprey; they don't have the swimming ability of salmon. Temperature, again, is probably the major factor, in terms of the question you're considering at this symposium, said Peery. He added that the improved ocean conditions that have helped salmon returns do not seem to have had the same positive impacts on lamprey returns.

In response to another question, on straying, Peery said that, because some of the fish he radio-tags are PIT-tagged fish, they have some information on their natal stream, and hence have some information on straying. There are indications that straying is higher during periods of higher water temperatures. That's not as much of a problem for steelhead, because they don't have to spawn right away, but it is a problem for adult fall chinook, which have to be somewhere to spawn within a fairly narrow window of opportunity, he said.

Dave Geist of Battelle National Laboratories in Richland then provided a presentation on the effects of temperature on adult salmon bioenergetics. He explained that the objective of this Corps-funded study was to evaluate the use of electromyogram (EMG) telemetry to look at energy use in migrating adults. This technology involves the implantation of a transmitter into the fish's swimming musculature, collecting the signals that come out of the musculature as the

fish swims, and sending a signal, once the capacitor fills up, to a receiver. It's like a glass of water that is being filled by a pitcher, Geist explained – the quicker the water flows into the glass, the sooner the water overflows the glass.

Geist touched on the following major points:

- Adult salmon have finite energy reserves.
- Physiological challenges during upstream migration are highly detrimental
- A difficult passage environment increases the risk that adult salmon will expend all of their available energy before successfully spawning
- Temperature and flow both affect the energy use of salmonids
- This is a recognized issue – the 2000 BiOp directed the agencies to fund research for the purpose of evaluating the relationship between energy expenditure and pre-spawning mortality of adult salmonids migrating through the FCRPS.
- Energy expenditure of adult fall chinook salmon using EMG telemetry, a radio-telemetry technique that involves implantation of a radio tag transmitter into the musculature of the fish as a means of estimating the energy expenditure of adult salmon.
- Oxygen consumption vs. EMG pulse rate (graph)
- Oxygen consumption vs. swimming speed (graph)
- Estimated delay period per dam and reservoir, energy used for all eight dams and reservoirs, total migration time (days) (table)
- Use of EMG telemetry to estimate energetics of dam passage – the goal of this study was to estimate the energy expenditure of upstream-migrating adult salmon and steelhead to assess the potential influence of delay, fallback, water temperature and dam operations on migration energetics and reproductive performance
- Spring chinook salmon – Median VO₂ vs. swimming speed (graph)
- Muscle type determines bioenergetics – red muscle vs. white muscle (broken-stick model)
- 96 EMG-tagged and calibrated salmon released below Bonneville Dam to study where the fish expend the most energy
- 2001 water temperature and flow at Bonneville Dam (graph) – only two days of spill, low flow, higher-than average temperatures
- Spring chinook salmon bioenergetics at Bonneville Dam: median fish took 26.8 hours to migrate over Bonneville Dam; expended 31.7 kcal/g, or 190 kcal for an average 6 kg fish; anaerobic energy not accounted for, but could be substantial, as considerable time was spent swimming at speeds which were greater than 80% of Ucrit
- Swimming speeds highest in tailrace (diagram)
- 80% of aerobic energy used in tailrace (diagram)
- Sample analysis – beginning energy for a 6 kg chinook, based on proximate analysis showing 19.7% fat and 19.4% protein, and subtracting for gonad growth and development and standard metabolism, this fish would have 11,990 kcal for spawning and migration.
- Energy use rate: 8 kcal/hr at 12 degrees C
- If there are no delays, at 12 degrees C, the fish will have plenty of energy to reach spawning grounds above the eight mainstem dams. Any delay, obviously, eats into that

- energy reserve
- How might temperature and flow affect adult salmon bioenergetics? The estimated impacts on energy use rate of temperature – the higher the temperature and swimming speed, the greater the energy expenditure.
 - As temperatures rise and flow increases, delays of 1-3 days at each dam might prove critical.

Geist offered the following conclusions:

- Delays at hydroelectric projects can contribute to excessive energy use in adult salmon migrating upstream to spawning areas
- The impacts would be exacerbated if water temperatures or flows were higher
- Little work has been done on fall chinook salmon which migrate later in the year when water temperature is warmer
- Future work should include consideration of anaerobic metabolism and non-intrusive means of measuring energy content.

Geist said that, in his opinion, with respect to the question before this symposium, increased temperature would likely be more of a factor than flow, in terms of potentially detrimental impacts on adult salmon. We need to build a bioenergetics model for adult salmon, and develop a non-intrusive technique for proximate analysis, he said.

We're talking about a fairly narrow change in flow and temperature, said Coutant – if the tailwater situation in any of the dams were changed, might that be enough to compensate for the effects of the proposed change in operation? I don't know the answer to that, Geist replied; I know there have been a number of attempts to model the tailrace environment, where the greatest energy expenditure takes place for adult salmon. One thing you might do is provide holding areas in the tailrace, where migrating salmon could rest. I don't have specific suggestion as to how operations might be changed to speed adult migrants through the tailrace, although again, temperature is likely the critical factor.

It sounds to me that what you're saying is that lower flows are better for migrating adults, said McConnaha, except to the extent that it might increase water temperatures. That's correct, said Geist.

E. Predicting Changes in Fish Responses. Chris Van Holmes provided a presentation titled "The University of Washington's Columbia River Fish Passage Model (CRiSP)." He touched on the following topics:

- CRiSP basics – models smolt downstream migration and survival through tributaries, dams and estuary; uses daily and hourly time-step inputs to model river parameter; describes detailed fish movement, survival and river conditions; migration and survival models are calibrated to PIT tag data; dam passage parameters are taken from NOAA estimates.
- CRiSP components: GIS-based river model, component submodels, river conditions,

- input parameters, calibrated parameters
- The CRiSP graphical user interface
- Model inputs – daily flows, hourly spill, water temperature, pool elevations, headwater dissolved gas, transport operations, fish release profiles, fish guidance efficiency, spill efficiency, dam passage mortality, pool-specific predator density.
- CRiSP submodels include: water velocity, dissolved gas generated from spill, mixing, fish transport and dam passage routing, migration timing, mortality from predation and GBD
- Sample submodel results
- Travel-time calibrations (graph)
- Snake River fall chinook survival calibration (graph)
- Hanford Reach fall chinook survival calibrations (graph)
- NMFS v. CRiSP: spring migrants (graph)
- NMFS vs. CRiSP: fall chinook (graph)
- Current CRiSP development – continued migration and survival calibration, reach-specific migration and survival equations, development of temperature modeling for examining temperature migration effects, add turbidity to river descriptions for potential incorporation in survival models
- Recent CRiSP modeling activities

The group briefly discussed the “Hanford Reach fall chinook survival calibrations” slide; Coutant noted that one of his concerns about CRiSP and other models is that they over-simplify things, and can introduce model-generated error. If CRiSP was doing a perfect job, we would expect all of these points to fall along the diagonal line, Van Holmes said. It’s pretty close for the Hanford Reach fish, but it’s more sporadic for fall chinook. Are we including any measure of that variability in the estimates? Coutant asked. Are you able to say, our prediction is plus or minus X percent? The model does include a Monte Carlo simulation, Van Holmes replied. And would it be fair to say that CRiSP pretty consistently overestimates survival, compared to actual observations? McConnaha asked. Yes, Van Holmes replied, but with respect to cohort estimation for the John Day to Bonneville reach, as Steve has mentioned, the quality here is poor. We have automated a cohort survival estimate process in which we create cohorts in the release groups and generate estimates of their survival through the system. The survival estimates down in Bonneville are quite low, and if we eliminated them from the calibration, the parameters would align more on the one-to-one.

If you were to apply this model to the question before us, said Al Giorgi, it seems to me that Chief Joseph would be your control point. That’s correct, said Van Holmes. Have you used CRiSP to analyze the operations we’re considering here? McConnaha asked. No one has asked us to model this specific operation, although we have modeled past Montana SORs, Van Holmes replied. And what were the impacts of those proposed changes in operation? McConnaha asked. Slightly lower flows at McNary, slightly lower survival due primarily to a slight increase in predation, Van Holmes replied.

Van Holmes then moved on to the process for evaluating and choosing reservoir survival submodels for CRiSP. He touched on the following points:

- How does one choose a survival submodel for CRiSP from among all of the models put forth in the past two decades?
- Criteria for judging models – examine r-squared across all years etc.
- R-squared of observed vs. model survival (table)
- Can models fit seasonal and year-to-year flow-survival patterns? (Graph)
- Fall chinook survival, Lower Granite-McNary, 1995-2003, modeled vs. observed for various models (graphs)

The ISAB asked a few clarifying technical questions; one participant noted that predators are not stationary. The model assumes a relative velocity difference between predators and migrants, Van Holmes replied. Coutant asked about the ability of CRiSP to incorporate radio-telemetry data; Van Holmes replied that CRiSP cannot incorporate data at that fine a level of detail. CRiSP is a linear model, he said. Coutant observed that is the type of data that is providing very useful information about fish movement. Giorgi noted that Zabel's model may no longer be relevant, given the new work that is being done to model Snake River survival. That's true, said Van Holmes – that's one of the things that has been exciting me about this symposium, hearing about that new work.

Are the model runs you've done on previous Montana SORs available? McDonald asked. They can be made available, Van Holmes replied; I think the magnitude of the effects of those SORs and the effects of the current SOR would likely be quite similar. How is the reach between Montana and Chief Joseph modeled? asked another participant. With the Corps' hydroregulation model, Litchfield replied.

One thing that struck me was that your model predictions for fall chinook were off, compared to your results for spring chinook, said McConnaha. Does that imply that we may be leaving something out in our thinking? Is there something in the equation that CRiSP doesn't include? Some of the information we've heard about the reservoir life history suggests that there may be more to this than we thought. That is something that CRiSP has not taken into account, Van Holmes replied; I'm rather excited at the prospect of incorporating that aspect of the fall chinook life-history into the model, because I think that is contributing to our lower level of confidence in CRiSP. The Snake River, for spring migrants, has a lot of information, Van Holmes said – calibrations have been performed on what we feel is a pretty good picture of what's actually happening in the river. We've gotten a lot of feedback, and we've made a lot of adjustments, based on what has actually been observed. For Upper Columbia fall chinook, we simply don't have that same level of review and detailed observation – for example, we have little information about predator densities.

Do these models incorporate operational improvements at the dams – changes in spill pattern, turbine efficiency etc.? asked another participant. We incorporate the best available estimates of fish guidance efficiency, as well as turbine, spillway and bypass survivals at each project, Van Holmes replied; when we do the calibrations, we use observed operational information for each project. As better information becomes available, we are able to incorporate that into the model. We use what we consider to be our best estimate of what's going on at each

dam, he said.

I think the implication of that question is, if your response variable is a composite reservoir survival, rather than a reservoir survival you would be backing out that dam effect, and maybe you would see sharper relationships in the flow or temperature responses of the fish, Al Giorgi observed. That's true, but at the current time, we don't have a basis for rejecting NOAA's dam passage estimates, Van Holmes replied. Those are the best estimates available, and we feel pretty confident in using them. They change over time, and as that occurs, we incorporate the changes into CRiSP.

Next, Jim Ruff provided a presentation on NOAA Fisheries' SIMPAS model. He touched on the following topics:

- The focus of the results presented today is solely on fall chinook
- Description of the SIMPAS model – a spreadsheet model covering all eight federal dams, a “fish passage accounting model” that apportions the run to various passage routes: turbines, spill, transportation etc. It accounts for both fish survival and mortality, as well as the fish that are collected and transported. The model starts at the head of Lower granite pool. Its main purpose is to model survival differences between alternatives.
- Development and history of SIMPAS – developed by NOAA Fisheries in support of the 1995 BiOp; has been used extensively since. The model has been extensively upgraded and improved in recent years; it is being used to evaluate the Updated Proposed Action (UPA) in the 2004 BiOp.
- How does SIMPAS work? Starts with a group of fish at the head of Lower Granite pool and applies a pool survival rate prior to the fish reaching the dam forebay. At the dam, the model assigns the surviving fish to various routes of passage and removes transported fish. It then recombines the surviving fish in the dam tailrace; the model repeats this process at each FCRPS dam
- SIMPAS model inputs for each species – more than 18,000 in all
- Sample outputs (table)
- The analytical approach to the 2004 BiOp – establish the effects attributable to the environmental baseline (hydro) compared to the effects of the UPA – gap analysis; establish a reference operation to describe the “best” survival rate associated with the existing configuration of the dams and reservoirs over the 1994-2003 study period; evaluate the estimated survival rate associated with the action agencies' UPA; compare the estimated system survival rates between the UPA and reference operations to obtain a relative difference in survival for each species, differences between the RO and UPQA operations: seasonal average summer flows for the two operations from BPA's 50-year HYDSIM hydroregulation model; in the RO, FCRPS storage reservoirs used fully to meet slightly higher summer flow objectives; the used 2000 BiOp flow objectives and draft limits; for the RO, exceedance probability of meeting 2000 BiOp flow objectives at Lower Granite and McNary was 10% and 78%, respectively; for the UPA, the exceedance probability of meeting the 2000 BiOp flow objectives at Lower Granite and McNary was 10% and 36%.

The reason for this difference is that we put a priority on trying to refill the storage projects by the end of June, and on taking away the draft limit to meet the summer flow objectives, said Ruff.

I didn't understand, said one ISAB participant. Ruff said that what he was trying to explain is how SIMPAS would be used to get a survival gap – a relative difference in survival between two operations. What we have done is to try to define a baseline survival rate with the dams and reservoirs in place, and compare that to a proposed action provided by the action agencies, Ruff said. There are two separate operations – typically the reference operation gives you a higher survival rate, while the proposed operation yields a lower survival rate. That difference is what we're calling the survival "gap," Ruff explained. My purpose here is to summarize, briefly, the differences between these two operations. Is one of them the Montana operation? asked MacDonald. No, Ruff replied – the analysis employs the 2000 BiOp flow objective of 200 Kcfs at McNary and 50-55 Kcfs at Lower Granite, using the federal storage projects to their current draft limits – 20 feet at Libby and Hungry Horse in July and August, if needed to meet the flow target. That is the proposed action the federal action agencies gave us, and that is what we are required to analyze. He emphasized that he is not presenting a NOAA Fisheries analysis of Montana's proposed operation at today's meeting – that is a separate analysis.

Moving on, Ruff touched on

- More sample outputs
- The differences between the reference operation and the UPA
- Development and use of flow-survival relationships – three major steps are necessary to complete survival gap estimates between the Reference Operation (RO) and the UPA using SIMPAS. Ruff defined the reference operation as a surrogate to describe the best survival rate that NOAA could come up with associated with the existing dams and reservoirs of the FCRPS over the 10-year study period (1994-2003). The reference operation essentially removes all operations for power, flood control and irrigation depletions, said Ruff – it just leaves the dams and the reservoirs. This process includes the following, said Ruff: 1) define and evaluate a retrospective analysis of survivals over the 1994-2003 study period; 2) determine if a flow-survival relationship exists and, if so, define a functional relationship and 3) apply each reach's flow-survival relationship to any flow changes derived from hydrosystem modeling of the UPA or RO
- Sample outputs: Snake River fall chinook pool survivals vs. flows (Lower Granite-Ice Harbor), fall chinook pool survivals vs. flow, McNary-Bonneville (graphs)
- Survival gap analysis for Snake River fall chinook – these pool survivals, together with changes in dam survival based on expected system configuration changes associated with the UPA, allow SIMPAS to determine the relative difference in survival between two operations. Relative (hydro) survival gap in draft 2004 BiOp between the 2004 and 2010 UPA and the RO ranges from -13% to -5%.

In response to a question, Ruff said this fall chinook analysis is not intended to look at the

proposed Montana operation – everything he has presented today is from the 2004 BiOp’s fall chinook analysis. Coutant noted that everything he has heard today indicates that temperature, not flow, is the critical factor in evaluating the survival impacts of Montana’s proposed operation. How can we conclude that SIMPAS has anything to do with reality if all you’re doing is evaluating water movement? How can SIMPAS just do away with temperature? he asked. We’re not just doing away with it, Ruff replied – if I can keep going here, I’ll explain how we’ve developed our estimates of changes in pool survival, which may answer some of your question. However, the short answer is that SIMPAS doesn’t have a temperature function, said Ruff; we’re calibrating the model based instead on the reach survival estimates that are generated by the Science Center. We then develop flow/survival relationships to estimate differences in pool survival.

We’ve just been hearing that that is, in large part, a temperature/survival relationship, rather than a flow/survival relationship, Coutant said. However, to the extent that they are co-variants, whether it is a temperature, or a direct flow effect, you’re calibrating to a set of observations, said McConnaha. Right, but everything we’ve heard over the past two days indicates that temperature is the critical factor, even if they are co-variants, said Coutant.

To what extent does the proposed action resemble Montana’s proposed operation? MacDonald asked. The UPA would draft both Montana projects to their draft limits – 20 feet down from full – if necessary to meet the flow target by August 31, Ruff replied – in most summers, that would be necessary. Montana has proposed that the full draft would not be completed until the end of September. Do we have empirical evidence that, when they release water from Libby and Hungry Horse that it actually shows up downstream? another participant asked. We have just heard that it is necessary to draft Libby and Hungry Horse most summers to meet the BiOp flow targets at McNary, and I wonder of there’s some way we can have an accounting of that water.

There are many issues associated with accounting, Litchfield replied; we don’t really have a good accounting of where all of the water goes. The Libby water, in particular, has to pass through many other projects before it reaches the Lower Columbia. A monthly time-step model washes all of that out, but that’s an assumption, not an observed flow. To me, it’s attenuation – it doesn’t show up, drop for drop, in the same place at the same time – you can’t say for sure that if you release an additional 5 Kcfs from Libby, that 5 Kcfs of additional flow will eventually show up at McNary. From what I understand, some of the projects can leak 5 Kcfs under some conditions, so hydro-regulation is hardly an exact science, as many in the region believe, Litchfield said. This is an area where we have to better, Coutant observed, because the fish don’t operate on a monthly time-step. If we’re going to figure this out, we have to know more precisely what’s going on in the river system.

Your regression is a between-year relationship, based on seasonal averages? Goodman asked. Yes, Ruff replied.

On the McNary-Bonneville flow/survival curve, I got confused, said Litchfield – I thought I heard you say you didn’t have enough marked fish to get a good reach survival

estimate. That's correct, Ruff replied. What are the dots we see on this graph? Litchfield asked. We have reach survival estimates for the Lower Granite-McNary reach, Ruff replied; we know the survival rate through that reach, in terms of estimated survival per mile. These are extrapolated survivals through the Lower Columbia, because we had no information. I see, said Litchfield – you were assuming the same survival rate you saw in the Snake. Correct, Ruff replied.

So if the Y-axis in this regression is Snake River survivals, are you using Snake River flows for your X-axis? Goodman asked. No, Ruff replied. Are you surprised, then, that you got a bad regression? Goodman asked. We looked at the survival per mile rate through the Snake, Ruff replied; we know that the fish are migrating faster as they go downstream. We have also looked at travel time/survival relationships, said Ruff – we thought about using those, but they weren't any better than what we have here – they were about the same. We did look at travel time, but we know the fish are migrating at a faster rate through the Lower Columbia, so you would think that their survival would be at least as good as it was in the Snake, and possibly better, although there is a greater concentration of predators in the Lower Columbia than there is in the Snake, Ruff said. What this points out to me is that there are still a lot of uncertainties; we need to PIT-tag more fish so we can develop empirical survival estimates in the Lower Columbia.

You're absorbing temperature into flow, essentially, said Coutant. Correct, Ruff replied. We heard yesterday that increased late-summer flow augmentation from Brownlee raises the water temperature, which may actually be detrimental to survival, Coutant said – how can we ignore temperature when, by adding flow, we're actually decreasing survival? Help us understand how NOAA Fisheries' work on the BiOp can succeed if it ignores temperature, Coutant said.

For management purposes, we are not ignoring temperature, Ruff replied – we are managing for temperature in the Snake River during the summer by releasing cold water from Dworshak. Our goal is to maintain temperatures of 20 degrees C or less at Lower Granite, and for the last several years, we have been successful in doing so. Both the RO and the UPA include continued cold-water releases from Dworshak, said Ruff. However, part of the reason you need that cold water from Dworshak is to counteract the effects of the warm water you're getting from Brownlee,, said Coutant – it seems to me that we're running flow augmentation in the Snake at counter-purposes. Help me understand how the fact that SIMPAS doesn't factor in temperature doesn't muddy the waters.

We know that flow and temperature are auto-correlated, Ruff replied; the temperature/survival function is an inverse relationship. We think that the empirical reach survival data that has been gathered in recent years under the current operation is indicative of what the survival rate really is under the operations that we're modeling here. NOAA Fisheries hopes that, during the upcoming FERC relicensing consultations with Idaho Power on Hells Canyon, that some sort of a selective withdrawal or temperature control system will be on the table.

Al Giorgi then provided a presentation titled “Managing the Columbia River: Instream

Flows, Water Withdrawals and Salmon Survival.” Giorgi noted that this study was recently completed by the National Research Council; its purpose was to advise the Washington Department of Ecology about the risks to salmon resources associated with proposed water withdrawals from the Columbia River. Giorgi touched on the following major topics:

- The proposed action: for the mainstem Columbia in Washington, withdraw an additional 0.25 MAF-1.3 MAF in new water rights. Existing water rights in Washington total 4.7 MAF. Summer is obviously the peak demand period, precisely the time period that is of interest to this symposium.
- Topics covered: hydrology and water management, environmental influences on salmon, water laws and institutions, strategies to improve the use of the water supply, and risks and uncertainties.
- Biological issues included a review of the available flow/temperature/fish response information; various parties made formal presentations predicting the effects of flow reduction; the results varied widely
- Committee conclusion: when river flows or temperatures reach critical levels/thresholds, pronounced changes in behavior and survival are expected. This constitutes a risk that is difficult to quantify in absolute terms.
- Broader context: get out of the weeds (human population centers expanding, particularly on the waterways; water demand will increase; there is no cohesive regional water management plan, currently; stage is set for tragedy of the commons; risk increases in low water years.
- Climatic effects (graph)
- Temperature – a naturally-increasing trend that is predicted to continue; in the summer, critical biological levels are already being approached or exceeded; actions that contribute to increasing temperature pose a risk to summer inhabitants; return flows can be a contributory factor

The NRC offered the following observations and suggestions, Giorgi said:

- Any new water rights must be flexible and interruptible
- Improved water monitoring and metering is needed
- The region must realistically value water to promote conservation
- A water market needs to be established; the state needs to charge for rights

With respect to the potential impacts of increased water withdrawals for summer flow augmentation, Giorgi offered the following “opinion piece:”

- Withdrawals compete with flow augmentation
- As a result of water withdrawals, flow augmentation water may not reach its intended destination
- Demand for future withdrawals is likely to increase
- Risk is highest in years with low base flows
- A Regional Water Use Plan, including Canada and the tribes, deserves consideration, however difficult it might be to negotiate

The concept of cumulative effects is a very important one, McConnaha said, in the context of the very small changes in operation that are under consideration here – the system is sort of suffering the death of a thousand cuts. He asked the ISAB members if they have any questions about this morning's presentations.

How much confidence do you have in the SYMPAS model's ability to evaluate the effects, on survival, of the Montana plan? MacDonald asked. John Stein replied that one thing he noted in the two regression relationships Jim Ruff showed earlier was that they corresponded with the sections of river I presented data on yesterday, although they weren't necessarily the same stocks of fish. For both of my data sets, I drew a line showing a flow/survival relationship in those reaches, Stein said. Despite the fact that Jim was talking about annual averages, while my work looks at multiple groups within a year, if you look at those two curves, they really weren't very different, with the exception of the 1997 data. For the McNary to John Day reach, I showed a straight line, which probably isn't that different from the fit of the curve generated by SIMPAS. To the extent that a flow/survival relationship would be used for that sort of prediction, there is some data supporting that, Stein said. The information we have on temperature is somewhat muddy; we recognize that models are lacking, at this point, in their ability to do those kinds of predictions. Specifically, with respect to the Montana Plan, I would have as much confidence in SIMPAS's ability to predict that tiny difference as I would have in any other model, Stein said.

MacDonald noted that it would be useful if more empirical data points could be generated; Stein agreed. Obviously the models are somewhat simplistic, added John Williams – when you look at the fall chinook survivals in the Snake, we can't really say that the larger fish we see in the lower river will have the same survival probability. Given that you now have larger fish in the lower river, in an area populated almost entirely by smaller Hanford Reach fish, the mechanisms impacting survival in the Snake may not have the same impact on fish once they enter the Columbia. To jump from one system to the other is based on faith, without data to tell you whether you're right or wrong. It could be entirely wrong to say that you would expect to see the same rate of survival in the lower river, because you're talking about different biological conditions.

Summer flow augmentation, as proposed, is to benefit the fall chinook coming out of the Mid-Columbia, rather than those coming out of the Lower Snake? Bisson asked. Litchfield said the nexus for demanding that the Montana reservoirs be drafted 20 feet by August 31 is the NOAA Fisheries Biological Opinion. That BiOp drafts the Montana reservoirs for one listed stock – Snake River fall chinook – there are no other listed stocks in the river at that time. The legal requirements that the federal government is implementing in Montana are driven by Snake River fall chinook below McNary.

Whitney noted that the NOAA Fisheries white paper on migration timing, on which Williams was the lead author, was very interesting. In particular, I recall that what you said in that white paper was that transportation may be counterproductive, because it gets the fish to the estuary too soon, Whitney said, and that early arrivals to the estuary return at a lower rate as

adults. As I recall, the same was true of in-river migrants. Williams replied that most of the paper related to spring chinook; it showed that, if we mark fish at Lower Granite, the fish that are transported return at a lower rate than the fish that work their way through the hydropower system and don't arrive below Bonneville Dam until some time later. We don't have very much information on the fish that arrive below Bonneville in late March and early April because there aren't many of them, said Williams.

What would you think would be the picture with fall chinook, based on your experience, in terms of early vs. late arrival in the estuary? asked Whitney. Those fall chinook that are transported early have much lower return rates than the fish that are transported in September and October, Williams replied; I have to conclude that that has to do with the relative size of those fish – the later migrants are larger. Based on the scale sample information Billy Connor presented yesterday, we know that 40-50% of the adults that return to Lower Granite had a yearling life-history as juveniles, yet we're transporting, we think, 90-95% of the Snake River fall chinook. You can do the math on that very quickly, Williams said

We saw some information yesterday showing that the SARs for transported vs. non-transported fish are roughly equal, said McConaha. Connor described his analysis of CWT-tagged yearling and subyearling chinook, noting that, among other factors, yearling migrants are entering the ocean when ocean temperatures are cooler than are the ocean-type subyearlings, which enter the ocean when temperatures are at their peak.

We have heard how important temperature is to this mix, observed Brian Marotz; while a flow-temperature relationship exists, the Montana flow augmentation water is not impacting water temperatures in the lower river. He noted that the 4.7 MAF in existing water rights in Washington alone is equal to the active storage space in Libby Reservoir. This strikes me as more a question of reallocation than one of biology, Marotz said.

Coutant noted that one of the reasons the flow/survival controversy has raged for so many years is a regional reluctance to work in the details. It doesn't do us any good to look at annual averages, monthly averages, the things we've done for so many years, because they're just not answering our questions, he said. There does seem to be a reluctance on the part of many in the region to consider new ideas that might conflict with the existing "belief system" – it's a cult, said another ISAB participant. We need new studies, but we also might need a counselor – someone to de-program us.

What is the value of the Montana water in terms of maintaining biodiversity in the Montana reservoirs? Bisson asked. That's an excellent point, said Litchfield. The big issue here has been the tradeoff, in terms of biological detriments for Montana reservoirs, in exchange for the supposed biological benefits for anadromous salmonids downstream. In Montana, we're talking about bull trout and sturgeon, which are also ESA-listed, in addition to species like rainbow trout and lamprey – there are many species, in addition to salmon, that are affected by the Montana withdrawals.

7. Research and Anadromous Needs – Discussion of Research Needs and Experimental

Feasibility.

The afternoon portion of today's symposium was devoted to a panel discussion involving Steve Smith and Mike Langeslay of the Corps, Al Giorgi of BioAnalysts, Chuck Peven of Chelan PUD, and Bill Muir and Billy Connor of USFWS.

The question we need to consider is experiments, said McConnaha; the action from the Council was proposed as a hypothesis, in the context of an experiment, and what we want to address this afternoon is, is it possible to design such an experiment?

I've worked with science panels quite a bit, said McConnaha, and have never yet met a group of scientists that didn't think we needed more information. Do you think that more data would lead to a better decision about this question, or do we have enough information to make an intelligent decision about changing summer operations?

If we're focusing on the narrow question of the effect of changing the operation of the Montana projects, and want to test a statistical hypothesis about the effects on anadromous fish, I don't see how we'll be able to do that anytime soon, Smith replied. If we're talking about an impact on survival of only 1-2%, I don't think we can measure that, said Smith – the number that sticks in my mind is that it would take 475 years of data to produce 80% confidence at that level of impact.

If that's the case, what can we do? McConnaha asked. What metrics would we be able to measure? Peven asked. We're talking about potential differences in travel time and survival, but it would take a very long time to separate the signal from the noise, Smith replied. There are various philosophical approaches to using regression lines to make predictions, he said; I believe I heard that Dr. Goodman would be willing to use some of those curves to make predictions.

Frankly, all bets are off, because of the new twist involving life history and its effects on the mark/recapture studies, said Goodman. If we set that aside, and say, if we got a regression line from a regression model of about this quality, with the sort of R-squared we're seeing, is there anything wrong with using that to estimate a difference? My feeling is no, Goodman said. The point isn't to look at the uncertainty of two independent estimates that you subtract, because the two estimates have exactly the same error structure – they're based on the same regression line. The correct appraisal of uncertainty is simply to say, with our uncertainty about the slope of that regression line, how does that propagate to a calculation of a delta of a specified quality? As long as your regressions are reliable enough that the slope isn't wandering all over the place, I'm comfortable with using the regression to compute differences in this way. What's troubling me about the discussion, currently, is that we may be taking too narrow a view of what the experiment ought to be. Maybe the experiment should be a 10-20 percent difference in flow, in order to get a signal you can differentiate from the noise. You could then extrapolate and say, how does this apply to a smaller delta? You need to tell us how big a change in flow we would need in order to generate a signal large enough to be detected. That might take 10 years, but in the grand scheme of things, that's not that long a time, Goodman said.

There is obviously a practical legal consideration involving listed species, McConnaha observed – is it even feasible to try to design a large-scale ecological experiment to tease out the differential impacts of temperature and flow? I don't think that's possible, said Giorgi. We need to decide where we need to monitor the response; if listed species are what we're monitoring, I just don't see an opportunity to do that – there are simply too few fish, and sample sizes preclude meaningful evaluation. If you want to pick out a small reach in the upper Columbia, and look at changes in reach-specific reservoir survival, that might be possible, but the problem you run into there is a lack of PIT-tag detections. I see limited opportunities to conduct the kind of experiment you envision, Giorgi said.

When we went through the summer flow augmentation review with the ISAB a few years ago, they made a lot of really good suggestions, Connor said; however, many of those suggestions simply aren't practicable – there are simply too many conflicting demands on the system. In terms of how many fish we could tag, said Connor, realistically, it's about 10,000 subyearling fall chinook per year – you're quite limited in the number of wild fish you can tag.

There is another dimension to the notion of experimental design, said Goodman – what has emerged, over the past two days, is that we're in a startling state of ignorance about the survival rates of these fish, in part because of this startling revelation about a second life-history. What kind of design do we need to pursue to obtain reliable estimates of the survival rates of those fish? This issue came up at a recent fall chinook transport meeting in Walla Walla, said Giorgi – one idea that was discussed was to extend the period of PIT-tag detection, although weather conditions and maintenance needs limit the period in which the bypass systems can be operated.

If we can somehow get more fish PIT-tagged – say, at Rock Island – could we then capture those fish during the winter? Pevin asked. I think there may be an opportunity to start up the bypass facilities sooner, and run them later, Langeslay replied. We have also been working on ways – perhaps trawling and mark/recapture – to calculate the abundance of reservoir-type fall chinook, added Connor. Would more in-reservoir sampling be useful? Coutant asked. We have to be careful about handling these fish, said Pevin; a more passive system would probably be better.

Could we approach this from the other end, and attempt to discover what percentage of the fish we're currently counting as mortalities have, in fact, simply committed to the reservoir lifestyle? Goodman asked. That would go a long way toward answering this question. An active, rather than a passive, tag, would be a feasible way to get at that data, said one of the panel participants.

It seems odd that we're devoting such effort to the effects on a small change in operations on a very small group of fish – undetected fall chinook – when we could be studying something much more important – the relative survival of barged fish, or how to improve adult returns, which is where we intend to focus our efforts in the future, said Muir. It's probably true that a good transportation experiment would be very useful, McConnaha agreed. We transport 95% of the fish we collect, but what percentage of the total run are we actually collecting? asked

Langeslay – that’s another thing we need to get a better handle on. The group discussed the potential of scale analysis to shed light on the life history of all returning adults.

Why don’t we collect scales now? Coutant asked. People were concerned about changing the sample site, and about the impacts on US v Oregon, John Williams replied. We couldn’t get it through the system this year, but will continue to pursue it in the future. One participant suggested that scales be taken from carcasses. Connor noted that he is collecting some scales.

Returning to the proposed Montana operation, said McConnaha, while I agree that information about the reservoir component of the Snake River fall chinook is fascinating, but who cares? The question is still, can we say something informative about the impacts of this proposed reduction in flow on fish in the Lower Columbia? I don’t think you can completely ignore the reservoir-type life history, said Pevin; after all, any changes to the system affect the riverine environment, and might tilt the balance in favor of one species to the detriment of another.

Goodman said that, to him, the life-history puzzle needs to be unraveled before any accurate survival estimates can be developed. Giorgi commented on CRiSP’s development; if you don’t see a response in the migratory behavior of these fish, why would you expect to see a difference in survival? he asked. Perhaps that’s where we should be focusing our research efforts – on migratory behavior. Goodman observed that it is possible that the reservoir-type fall chinook are making a lifestyle choice that will ultimately benefit that population.

If it would take 475 years, using conventional statistics, to separate the signal from the noise, what about unconventional statistics? McConnaha asked. Is there a better model we could put together now, and continue to refine? I think that approach makes sense, said Giorgi; if we could better describe the life-history dynamics by taking smaller, more detailed snapshots, I think we might be onto something. You might be able to use active tags and reservoir sampling to put together a nice, detailed suite of data.

Most data we’ve seen have indicated a positive correlation between flow, the speed of travel and survival, MacDonald observed. That kind of professional judgment would, in my opinion, hold up, even as the discussion about the reservoir-type fall chinook takes place. It’s analogous to the question of, “does smoking cause cancer?” If we waited for absolute certainty, we would still be in doubt about the answer to that question. The reluctance to use regression-type modeling, in conjunction with professional judgment, is causing some of the stagnation that is paralyzing the region’s ability to make decisions, MacDonald said.

Giorgi asked what research gaps the ISAB would like to see filled. MacDonald replied that differential mortality is an extremely important question. With respect to water velocity, perhaps those fish are better off moving through the lower river at a very slow pace, he said – it’s a question I’d like to see answered.

Whitney said that, to think outside the box, he like the linear regression approach. However, when it comes to practical application, it seems like we need more studies to really see, measure and document what those effects are, and come up with better water management

practices.

We need to measure the velocities in the reservoir, said Coutant – if you're looking at an average velocity across the reservoir, that's not what the fish experience at all. One gap I see is actually going out and measuring velocities in the areas through which fish are moving, he said. We would need to look hard at the pressure points in the system, and decide where we need to measure. If the goal is to deliver flow to McNary, then John Day reservoir might be an appropriate place to measure.

One question is, how good are our velocity measurements at predicting the actual conditions fish see? said Coutant – maybe they're accurate, and maybe they're not. We could be way off, he said. I can visualize a situation where we might be encouraging the residualization of fall chinook, which could be a good thing, added Whitney.

It's true that we're still doing the same basic kinds of studies Karl Sims was doing back in the '70s, McConnaha observed. Isn't there something else we could be doing, perhaps along the lines of viewing the mainstem in terms of flow and normative habitat, rather than simply flow and survival? You might be able to do something with temperature monitoring, which would take us beyond the existing temperature modeling in terms of level of detail – for example, where the fish are jumping from cool area to cool area on their way upstream, replied another ISAB participant.

Another hypothesis I've thrown up in the past is the idea that the hydraulic environment – the influence of turbulence – is probably as important as, say, velocity, in its influence on fish behavior, Coutant said. The idea is to think like a fish, and say, well, what happens when that turbulent environment – that cue – disappears as the reservoir widens out and slows down. The fish might well turn back upstream, trying to find that cue again. There's a hypothesis, something to test, said Coutant. We could do some turbulence measurements under different flows in one of the reservoirs, so that we could calculate turbulence intensity, using 3-D modeling. If we could find an optimum turbulence habitat profile to encourage the fish to migrate in a straight shot, we might be able to develop a more effective reservoir operation at some point in the future. To me, that's a gap in our knowledge of flow and migration success, Coutant said.

Muir observed that it now appears that size at outmigration, rather than speed of outmigration, appears to be a more critical factor in the ultimate survival of those fish. If the fish are allowed to take 50 to 60 days to move down the system, rather than two days in a barge, they're much larger and better equipped to handle the predation below Bonneville.

So the Council has posed this as a hypothesis, said McConnaha. Is there anything the field researchers can do, or plan to do, to shed light on the Council's hypothesis that this change will have no discernable effect? Connor replied that, even if he looks at local velocities and fish movement, that won't say much about what's happening in the Lower Columbia. Other than continuing to support the incremental effects of continued flow augmentation releases on survival, I'm not sure our work will add a lot to our knowledge about this proposed change, he said. Smith said it seems important, to him, to learn as much as possible about the reservoir-type

Snake River fall chinook this year. That's something I'll be starting on immediately, he said; we will continue to generate new data points, and to mine the existing data set.

Is there more we could be doing in the Mid-Columbia? McConnaha asked. There's always more we could be doing with temperature, Pevin replied; we're still trying to investigate and determine what's going on with temperature in the reach. Again, the lack of PIT-tag detection is a limiting factor in the Mid-Columbia; we might be able to do more reservoir seining if the region deemed that a high priority.

One thing we haven't talked about yet is non-intrusive marking techniques, such as strontium marking, which is easily detected, well-proven to work and safe for the fish, might give us an opportunity to mark some of these fish at a time of year when it's dangerous to handle the fish, Coutant said. It's a batch mark, though, Giorgi observed. True, but it is still a technique that might serve us well for some of this work, Coutant replied.

Bill Muir said his agency has discontinued its Snake River fall chinook survival study, and will be concentrating mainly on piggy-backing with the transport study; obtaining an adequate supply of good-quality sample fish has been a problem in years past. Connor added that his group hopes to increase the number of wild fish marked in 2005.

One other thing we might consider is studying PIT-tag mortalities, as well as PIT-tag survivals, said Coutant – there are thousands and thousands of PIT tags in the sediments of our reservoirs, and those deposition zones might tell us something about where those fish are dying. I think that would tell us a lot about the mortality side of the survival equation, he said.

Is there an opportunity to collect and tag more Hanford reach fall chinook? Geist asked. One problem is that those fish are awfully small, Muir replied – if you tag that far upstream, you introduce a fair amount of size bias.

Williams said that, in recent years, the return rate for fall chinook is roughly equal to that for spring chinook. He discussed the relative egg-to-smolt and parr-to-smolt survival rates for spring and fall chinook, noting that as many as ten times as many fall chinook are surviving to the smolt stage than are spring chinook. In other words, he said, spring chinook are dying at a higher rate early in their life cycles. Perhaps theoretical modeling might help us determine where, in the life cycle, the bottleneck is occurring. Somehow, we've got to try to put all of the various pieces of information we've been discussing into a bigger-picture view of fall chinook.

Mark Reller of BPA suggested that getting a good handle on the magnitude of the physical change would be the logical place to start considering the experimental design that would get at the biological response question. You kind of need to start one step earlier, and define your hypothesis, so that you're clear about where you're going with this, Pevin replied. I think the Council has given us a hypothesis to test, Coutant said – I think we do need to see if it's even possible to measure such a small change in velocity. How the gates are adjusted at each dam may have more influence on velocity than the amount of water flowing through a given point in the system, Coutant observed.

Langeslay said that, in his opinion, it is very unlikely that, even if an appropriate study can be designed, that it will show a significant change in physical water velocities.

8. *Wrap-Up.*

Eric Merrill said the ISAB will work on its report on the question posed by the Council, and will try to complete that prior to November 30, when the final 2004 BiOp is due out. Coutant said he had been pleasantly surprised by the quality and variety of the information presented at this symposium. MacDonald said that, in his view, there are still a few critical pieces of information outstanding – the extent and effect of load following at Libby, the degree to which the Montana releases are actually delivered to the river, the need for a better, more formalized PIT-tag monitoring system in the Snake and the Mid-Columbia. MacDonald added that it might make sense to consider transporting the Snake River fall chinook to below McNary only, rather than giving them a ride all the way to the estuary.

Bisson said he, too, feels that he has learned a lot at this symposium. I know it was focused on the survival of fall chinook in the lower river, he said, but I was disappointed not to learn more about the effects of this change in operation on resident fish upstream – the potential benefits for bull trout and other species. Litchfield said there is a great deal of written information available on this topic, much of which the ISAB has already reviewed. That's a very important point, said McConnaha.

Litchfield said that, on behalf of the Montana Council members, who were unable to attend today's session, Montana really appreciates the time and effort those who have participated put into this symposium. They asked me to highlight a couple of things. First, he said, the reservoir operations in question are entirely driven by the requirements in the BiOp. NOAA Fisheries is in the process of finalizing the new BiOp, he said, hence our interest in resolving this question as soon as possible.

With respect to load following, said Litchfield, the information I presented to you yesterday was monthly time-step data. Even when flows are flat for a time, there is still some load-following. as Brian Marotz told you yesterday, short periods of dewatering are not very detrimental on the habitat downstream, but several days of dewatering are. He discussed the flow information presented during the symposium, noting that, even if the ISAB takes those graphs as gospel, the changes Montana is proposing will not produce a measurable change in the physical environment in the lower river.

I, too, learned a lot at this symposium, Litchfield continued; I think what I've heard turns our current management strategy on its head. We heard that half of the fall chinook we're getting back are coming from the reservoir-type fall chinook, a life-history type we've only recently learned exists, and for which we are not consciously doing anything. Another confusing thing is, what I think I heard today is that what the returning adults need is the polar opposite of what the juvenile fish need.

Litchfield invited the ISAB to study the Mainstem Amendments with an eye toward assessing their scientific validity. He thanked the ISAB and the other participants for their time.

McConnaha touched on some of the things he's taking away from this symposium, including the fact that it may not be the best idea to speed the fish downstream.

With that, the symposium was adjourned.